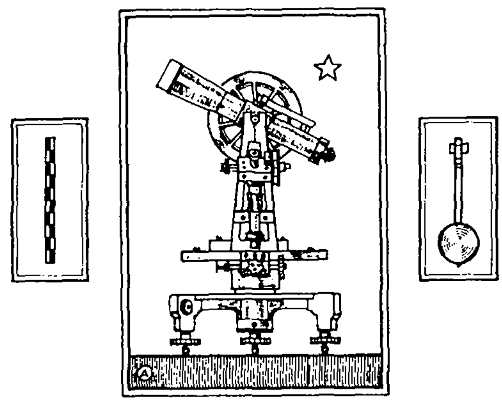
GEODETIC LETTER



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INTRODUCTION AND REVIEW

Hugh C. Mitchell

This number of the GEODETIC LETTER is given over to a consideration of State-wide plane-coordinate systems. It may be regarded as a continuation of the May 1935, number, which was devoted largely to an academic study of the use of geodetic control in cadastral surveys through the medium of plane coordinates. The present number gives consideration not only to cadastral surveys, but also to detail surveys of other types which have been based on State plane-coordinate systems. It consists of a number of articles, some of which partake of the nature of engineering reports in that they tell of things accomplished. These articles have been prepared by men whose work has made them authorities in matters whereof they write. In a way, the May 1935, number of the GEODETIC LETTER was the story of what engineers thought of the value and utility of geodetic control and State plane-coordinate systems, while this number tells of what has actually been accomplished in various fields in the short time that has elapsed since the State systems were devised. With several exceptions, the articles which make up this number describe particular instances of such accomplishment.

The national geodetic survey provides such control through the medium of thousands of well-monumented points for which position data have been determined. Since, in any area, lost stations of the control survey can be readily reestablished from a few remaining stations, any dependent survey is thereby insured against loss.

For many years the problem had been one of finding a simple and practicable means of utilizing for detail surveys the admitted values of data pertaining to monuments established in the national control survey. Prior to 1933 this could be done only through the geodetic methods and formulas by means of which such control surveys are originally executed and normally extended, or by setting up systems of plane coordinates of very limited extent. Lack of training and experience on the part of engineers and the need for special equipment in the way of instruments, machines, and mathematical tables have prevented any but a very small use of geodetic control data by the first-named method. That use has therefore developed through the second method - the establishment of local systems of plane coordinates, on which x and y values for the triangulation stations could be computed from their latitudes and longitudes. The computations involved in the transformation of geodetic positions to plane coordinates on a local system are quite simple, but there is a serious limitation to such use - the rapidity with which the accuracy of the plane coordinates diminishes with increasing distance from the origin of the projection. This loss of accuracy is the direct result of the type of projection which it is necessary to use. The only practical way of overcoming it is to limit the extent of the area by a single plane projection. Thus for the triangulation of Greater New York, executed under the direction of the Coast and Geodetic Survey in 1903-8, three different systems of plane coordinates were adopted for the reduction of the geographic positions to plane coordinates, the form in which it was necessary to put the position data in order to make such data of the fullest use and value to the city engineering department.

As the use of the national control survey data for referencing and controlling detail surveys of various kinds became more general, the reduction of geographic positions to plane coordinates on a tangent plane was greatly simplified by the publication of tables which in a few years ran into several editions.[1]

It was in 1933 that a satisfactory method of using geodetic data over a large area on a single plane base was developed. In that year, in response to a request from the North Carolina Highway Commission, Dr. O. S. Adams, a Senior Mathematician in the Division of Geodesy of the Coast and Geodetic Survey, devised a plane projection system which included the entire State of North Carolina on a single plane, and at the same time maintained acceptable scale factors to its very borders. In the article commencing on page 10, Dr. Adams describes in a general way the two kinds of map projection used in devising plane coordinate systems for the various States. In the year which followed the adoption of the North Carolina System, comparable systems were developed for the others States of the Union, projection tables were prepared by means of which geographic positions on the standard datum could readily be transformed into plane coordinates on the proper systems, and in the offices of the Coast and Geodetic Survey such transformation of coordinates was commenced, and is still in progress.

Already three publications[2] of geodetic data, the last three to appear, contain both the geographic positions and the plane coordinates of all stations upon which they report.

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1 U.S.Coast and Geodetic Survey Special Publication No. 71, Relation Between Plane Rectangular Coordinates and Geographic Positions.

2 Special Publications No. 198, First- and Second-order Triangulation in Tennessee; No. 202, First- and Second-order Triangulation in California; and No. 203, First- and Second-order Triangulation and Traverse in Minnesota.

In one State, New Jersey, early recognition was given the value and use of the State coordinate system by act of legislature. [3] In the short time that has elapsed since its establishment the New Jersey Coordinate System has found wide recognition, many organizations within the State having adopted it as the base for their surveys and maps. The number of such organizations named by Professor Kissam on pages 17 to 19 suggests an engineering directory.

After all, it is logical that the same base should be used for both engineering and cadastral surveys, since the planning, execution, and maintenance of engineering projects require not only accurate surveys and maps of the land being used, but actual control of the land by ownership, lease, or other means, as well. And it cannot be contended in cases where the land to be used is of small value that accurate surveys of the boundary lines are unnecessary, since the construction of an engineering project gives such land a value that will require surveys made with commensurate care and accuracy.

That the State coordinate systems have been used as bases for surveys for many purposes may be seen by reading the first paragraph of Mr. Whitmore's paper on page 21. So extensive have been the surveys made for the purposes of the Tennessee Valley Authority that the coordinate systems of seven States have been used in that work. The cadastral features of the Tennessee Valley Authority surveys were selected for special attention in this journal, it being left to surveys in other regions to exemplify other purposes and uses. Thus Mr. Studdert's article on page 27 gives what may in time become a typical description of a survey made for a large reservoir (flood-control) project, while the Denver survey described on page 32 is sure to become a model for city surveys in other parts of the country. In adopting the Colorado Coordinate System as a base for the Denver survey and map, a momentous decision was made. No other city in this country has the combination of size with resulting large land values and unusually high altitude above sea level, so that in no other city would a decision which must choose between a plane projection at sea level and one 5,000 feet above sea level involve such different results. In choosing the State coordinate system for the Denver survey, the engineers responsible therefor acted with deliberation, after considering all phases of the matter.

In September 1935, a special committee of the Committee on Control of the Federal Board of Surveys and Maps was appointed to study and report on the possible use of the State plane-coordinate systems by members of the Board. In September 1936, the report prepared by the special committee and adopted by the Committee on Control was formally adopted by the Board without a dissenting voice. The full text of the report as adopted will be found on page 8, while on page 68 is given a Discussion of Plane Coordinates which was prepared in support of the formal report. It is too soon for any results of this report to show, though there have been a number of surveys made by federal bureaus for which the State coordinate systems

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[3] See GEODETIC LETTER, May 1935. Page 18.

were adopted as bases. It is hoped that at some future time, information can be obtained to determine how extensively the advice of the Board has been followed, and it is felt that the results of such a survey will be particularly gratifying.

Since, as has already been said, the use of land for engineering purposes requires some form of legal control over such land, the accurate description of the land becomes a matter of importance. Not only should the boundaries be established with accuracy, but their descriptions should be such that they can at any time be reproduced surely and economically. It is believed that referencing such boundaries to stations of the national control survey provides the required security and economy. The value of coordinates as legal evidence in the restoration of lost land corners is discussed on page 39 by Mr. Clement who writes with authority on the public land surveys of the country.

To satisfactorily serve their purpose, descriptions of land boundaries by means of State coordinate systems should be supported by the weight of authority. In New Jersey such quality has been given them by act of legislature (see Note 3, page 3). It is to be expected that in other States similar support and recognition will be given the State coordinate systems which have been devised for their areas. Already several States have indicated an active interest in this matter, foremost among which is Iowa, where, under the direction of Professor Holt, desire is being transformed into action, and an act recognizing the Iowa Coordinate System prepared for introduction into the State legislature at an early date. On page 44 Professor Holt presents an article in which the proposed Iowa Act is included, and in which the component parts or sections of that act are analyzed. The proposed Iowa Act was prepared by Professor Holt in cooperation with Professor Kissam and members of the Coast and Geodetic Survey, and is believed to provide a model which, with small changes in the enabling sections and the proper technical description for the particular State substituted for that of the Iowa System, will serve at least as a starting point for similar legislation in any other State. The technical descriptions of the coordinate systems established for the various States by this Bureau may be had by addressing a request to the Director, U.S.Coast and Geodetic Survey, Washington, D.C.

A law providing for a scientific method of describing land boundaries should be administered in a scientific way. Two of the civil divisions of our country recognize this twin advantage by maintaining land courts before which must come all matters relating to land titles and boundaries. These land courts, in Massachusetts and in Hawaii, maintain engineering departments which prescribe standards for making surveys and describing boundaries. One requirement in such surveys and descriptions is the use of triangulation control stations for reference purposes.

Under the direction of Mr. Houdlette the geodetic control surveys of Massachusetts have been greatly augmented by local control surveys. Mr. Houdlette's description (page 53) of the present status of those surveys is a splendid companion piece to the letter from Mr. Clarence B. Humphrey, Engineer for the Massachusetts Land Court, which was published in the May 1935, number of this journal. The adoption of the Massachusetts Coordinate System by the land court, as reported by Mr. Houdlette, has resulted quite naturally from the adoption of the State system as a base for the local control surveys.

The history of land surveying in the Hawaiian Islands is most interesting. When the Mahele or peaceful revolution to which reference is made in the paper by Mr. Whitehouse on page 59 occurred, and the lands of the islands were divided among the people, the lords, and the crown, surveyors were put to a test of unsurpassed severity to find means of providing accurate and satisfactory record descriptions of these lands. Out of need for coordination of the surveys of the many small irregular parcels of land came first the trigonometrical survey of the islands, and as a natural corollary, later came the establishment of a land court. In the two fine articles contributed by the Territorial Surveyor (page 59) and by the Registrar of the Land Court (page 64), the engineering and judicial procedures involved in cadastral surveys in the Territory of Hawaii are very clearly described. It should be noted that a territorial system of plane coordinates has not been devised for the Hawaiian Islands, though the relatively small sizes of the various islands would permit of each island being made a separate zone in such a system with limiting scale accuracy which would be of the order of 1 part in 28,000 for the largest island, Hawaii, and of a very much higher order of accuracy for the other islands. The lack of such island-wide projections is apparently felt, as reference is made (page 62) to the use of plane coordinates on a local system and the limitation on such use which occurs in surveys of large estates.

In any study of State coordinate systems for cadastral surveys, one cannot ignore certain collateral matters which are of importance if a completely satisfactory use of such a system is to be achieved. Two of the most important of these relate to the establishment of a State Survey and Map Office and of a State Land Court. In a great measure these two organizations should be interdependent, each supplementing and supporting the other. In the Survey and Map Office could be gathered together all survey and map information relating to the State and of value to its people. The material in such an office should be readily available to all interested persons. Such an office could be very effectively organized as the engineering division of the land court, in which case the map department would serve as the archives section of that court.

In writing an act designed to give legal status to a State coordinate system, it is altogether out of the question to include in the act specific instructions or requirements for surveying standards. The inclusion of sufficiently specific and accurate instructions would make an act so bulky that it would probably become a nuisance rather than a benefit.

Plane-coordinate systems may be regarded simply as engineering tools - a means to an end - and any abuse of their fine qualities would naturally lead to unsatisfactory results, and tend to discredit them. Such use must therefore be regulated. A land court, through its engineering department, should be qualified to provide the necessary control by establishing and maintaining suitable rules and standards.

If a full realization of the benefits that should come from a State coordinate act are to be realized, it should be administered by a land court which, according to a memorandum from Professor Kissam, should be vested with certain specific functions. In the words of Professor Kissam, a Land Court Law should:

1. Authorize the appointment of judges and a chief engineer.

2. Place all matters dealing with real estate under the jurisdiction of this Court with a right of appeal under a time limitation to a higher court.

3. Set up a form of petition to the Land Court for the purpose of confirming and registering the title, empowering the Court to act on this petition.

4. Make the paper resulting from the Court procedure act as final evidence of title; cause it to be filed in the Recorder's Office, and require that any liens or encumbrances must appear on this paper to have legal significance.

5. Require the Court, when registering title, to describe the property by means of State Plane Coordinates, and to stake out the property, marking each corner by a monument bearing a disk showing that the property is registered in the Land Court.

6. Most important of all, no prescription or adverse possession can give title to land so registered.

7. A new certificate of registration should be required when any part of, or the whole of the property is sold.

In Hawaii the Torrens System of land registration has been found quite satisfactory. In establishing any State land court, therefore, careful study should be given that system as to its value in promoting the work of the court.

It is with a great deal of regret that this group of authoritative papers dealing with the use of State plane coordinates in surveys in various fields of engineering is gathered together without having at least one formal mention of a field in which those coordinate systems should have and eventually will have very great value and use - the field of highway engineering. It is reported that test uses of State plane coordinates have been made in a limited way in Texas and have proved quite satisfactory; that the highway department of Oregon has adopted the State system as a base for its surveys; that an eastern State is making right-of-way surveys of its highways, describing the monuments of those surveys in terms of the State coordinate system. These are but desultory instances; the great value of State plane-coordinate systems as an engineering tool in highway work is yet to be developed.

In closing this perhaps too lengthy review of activities in a field of engineering that will present what to many who read these lines is a new solution of an age-old problem, it is desired to express deep appreciation to all who by their efforts have contributed so much in preparing this record of progress in scientific land surveying. Especial acknowledgment is made to Dr. O. S. Adams and Lieut. H. W. Hemple of the Division of Geodesy, U.S. Coast and Geodetic Survey, who have given constant assistance in editing this report as the various papers which comprise it were being assembled. Acknowledgment, too, is made to the Mr. Emerson Goble, Managing Editor of National Real Estate Journal, for permission to reproduce the article by Mr. de Graffenried which appears on page 57. With such an article appearing in the Journal of the National Association of Real Estate Boards, and a kindred article [4] in the Journal of the American Bar Association, one cannot help but be optimistic and feel that the old order of inaccurate and poorly defined land boundary surveys is passing, and in its place is coming a scientific method with basic attributes of permanency and accuracy.

[4] "Scientific Boundary Descriptions," by Philip Kissam, American Bar Association Journal, May 1936, page 335.

FEDERAL BOARD OF SURVEYS AND MAPS

STATE PLANE-COORDINATE SYSTEMS

In September, 1935, a subcommittee was appointed by the Chairman of the Committee on Control of the Federal Board of Surveys and Maps to make a study of the State plane coordinate systems devised by the Coast and Geodetic Survey, with special reference to the question of the adoption of these systems by the various Federal agencies.

The interests of any undertaking which is based on surveys and maps are best served if such data for any area are fully coordinated on a single base. At present there are in use an indefinitely large number of systems of plane coordinates, each of limited extent, unrelated to one another, which will be added to by like systems in future years.

In order to provide a means by which this condition could be alleviated, and to meet the demand of many surveyors and engineers for a method whereby they could use the national geodetic control in their own surveys and still apply the methods and formulas of plane surveying, instead of using formulas pertaining to spherical coordinates, these State plane coordinate systems were devised.

The subcomitttee made an exhaustive study of the matter and submitted an extensive report which was adopted by the Committee on Control. The report was placed before the Board at the February 1936 meeting, and thoroughly discussed at the March and April meetings. In compliance with the instructions received from the Board, the whole subject has been reviewed by the subcommittee and the original report has been revised and clarified in accordance with the representations made by members of the Board, and is transmitted herewith as an exhibit.

After careful consideration of the subcommittee's study, this committee believes that the Coast and Geodetic Survey State plane-coordinate systems adequately meet the needs for a method of coordinating local surveys and placing them on a single basis; that by their use surveyors and engineers may more easily base surveys on the national geodetic control without resorting to spherical coordinates; and that their use to the fullest practicable extent should be encouraged by national and state recognition. The use of this system in all local surveys should be encouraged and facilitated by showing the State plane-coordinate systems as supplementary projections on maps published by federal mapping organizations where it is practicable to do so.

It is therefore recommended:

(a) That the Federal Board of Surveys and Maps recommends to its member organizations that, wherever practicable, they adopt the systems of plane coordinates devised for the various States by the Coast and Geodetic Survey, and to use these State systems of plane coordinates as bases for such of their surveys and maps as will not, because of their nature and extent, require the use of some other system of coordinates or method of recording.

(b) That the Federal Board of Surveys and Maps recommends to its member organizations that, wherever practicable, they show the appropriate State plane-coordinate systems as supplementary projections on all maps and charts produced by them which may have value and use for engineering purposes, but which because of their nature or extent require a geographic base. Such supplementary projections may be shown on charts and maps by ticks or other symbols, and should be so labeled that a complete and accurate identification of the projection which they represent can be made readily, and no confusion arise even where several projection systems are shown.

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NOTE

The above report was adopted by the Federal Board of Surveys and Maps at the meeting of September 8, 1936, having been submitted bo the Board by the Chairman of the Committee on Control, C. L. Garner, U.S.Coast and Geodetic Survey.

It was prepared by a special committee composed of the following members:

O. S. Adams, U.S.Coast and Geodetic Survey.

Donald B. Clement, General Land Office.

H. W. Hemple, U.S.Coast and Geodetic Survey.

R. M. Herrington, U.S.Engineer Reproduction Plant.

Hugh C. Mitchell, U.S.Coast and Geodetic Survey, Chairman.

R. M. Wilson, U.S.Geological Survey.

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STATE-WIDE SYSTEMS OF PLANE COORDINATES[1]

O. S. Adams

The U.S.Coast and Geodetic Survey has established a nation-wide network of arcs of triangulation that at the present time has a total length of some 65,000 miles. These arcs are fairly evenly distributed throughout the country and they thus form the basis for the control of further surveys that may be made locally or regionally wherever the data are readily accessible. Experienced engineers and surveyors realize the fundamental importance of rigid checks on any observational data. In an independent survey certain checks can be afforded by the methods of observation but an external check by means of work that has already been established and shown to be correct by various checks in the net to which it belongs, is of the greatest importance in all such subsidiary surveys.

Much remains yet to be done in the establishment of these fundamental Federal surveys. In spite of the fact that, during the past few years, there has been a rapid expansion of the horizontal control net of the nation, very much more remains to be done. There are large areas that are not now supplied with the fundamental data. The rapidity with which the nationalnet may be completed will depend almost entirely upon the demands made on the Federal Government by engineers, planners and others who may require the horizontal control survey data in the execution of their work.

In addition to the data established by the Coast and Geodetic Survey, there are many surveys that have been made by other bureaus of the Government, such as the Geological Survey, the Army Engineers, etc. Whenever these surveys are properly tied in with the fundamental net of the Coast and Geodetic Survey showing an error of closure acceptable for first-, second- or third-order surveys, they in turn may become control data for subsequent work. In sum total, therefore, there exist many thousands of stations that are accurately located and correlated to each other scattered fairly evenly over the country.

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[1] Paper read before the Surveying and Mapping Division of the American Society of Civil Engineers, Pittsburgh, Pa., October 14, 1935. Abstract of paper appears in the January number of CIVIL ENGINEERING.

In view of this fact, it is of supreme importance to arouse the interest of engineers and surveyors throughout the country in the great advantages to be gained by basing local and regional surveys on this fundamental control. Since this control net is so extensive and reaches from one end of the country to the other, it is necessary to take into account the curvature of the earth in the computations. The final data are consequently expressed in terms of latitude and longitude and in azimuths and lengths. These geodetic computations are rather involved and it generally requires some study before they can be made with ease and certainty by even well trained engineers and surveyors. The actual computations are not so difficult but if one wishes to delve into the theory upon which they are based, the mathematics involved is often beyond the grasp of those who may wish to understand fully the significance of the computations.

The Coast and Geodetic Survey has tried for fifty years more or less to encourage the use of control surveys in the form of geodetic positions among the engineering profession. While in certain instances we met with success, on the whole the batting average was very low. Although I am sure that many were needlessly frightened off by an exaggerated view of the difficulties to be encountered, yet the fact still remains that they were frightened off and as a result failed to take advantage of the control surveys. A wise general, when he does not meet with full success in one method of attack, will change his tactics and seek to attain his objective in some other way.

During 1932 and 1933, the Coast and Geodetic Survey cooperated with the State of North Carolina in the completion of the first-order horizontal control in that State. Early in 1933, Mr. George F. Syme, of the State Highway and Public Works Commission, requested us to consider the possibility of setting up a system or systems of plane coordinates for the State, At the request of Dr. William Bowie, Chief of the Division of Geodesy, I undertook a study of the possibilities for the State. While working on the project, I had several conferences with Colonel C. H. Birdseye of the U.S. Geological Survey, who was much interested in the subject of plane coordinates for use in State-wide survey operations. As a result of my study and of the various conferences, the system for North Carolina was devised. Not long after the computation of the tables occurred the tragic death of Mr. Syme and the direction of the work in the State passed into the hands of Mr. O. B. Bestor, who has been carrying on survey operations in the State with the coordinates of the triangulation stations on the State system used as control of his local surveys. Several thousand miles of traverse have been run and computed on the plane with no greater complications than those involved in latitudes and departures.

This was, therefore, the start of the computation of tables for State-wide systems of plane coordinates, a computation which was undertaken at the request of a practical engineer and surveyor. What I wish to convey is the fact that the incentive for the initiation of such schemes came from engineers outside of the Government departments and not as a result of a brain storm of some theoretical mathematician and geodesist.

As a basis of the North Carolina system the Lambert conformal conic projection with two standard parallels was chosen. A conformal projection was employed because the angles are better preserved in this class of projections than in any other class. By holding the scale exact along two standard parallels it is possible to keep the departure from true scale within a prescribed maximum for a much wider strip of country. The tables for the reduction of geodetic positions to plane coordinates were confined to the elements necessary for such reductions. No table of meridian and parallel intersections was computed. It was planned that the Coast and Geodetic Survey should compute the plane coordinates of all of the stations in the control net and have these available as well as the geodetic positions. The engineer or surveyor would then have nothing more to do than to make use of the computed coordinates in his work.

The Lambert projection is suitable for a State with greatest extent in an east-and-west direction since it can be carried almost indefinitely in that direction. If the departure from true scale is to be kept within one part in 10,000 the extent in a north-and-south direction must be kept to the limit of 158 miles.

After the system for North Carolina had been established, we began a study to see what could be done for a State with greatest extent in a north-and-south direction. New Jersey was chosen as the State to be studied in this respect. Again we wished to make use of a conformal projection for the same reason as before. After a careful consideration of the matter we finally decided to apply a modified form of the transverse Mercator projection. To apply this projection with complete rigidity it would be necessary first to map the ellipsoid on the conformal sphere and then to map this sphere on the plane. However, we wished to hold the scale constant along the central meridian of the region to be mapped. This could not be done unless slight departures from full rigidity should be introduced. Accordingly we found that for the limited region to be mapped a satisfactory solution could be found by adapting our formulas for geodetic positions to the calculation of the elements required for the computations of the coordinates.

I shall not attempt at this time to explain the process but I think you can get a picture of the whole by thinking of the ordinary Mercator projection with which, I take it, you are all more or less familiar. Let us suppose that we have a zone of 79 miles on each side of the equator mapped on an ordinary Mercator projection. Then if we reduce the scale along the equator by one part in 10,000 we shall have a map that has the scale too small along the equator and too large by the same amount along the top and bottom of the map.

As a consequence there will be two parallels equidistant from the equator along which the scale will be exact. Now if we use our imagination further and think of the great circle from which the surface is mapped as being a meridian instead of the equator, we shall have a true picture of what is done. Unfortunately for our purpose, the earth is not a true sphere and the meridian is an ellipse and not a circle. However, with slight sacrifice of conformality we can neglect the ellipticity and thus attain our purpose for the small area that is to be included in any one system.

We thus found that this system gave a satisfactory solution for the State of New Jersey and accordingly tables were prepared for that State and satisfactory formulas were devised for the reduction of geodetic positions to coordinates.

We had thus developed two systems of conformal projections that are admirably suited as bases for plane coordinates: the Lambert projection for regions of greatest extent in an east-and-west direction and the transverse Mercator projection for those regions with greatest extent in a north-and-south direction.

Soon after we had reached this point in our investigations the Civil Works Administration program was launched. The need of such plane-coordinate systems for all of the States was apparent and accordingly the computations were expedited and systems for the forty-eight States were completed early in 1934.

As before stated, it is the plan of the Coast and Geodetic Survey to reduce all of the stations from geodetic positions to plane coordinates on these systems. After these computations have been made the resulting coordinates will be made available for distribution either in the State triangulation and traverse publications or in the form of lithographic reproductions. Up to the present time three State publications have been issued which contain both the geographic positions and the plane coordinates of the stations. These publications are those for the States of Tennessee, California and Minnesota. Several other States have all of the computations ready for publication but at present our program is held up due to lack of funds for publication.

In all of the arcs of triangulation that have been orbserved since about 1927, there is established at each main station an azimuth mark distant a good fraction of a mile from the station and such that it is visible from the ground at the station. In the main scheme of the arcs, it is generally necessary to use observing towers as the main scheme stations are seldom intervisible from the ground. In view of this fact the establishment of the azimuth marks is a great aid to the use of the control for local or regional surveys. The azimuth of this mark from the station is determined and in the plane-coordinate computations this geodetic azimuth is in turn reduced to a plane or grid azimuth for use in local plane surveys. These grid azimuths are given in the lists of plane coordinates so that the surveyor will have all of the data necessary for the control of his work.

After the coordinates of the control stations have been computed, it scarcely makes any difference on which of the two projections the computations were based. The method of using the coordinates is essentially the same on both of the systems and the computation of surveys by plane coordinates is about the same on either system. The method of traverse computation by means of latitudes and departures is familiar to all who have studied plane surveying and is in general use among surveyors and engineers in some form or other.

In almost all of the systems, the aim was to keep the variations of scale within one part in 10,000. This limit was slightly exceeded in the North Carolina system because the engineers in that State preferred to let the departure exceed this limit rather than have the State divided into two zones. In the computation of third-order traverses it is probably not necessary to take into account these variations of scale. In the most accurate work, however, it is advisable to correct the measured lengths for this variation of scale before computing a given traverse.

Since in both systems of coordinates the reductions to coordinates are made from geodetic positions, the sea-level lengths are involved in the starting data. There are, therefore, two separate reductions that should be applied to measured lengths before they are employed in the computation of a traverse, if the most accurate results are required. That is, the lengths should first be reduced to sea level and then a correction should be applied for the variation of scale on the grid. These grid variations are listed for every minute of latitude on the Lambert grids and for every 5,000-foot distance from the central meridian on the transverse Mercator grids. It is thus a very easy matter to determine this grid correction for any given line and in most cases it is sufficiently accurate to determine a mean correction for any given traverse. For a traverse that is properly tied in with the control, there will be a starting station and an ending station for which the coordinates will be given. By consideration of these coordinates it is very easy to determine from the coordinate tables just what mean grid factor may be required for the measured lengths of the traverse in consideration.

A number of the States have already made very extensive use of the coordinates in their local work. The use of the grid was started at once in North Carolina and it is still in active use for all local surveys under the direction of Mr. O. B. Bestor. In New Jersey the system has been used extensively in the computation of local traverses and under the able direction of Professor Philip Kissam of Princeton University, a law has been passed that legalizes the definition of property boundaries in terms of the coordinates of the angle points of the property. This is a significant advance both in the interest of the coordinate systems and in the interest of cadastral surveying in the State, and it forms an important advance in the method of the definition of property boundaries.

The coordinates in Tennessee are in wide use by the various divisions of the Tennessee Valley Authority. Traverses are being computed directly on the grid and the corners of all Government purchases of property are being tied in with the State system of control. This method fixes for all time the exact location of these points. If at any future time the marks at any of them should be destroyed, they could be restored by means of their coordinates. Monuments, even of the most permanent type, may be destroyed in time but the coordinate relations still persist and the actual situation of the monument can be relocated and remonumented in all cases of loss by destruction of the mark.

Extensive use is being made of the coordinates in North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Louisiana, New Jersey, Connecticut, Massachusetts, Iowa and many other States. An accurate map of Denver and vicinity is being made by the U.S. Geological Survey under an appropriation of the Works Progress Administration and the work is being based on the Colorado grid.

The matter of city surveys brings up the question regarding sea level and ground level, or rather, whether grid scale should be used, or a scale on a mean ground-level plane. It seems to me that the importance of having the work tied in with the control net far outweighs the need for exact ground level distances. A circular letter was sent to a number of representative engineers and surveyors to get a general recommendation on this very point. Most of the replies that we received looked at the matter in the same way as we had considered it. Actual lengths and areas can easily be determined from a map made on the State grid even though the coordinates may give slightly different results. Denver is probably at a higher elevation than any other large city in the country and, if its engineers find the use of the State grid satisfactory for their work, it should be equally so for any other such city in the country.

It is our opinion that all local surveys that consist merely of traverse can be computed on these State-wide plane coordinate grids with much less effort than would be required by any other method. If, however, a local survey is carried on by means of triangulation, then it is probably simpler and more economical to compute the work geodetically. Triangulation can be computed and adjusted on the grid but the calculations required are equal if not greater than would be required by the geodetic method. Of course, if any engineers or surveyors wish to compute all of their work geodetically, we would not desire to discourage them, if they will base their work on the Federal control surveys. We think, however, that they would be overlooking a great advantage if they did not use the grid for their traverse computations.

The members of the Corps of Engineers, U.S.Army, are becoming much interested in the State grids and they are actually using them in some sections. There is no doubt that they would use them much more extensively if stations of the control surveys were more accessible in regions in which they are carrying on their work. It is hoped that arcs of triangulation may be observed along the principal rivers of the country in the not distant future. These arcs would then serve as bases for the more detailed surveys of the Army Engineers.

At the instigation of Professor Philip Kissam, the Federal Board of Surveys and Maps appointed a subcommittee on control to study the advisability of the Board taking action of approval of the use of the State-wide plane-coordinate systems. After an exhaustive study of the matter, the subcommittee presented a report to the full committee on control recommending the approval of the use of the State grids whenever feasible both by Federal bureaus and by private engineers and surveyors. Final action was taken by the Board at its meeting on September 8, 1936. This should give an added impetus to a wider use of this tool which we feel to be very important to the engineering profession and which will tend to increase the accuracy of local surveys and as a result, put them in shape to be of further service to other surveys in the same vicinity.

The Coast and Geodetic Survey has issued three special publications on the subject of these coordinate systems and their use and these publications can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., for a nominal sum. These are Special Publications Nos. 193, 194 and 195. The first is a general treatise applying to both of the systems but the other two apply each to only one system; 194 to the Lambert grid and 195 to the transverse Mercator grid. For any further information about these plane-coordinate systems and their use or about the subject of projections in general, application should be made to the Director of the Coast and Geodetic Survey, Washington, D.C. We are always glad to furnish any in-information we can on this important phase of geodesy which is destined to become even more important in the time to come.

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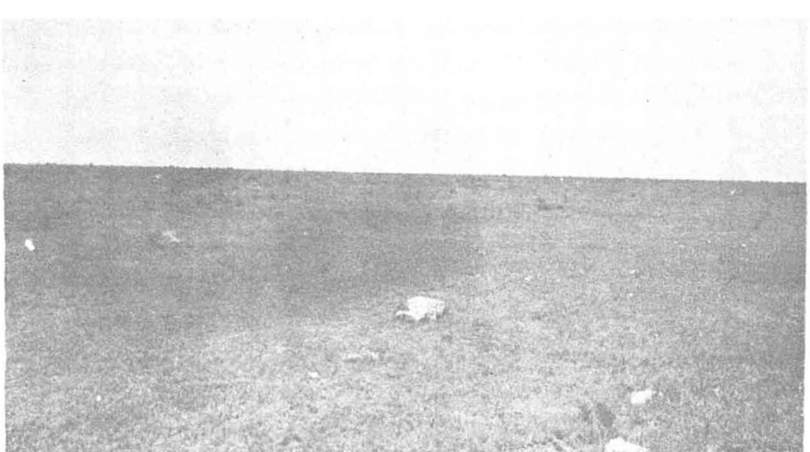

The north boundary of Texas was originally marked with fifteen monuments. This illustration shows one of the seven which were identified seventy years later.

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THE UTILIZATION OF THE PLANE COORDINATES IN NEW JERSEY

Philip Kissam

About December 1, 1933 the U. S. Coast and Geodetic Survey initiated a Civil Works Administration project in New Jersey for the purpose of establishing supplementary control surveys. When this was generally known among the engineers throughout the State they gave an immediate and enthusiastic approval of the work. The great interest shown was not only because of the establishment of many control points conveniently located, but also because of the introduction of the method of plane coordinate computation by which surveys could be easily referred to geodetic control. The Civil Works Administrator himself was enthusiastic about the project. When the work was taken over by the Federal Emergency Relief Administration, members of the directing body again expressed their enthusiastic approval of the work.

Later, when it became necessary to decide whether such a project was worthy of continuance, the New Jersey Society of Professional Engineers and Land Surveyors unanimously adopted resolutions endorsing it and urging its continuance.

It soon became evident that to give full utilization of the control survey for property location, a legislative bill should be enacted providing legal recognition of the New Jersey Plane Coordinate System. Such legislative action was taken during the early part of 1935 and signed by Governor Hoffman on March 25, 1935. With the passage of this law the interest of various State Departments was focused on the work, and requests were made to the U. S. Coast and Geodetic Survey to establish triangulation stations on the properties of the Department of Institutions and Agencies and throughout the State parks controlled by the Department of Conservation and Development. The U. S. Coast and Geodetic Survey immediately complied with these requests, establishing the Newport-Freehold Arc and part of an arc in northern New Jersey, when the work was interrupted through lack of funds.

From the outset of the operation of the project, the central administrative office in New Jersey began to receive requests for information regarding horizontal control. The number of these requests has been continually increasing, so that the central office has become, as well as an administrative office, a bureau of survey information. The largest volume of such requests comes from the New Jersey Riparian Stream and Waterway Survey. This Survey extends throughout the entire State and is organized for the purpose of mapping streams and waterways. Traverses run for this project are monumented and the work is computed on the New Jersey System of Plane Coordinates.

The second greatest volume of requests for information comes from municipalities. Borough engineers are enthusiastic over the opportunity for permanently marking the boundaries of city property and are establishing the positions of city monuments by means of the State Plane Coordinates. This development is unexpected, as it was originally felt that the need for permanent points using plane coordinates would be greater in the country than in the towns.

Many counties in New Jersey have established very fine engineering organizations. Engineers from these organizations have made full use of the facilities offered. In Essex County a new map is entirely controlled and plotted by means of the New Jersey Plane Coordinates. Middlesex County has started such a map. Requests for information and data have been received from County Park Commissions and Planning Boards.

Private individuals, or partnerships, and several large corporations have adopted this System for describing their properties, and many requests have been received in this class. Other State Departments not mentioned above have requested information: The Highway Department, The Hackensack River Authority, The Port of New York Authority, and The Passaic Valley Flood Control.

Federal Bureaus are utilizing the System. The U. S. Engineer Office at Philadelphia has adopted the New Jersey System of Plane Coordinates for all its work within the boundaries of the State. Approximately two-thirds of New Jersey falls within its territory. Large orders for descriptions and coordinates of monuments received from this organization have been filled. The U. S. Coast and Geodetic Survey has utilized preliminary computations of plane coordinate traverses in their work of charting the coast line from aerial photographs. The Resettlement Administration has adopted this System for control of surveys within the boundaries of their work, as well as for the description of property. Four requests for information were received from U. S. Corps of Engineers and requests were received from the National Park Service, the U. S. Geological Survey, and the U. S. Department of Agriculture Soil Erosion Service.

It is difficult of course, to determine just what utilization has been made of the data requested. While some may never be used, in many cases information given out has been passed along to other organizations and individuals, and used by them also. There is no doubt, however, that the System is being utilized in an extraordinary degree considering the short time that it has been in existence. Practically every survey organization of importance within the State is utilizing the System to some extent. Although the State Highway Department has not yet felt that savings could be made by controlling all its traverses by this method, it is believed that should the public demand adequate descriptions of land purchased by the Highway Department, this System would provide that Department with an invaluable facility.

The U.S. Engineer Office, Second New York District, believes that no savings would accrue from utilization of the System in the Metropolitan area. However, in this connection, an incident has already occurred which illustrates the advantages of using a standard coordinate system. The maps of the New Jersey Riparian Stream and Waterway Survey are of considerable use to the U.S. Engineers. They provide the latest data on navigable waterways. Had the U.S. Engineer Office converted its maps to the coordinate system, this information could be plotted with a minimum of difficulty. Also, it is usually more convenient for the New Jersey Riparian Stream and Waterway Survey to connect with the monuments of the U.S. Engineer Office than those of the New Jersey Geodetic Control Survey, as the former are placed along the rivers. The work of the Stream Survey would be greatly facilitated if coordinates of these monuments were available.

Surveying thought and practice in New Jersey are rapidly taking cognizance of the advantages of a standard geodetic datum expressed in terms of plane coordinates. It is the belief of the writer that the time is not far distant when so many surveys will have been made and computed on the standard coordinate system in certain areas that it will be advantageous to utilize that system for even the smallest piece of survey work.

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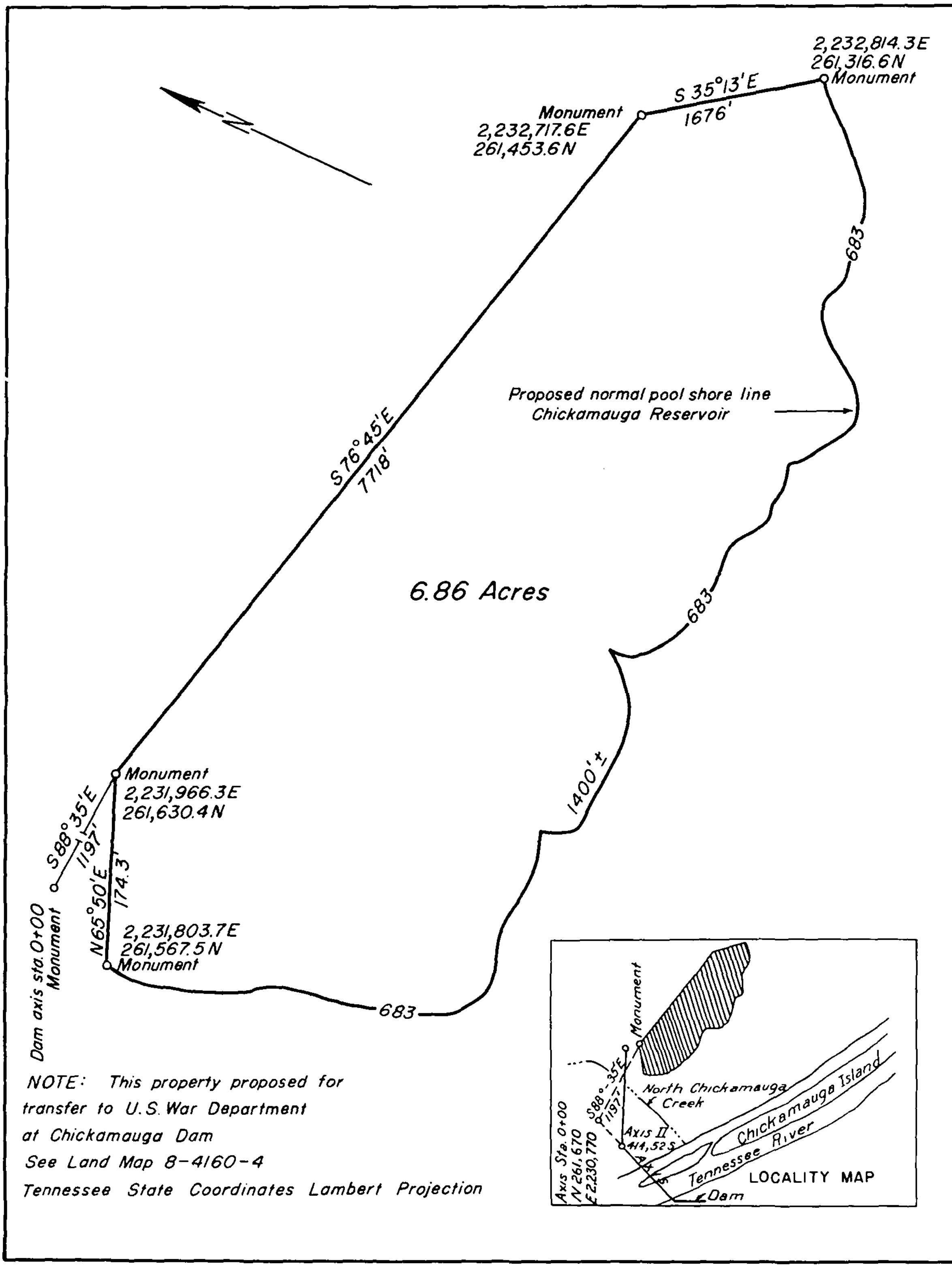
2,232,814.3E
261,316.6N
Monument
S 35°13'E
1676'
Monument
2,232,717.6E
261,453.6N
683
Proposed normal pool shore line
Chickamauga Reservoir
S76°45'E
7718'
6.86 Acres
683
1400'±
Monument
2,231,966.3E
261,630.4N
S88°35'E
1197'
N65°50'E
174.3'
2,231,803.7E
261,567.5N
Monument
683
Dam axis sta. 0+00
Monument
NOTE: This property proposed for
transfer to U.S. War Department
at Chickamauga Dam
See Land Map 8-4160-4
Tennessee State Coordinates Lambert Projection
Monument
S88°-35'E
1197'
North Chickamauga
Creek
Chickamauga Island
Axis II
Tennessee River
Axis Sta. 0+00
N 261,670
E 2,230,770
Dam
LOCALITY MAP

Fig. 1

USE OF STATE PLANE-COORDINATE SYSTEMS IN PROPERTY SURVEYS BY THE TENNESSEE VALLEY AUTHORITY

George D. Whitmore

The Tennessee Valley Authority uses the various State plane-coordinate systems as the basis for all control surveys; for all aerial mosaics and aerial photographic index sheets; all reservoir maps; all cadastral maps; all record plats of final boundary line of government property; and for many special surveys, such as ranges for measuring future silt deposits, and the large-scale topographic surveys of certain parts of city areas. The planimetric and topographic map sheets of the entire Tennessee River watershed, being prepared in cooperation with the U.S. Geological Survey, all show the State plane-coordinate grids by marginal ticks. In short, the State plane-coordinate systems, of which seven are in use at this time, are now the computing and plotting bases for practically every survey and map, of every description, executed by this organization.

One of the most important of these uses is in the property survey program of the lands needed for the large reservoir sites. This program is comprised of two major parts. The first part is called locally the Land Acquisition Surveys. These are the surveys and their resulting maps, executed mainly by a procedure involving the use of large-scale aerial photographs and standard planimetric mapping methods, the principal purpose of which is to facilitate the buying, or acquiring, of the necessary lands.[1] The salient point is that these cadastral maps are plotted and compiled on the basis of extensive traverse ground control, and that all such control is computed on the proper State plane-coordinate system. The finished maps -- used for land appraisals, for abstracting and title examination, and for the actual purchase -- all show grid lines of the State plane-coordinate systems. Hence, the approximate plane coordinates (probably correct on the average within 10 feet) of each and every property corner within the surveyed area are available merely by scaling from the map.

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[1] Note: A rather complete description of this procedure is published in the July-August-September, 1936, issue of "News Notes" of the American Society of Photogrammetry.

S. L. COBLER, A WIDOWER TO THE UNITED STATES OF AMERICA 10/30/36

TVA 532
Tennessee Valley Authority

WARRANTY DEED

THE STATE OF ALABAMA
COUNTY OF JACKSON GR 275

KNOW ALL MEN BY THESE PRESENTS, That for and in consideration of the sum of FOUR THOUSAND ONE HUNDRED FIFTY-NINE AND 16/100-------($4,159.16---) dollars, cash in hand paid to the undersigned by the United States of America, the receipt of which is hereby acknowledged, we the undersigned grantors,

S. L. Cobler, a widower,

have this day bargained and sold, and by these presents do hereby grant, bargain, sell and convey unto the United States of America, the following described tract or parcel of land lying and being in Section Three (3), Township Six (6) South, Range Five (5) East, Jackson County, Alabama, and more particularly bounded and described as follows:

A tract of land lying in Jackson County, State of Alabama, on the left side of the Tennessee River, in the South Half (S½) of the Northwest Quarter (NW¼) of Section Three (3), Township Six (6) South, Range Five (5) East, and more particularly described as follows:

Beginning at a fence corner at the southwest corner of the Northwest Quarter (NW¼) of Section Three (3) (coordinates N. 1,470,588; E. 416, 239), said corner being North Six degrees twenty-four minutes West (N.6° 24' W.) twenty-six hundred (2600) feet from the southwest corner of Section Three (3) (N. 1,468,004, E. 416,529), and a corner to the land of T. E. Morgan; thence with Morgan's line, the west line of Section Three (3), and a fence line, North five degrees thirty-three minutes West (N. 5°33' W.) thirteen hundred four (1304) feet to a fence corner (N. 1,471,886; E. 416, 113), a corner of the lands of T. E. Morgan, and the G. T. Cabiness Estate, thence with the line of the Cabiness Estate, and a fence line (South eighty-nine degrees nineteen minutes East (S. 89° 19' E.) two thousand six hundred sixty-four (2664) feet to a fence corner in the east line of the Northwest Quarter (NW¼) of Section Three (3) (N. 1,471,854, E. 418,777), a corner of the lands of the G. T. Cabiness Estate, and W. L. Evans; thence with Evans' line, the east line of the Northwest Quarter (NW¼) of Section Three (3), and a fence line, South six degrees (6°) no minutes (00') East, thirteen hundred eleven (1311) feet to a hedge stump at a fence corner, and at the southeast corner of the Northwest Quarter (NW¼) of Section Three (3) (N. 1,470,550, E. 416,914), a corner of the lands of W. L. Evans, W. T. Campbell, and H. O. Weeks, thence with Weeks' line, the south line of the Northwest Quarter (NW¼) of Section Three (3), and a fence line, North eighty-nine degrees eleven minutes West (N.89 °11' W.) two thousand five hundred fifty (2550) feet to a point on the ground shown by S. L. Cobler, a corner of the lands of H. O. Weeks, and T. E. Morgan; thence with Morgan's line, the south line of the Northwest Quarter (NW¼) of Section Three (3), and the fence line North eighty-nine degrees eleven minutes west (N. 89°11' W.), one hundred twenty-five (125) feet to the point of beginning.

The above described land contains seventy-nine and six-tenths (79.6) acres more or less, subject to the rights of a county road which affects approximately five-tenths (0.5) acres, and is known as Tract No. GR 275, as shown on Map No. 8-4159-45, prepared by the Engineers of the Tennessee Valley Authority.

The coordinates referred to in the above description are for the Alabama Mercator (East) Coordinate System as established by the U. S. Coast and Geodetic Survey, 1934, The Central Meridian for this coordinate system is Longitude Eighty-five degrees (85°) fifty minutes (50') no seconds (00").

TO HAVE AND TO HOLD the said tract or parcel of land unto the said United States of America, its successors and assigns, in fee simple forever; and for the consideration aforesaid, we do for ourselves, for our heirs, executors and administrators, successors and assigns, covenant to and with the said United States of America that we are lawfully seized and possessed in fee simple of said tract or parcel of land; that we have a good and lawful right to sell and convey the same as aforesaid; that the same is free of all encumbrances, and that we will forever warrant and defend the title thereto against the lawful claims of all persons whomsoever.

It is understood and agreed that wherever in this instrument the singular number is used, it applies to the plural if and when necessary, and that when the plural is used, the plural likewise applies to the singular if and when necessary.

IN WITNESS WHEREOF, we have hereunto set our hands and seals on this the 30 day of October, 1936.

S. L. Cobler

U. S. REVENUE STAMPS $4.50 PAID.

THE STATE OF ALABAMA)
COUNTY OF JACKSON)

I, C. A. Wann, a Notary Public, in and for said county, in said state, hereby certify that S. L. Cobler, a widower, whose name is signed to the foregoing conveyance, and who is known to me, acknowledged before me on this day that, being informed of the contents of the conveyance he executed the same voluntarily on the day the same bears date.

Given under my hand and official seal of office this the 30 day of October, 1936.

SEAL

C. A. Wann

THE STATE OF ALABAMA---JACKSON COUNTY I, R. H. McAnelly, Judge of Probate hereby certify that the foregoing instrument was filed for record on the 30th day of Oct. 1936, duly recorded and compared, there being no tax due. R. H. McAnelly, Judge of Probate

Fig. 2

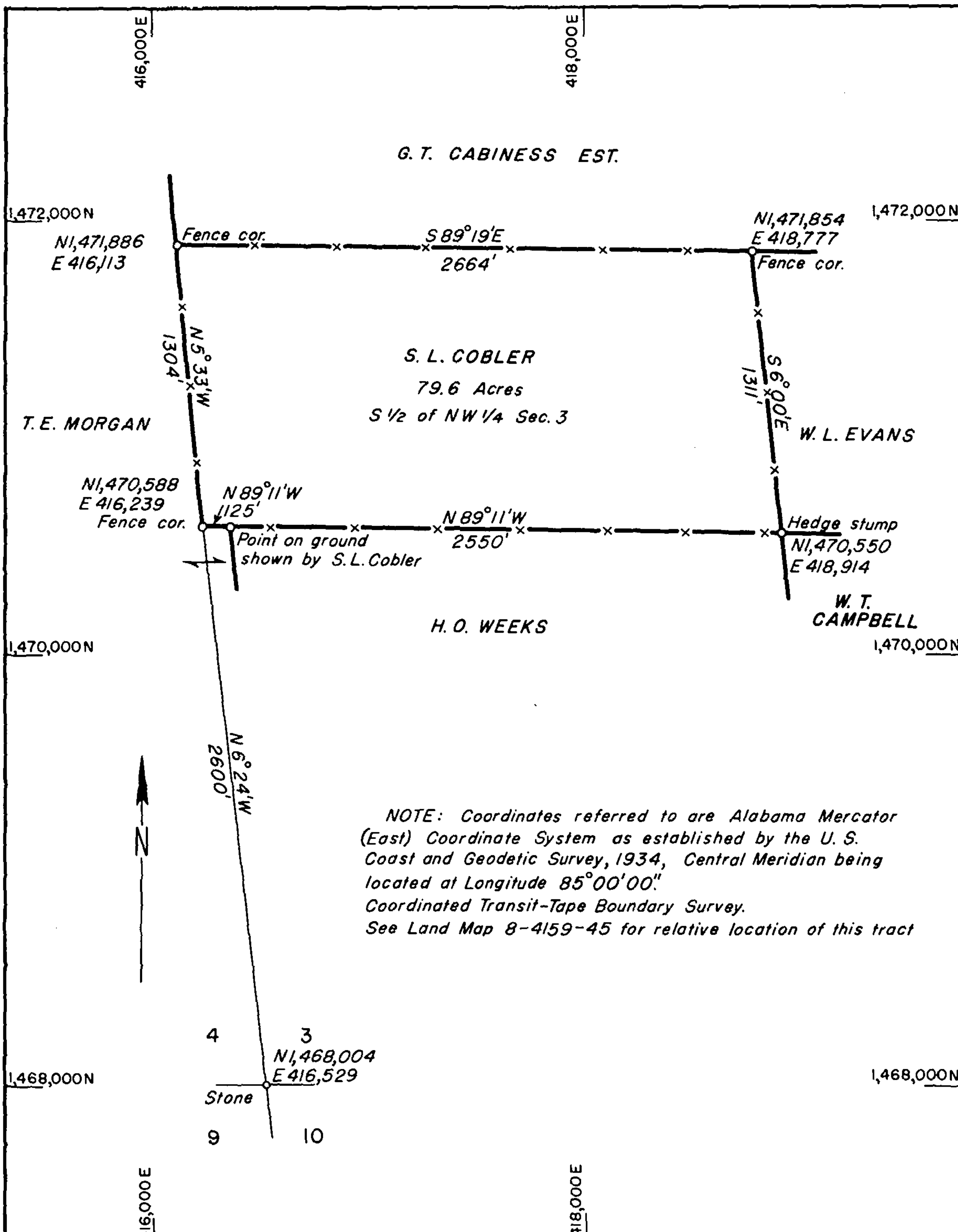
416,000E
418,000E
G. T. CABINESS EST.
1,472,000N
N1,471,886
E 416,113
Fence cor.
S 89°19'E
2664'
N1,471,854
E 418,777
Fence cor.
N 5°33'W
1304'
S. L. COBLER
79.6 Acres
S 1/2 of NW 1/4 Sec. 3
S 6°00'E
1311'
T. E. MORGAN
W. L. EVANS
N1,470,588
E 416,239
Fence cor.
N 89°11'W
125'
Point on ground
shown by S. L. Cobler
N 89°11'W
2550'
Hedge stump
N1,470,550
E 418,914
W. T.
CAMPBELL
H. O. WEEKS
1,470,000N
N 6°24'W
2600'
N
NOTE: Coordinates referred to are Alabama Mercator
(East) Coordinate System as established by the U. S.
Coast and Geodetic Survey, 1934, Central Meridian being
located at Longitude 85°00'00".
Coordinated Transit-Tape Boundary Survey.
See Land Map 8-4159-45 for relative location of this tract
4
3
N1,468,004
E 416,529
1,468,000N
Stone
9
10

FIG. 3

These land acquisition maps are not used, however, as record plats. The actual purchase contract is based on a written deed description, such description being prepared from the information contained on the maps supplemented by comparison with the old deeds. It is not at this time practical, therefore, to include the plane coordinates of property corners in these written deed descriptions.

It is evident that such deed descriptions, being based on data secured from large-scale cadastral maps, will not permit precise retracement or relocation of the property lines in future years. This is not considered important, however, since all of these private property boundaries will be inundated, and it is assumed there will never be any need to retrace or relocate them precisely on the ground. On the other hand, the outside boundary line of the government land -- that is, the line between government property and private property -- does become important. It and its monuments may have to be retraced and relocated many times in the future, both by government and private surveyors. It is believed there is no better way to insure that such future relocation will be accurate than by the method of plane coordinates. It is believed also, of course, that State plane-coordinate systems offer many advantages over spherical coordinates or local plane coordinates.

The second part of the cadastral surveying program, therefore, comes after all of the land needed for any reservoir project is acquired. The outside boundary line of the large block of government-owned land is then monumented, a concrete monument being placed at every angle point, and the boundary traversed with tape and transit. In sectionized areas, "angle points" include each intersection of the boundary with section- and quarter-section lines. At intervals averaging perhaps every three or four miles, the boundary traverse is connected to the nearest horizontal control monuments. The computing of the final boundary survey thus automatically includes the State plane coordinates of every angle corner.

These coordinates of the boundary corners and other data will then be shown on the "final boundary-line plat" of each reservoir, this being a record plat, with copies being filed in the proper county records. Thus there will always be available for the use of local surveyors, in map form, a mathematical record of the plane coordinates of each angle point on the government boundary line, together with corresponding plane azimuths and lengths of the boundary courses. This should certainly encourage the use of these plane coordinates in future local surveys, both public and private in character.

On several occasions it has been necessary for the Authority to transfer certain parcels of lands to other government agencies. This sort of transfer is not usually effected by recorded deed, but rather by memorandum, accompanied by a metes-and-bounds description and plat. In each case, the description of the land parcel has included the State plane coordinates of the corners, together with the corresponding plane azimuths and lengths of the courses. Figure 1 illustrates such a plat.

It happens occasionally, for one reason or another, that it becomes necessary to make a conventional transit-and-tape boundary survey of a property tract previous to actual purchase from the private owner. In such cases the present practice is to run a transit-and-tape traverse around the boundaries, then to connect this traverse to the nearest coordinated control monuments. The written deed description of the tract then usually includes the State plane coordinates of the property corners, as illustrated in the attached specimen deed and plat, Figures 2 and 3.

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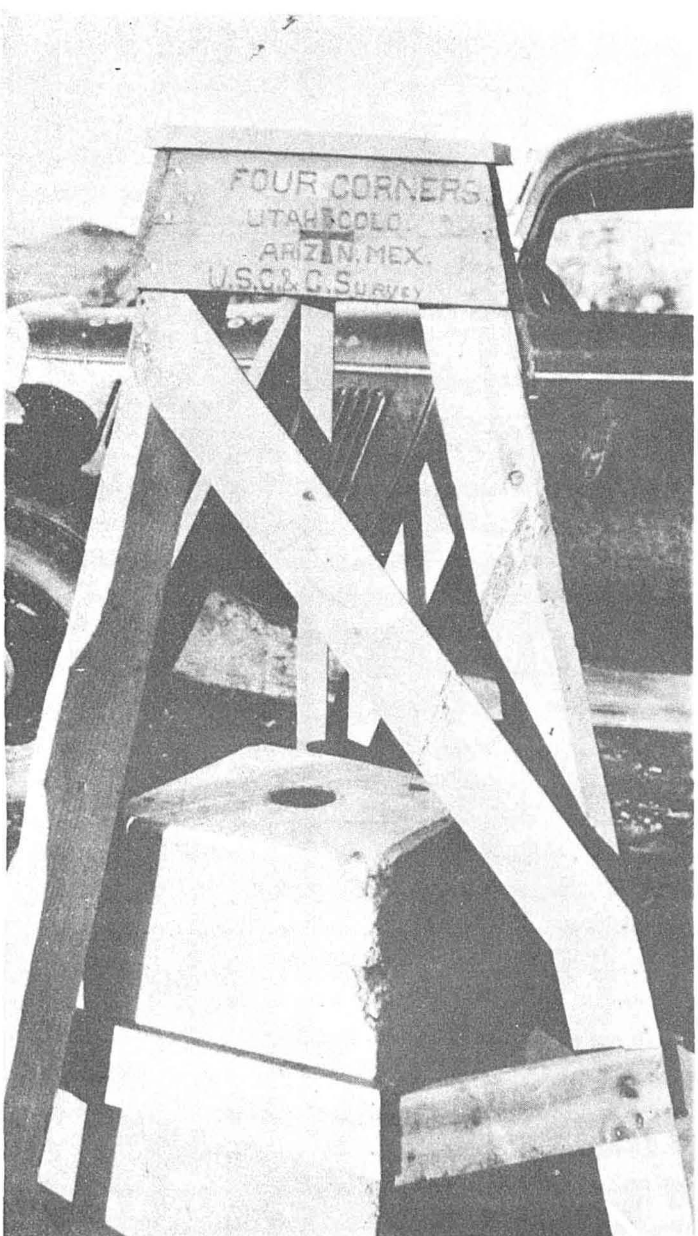

AN IMPORTANT SURVEY STATION

This General Land Office monument at the corner common to four States marks a triangulation station of the U.S. Coast and Geodetic Survey. Surmounting the monument is the wooden stand used for mounting surveying instruments.

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PRELIMINARY SKETCH
of
PROPOSED
DENISON RESERVOIR

MAPS, MONUMENTS AND CONTROL SURVEYS

W. W. Studdert

The civil engineer engaged in field surveys, on entering a new territory, always asks those in authority, "Where can I get the best maps of this area?"

Those of the immediate territory believe the engineer has asked them a simple question. Little do they realize that their township and county maps are no more than pictures unless they have been based upon control surveys and monumented lines.

A few years ago the writer had the occasion to ask for "the best maps of this area" in a certain Central American country. There were none, not even of the picture type maps such as are found in this country of townships and counties. Many engineers have faced the same problem over and over again, that problem of proceeding with assumed datums, with no guidance except their own ability and plotted courses. Strange as it may seem, my problem in the tropics was but little different from that encountered by the engineers in this country where the "picture" maps of the areas are in no way related to the fine system of control surveys laid out by the U.S. Coast and Geodetic Survey, by the U.S. Geological Survey, and by other government agencies.

To show the waste created by the type of man described by Director R. S. Patton, of the U.S. Coast and Geodetic Survey, when he writes in the "Geodetic Letter" of August 1934, page three, "They (the engineers) are the henchmen of progress; expansion; change.", let us assume that the average civil engineer engaged in field surveys directs the expenditure of $10,000 a year in such practice. Over a twenty-five year period a sum of $250,000 will be expended. Unless this engineer is actually, by performance as well as by definition, a henchman of progress, this sum serves only to satisfy his immediate needs, leaving no material traces of his efforts of a quarter of a century of labor.

It may be advanced that the accuracy of an engineer's survey does not always warrant that his lines be monumented. In my opinion even fourth-order surveys should be so monumented that they will serve other engineers at a later date. About 1750 A.D., a young man from William and Mary College, Williamsburg, Virginia, was commissioned to make certain surveys by compass and chain in the Dismal Swamp, south of Norfolk, Virginia. He monumented his survey points with cast and wrought iron markers. They are in existence today and continue to serve the public 186 years after they were set. He continued in later life to direct us on our course, but his youth was given to a calling of which we will continue to hear more and more, - surveying and the monumentation of surveys. He was George Washington, our first National Engineer.

Several of our governmental departments, namely, the Corps of Engineers, The U.S. Coast and Geodetic Survey, the U.S. Geological Survey, and the Geodetic Control Surveys of the various States are making it a practice to monument all of their horizontal and vertical control surveys. State highway departments should be encouraged to follow suit in order that the hypothetical $250,000 spoken of earlier can be saved for the taxpayer. Millions of gasoline tax dollars have been ignorantly wasted by highway departments through failure to monument and tie together their surveys. This is written with positive knowledge, for as chief of a survey party of a State Highway Department, numerous right-of-way third-order surveys were run under my direction but were not permanently monumented. Several years later, I advised a U.S. Geological Survey topographic engineer that such lines were available to use in conjunction with his traverse for quadrangle maps. He later reported that while the notes were acceptable, he was unable to make the necessary ties as the temporary marks which I was compelled to place at the stations of my survey had already disappeared, due to the resurfacing of the highways, and the widening of the right of ways that destroyed the value of the reference ties.

There have been many articles written on the feasibility of the use of the State plane-coordinate systems based on the Lambert conformal projection. To one who has used these systems, the many articles are a cheering sign of the condition of the minds of the "henchmen of progress", showing an inquisitive, enthusiastic, and progressive attitude.

That the many government agencies composing the Federal Board of Surveys and Maps have adopted the U.S. Coast and Geodetic Survey plan of State plane-coordinates is an indication that to engineers in State, county, city, and private employ will be given the leadership to further expand the uses of these systems.

When tentative plans were being drawn for the field surveys of the Denison Reservoir on the Red and Washita Rivers along the Texas-Oklahoma border, it was decided that plane coordinates were, for many reasons, ideal for such a survey.

There were four conditions to be satisfied in selecting the type of system to be used:

(1) Necessity for using a system that all could understand graphically and theoretically.

(2) The U.S. Engineer Regulations called for geographic positions.

(3) Third-order accuracy must be obtained.

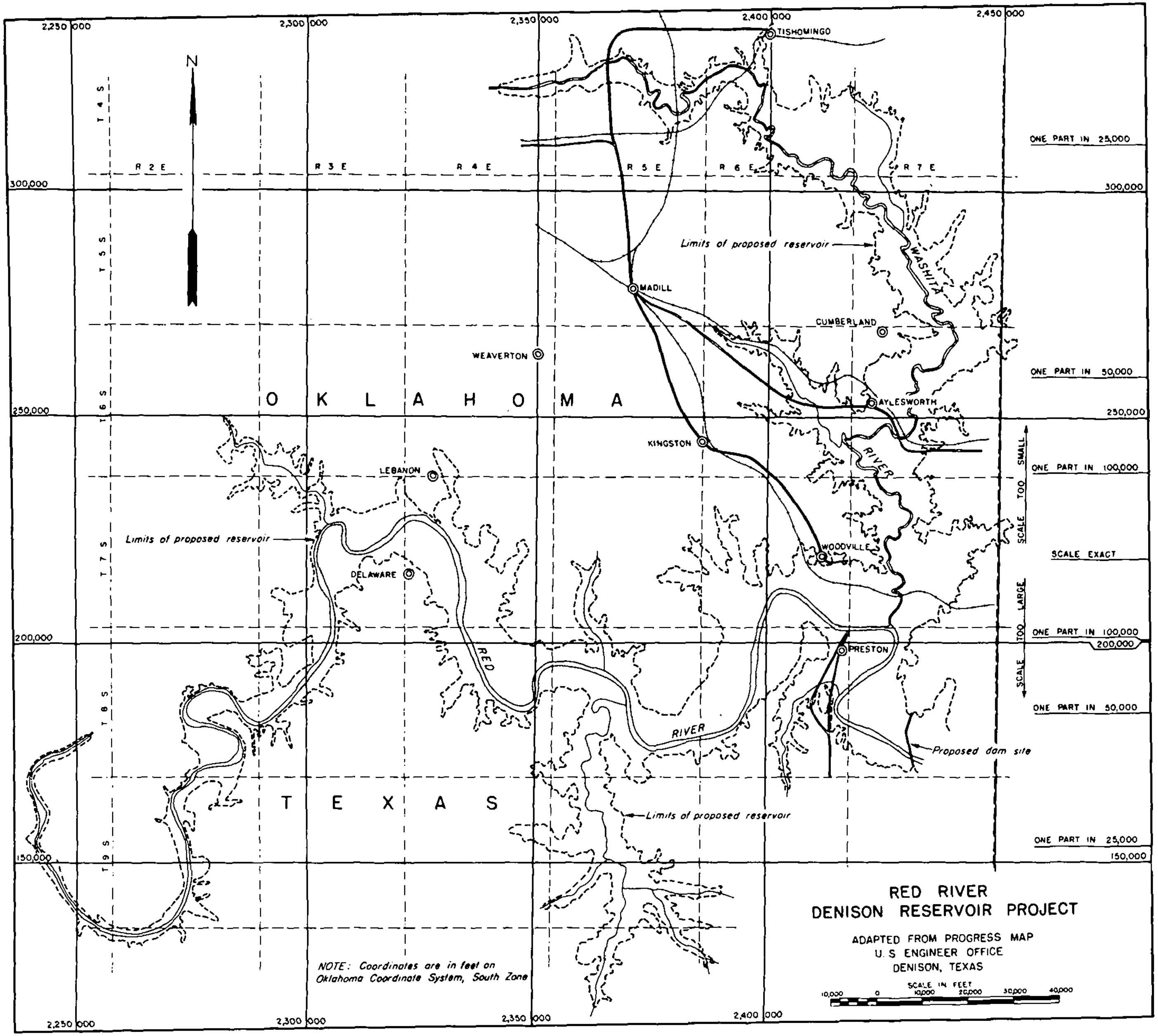
(4) All available data should be used.

The entire organization was to be recruited locally, in so far as possible. Engineers were available for this work whose experience was mainly in highway and land surveying and in construction work. While all of the engineers employed had an excellent background for such work, very few of them had experience in making geodetic or other surveys of a precision above fourth-order accuracy.

The computations of geographic positions are simple to one who understands their use, but to the engineer who has never dealt with them, they give a feeling of helplessness.

Any system of plane coordinates would have satisfied condition No. 1. To conform to the regulations of the U.S. Engineer Office, the Oklahoma Coordinate System, South Zone, was the ideal compromise as it was mathematically related to the geographic datum, and computations of plane coordinates from geographic positions could easily be made. Third-order accuracy immediately made itself graphically understood as 1:5,000. Every chainman realized his responsibility, as did each instrument man. The length of a survey in feet divided by 5,000 can give a very small result. If this same value were expressed in degrees, minutes, and seconds of latitude and longitude, only the party chief could compute the error of closure. There were in the area of the Denison Reservoir various lines of local control surveys established by survey projects of the Works Progress Administration sponsored by the Oklahoma Conservation Commission under the direction of Professor N. E. Wolfard of Oklahoma University. All of these lines were based on the Oklahoma Coordinate System, South Zone. If we should adopt the same system, no additional computations would be necessary to make those surveys part of our scheme.

The selection of the Oklahoma Coordinate System for use on the Denison project has proved to be of greater advantage than was originally anticipated. Our newly organized body of engineers and surveyors, after a few hours of study of the U.S. Coast and Geodetic Survey Special Publications No. 193 "Manual of Plane Coordinate Computations" and 194 "Manual of Traverse Computation on the Lambert Grid", were able to take the field with full confidence and knowledge of the job to be done. I want to pause right here and give credit where credit is due. In my mind and in the minds of many of my associates, U.S. Coast and Geodetic Survey Special Publication No. 194 is an engineering masterpiece in presenting to the uninitiated the problems of using geographic positions with the Lambert Grid and State plane coordinates. The simplicity of its presentation with its follow-through



RED RIVER
DENISON RESERVOIR PROJECT
ADAPTED FROM PROGRESS MAP
U.S. ENGINEER OFFICE
DENISON, TEXAS
SCALE IN FEET
NOTE: Coordinates are in feet on Oklahoma Coordinate System, South Zone
OKLAHOMA
TEXAS
TISHOMINGO
MADILL
CUMBERLAND
WEAVERTON
AYLESWORTH
KINGSTON
LEBANON
WOODVILLE
DELAWARE
PRESTON
WASHITA
RED
RIVER
Limits of proposed reservoir
Proposed dam site
ONE PART IN 25,000
ONE PART IN 50,000
ONE PART IN 100,000
SCALE TOO SMALL
SCALE EXACT
SCALE TOO LARGE
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E
R 7 E
T 4 S
T 5 S
T 6 S
T 7 S
T 8 S
T 9 S
2,250,000
2,300,000
2,350,000
2,400,000
2,450,000
300,000
250,000
200,000
150,000
N

method is the best salesman that any system could have. It is written and presented so plainly that even our untrained rodmen of less than high school education have been able to grasp the whole story.

The shore line of the Denison Reservoir as proposed is approximately 1500 miles long. This was accurately located by a network of 900 miles of third-order traverse control surveys. U.S. Geological Survey triangulation stations and Oklahoma Conservation Commission second-order traverse lines were used as the base for our plane-coordinate system. Ten 15-men parties were organized and put into the field on June 15th, 1936, at widely separated points. As their lines tied into one another, as a matter of record, various "busts" were evident. For the supervising engineer, this is where the plane-coordinate system is a great help. By following a schedule of eliminating possible errors, a "bust" is soon located. If geographic position computations are being used in the traverse a discrepancy is not nearly so easily located.

The Lambert Grid with plane coordinates is ideal for map work. It gives a scale which is readily ascertainable with the regular meshes of the projection. At a glance one may readily estimate distances without applying a scale to the map. The geographical projection may be superimposed with mathematical precision if desired.

We learned one valuable lesson on this project, which escaped early notice, and to my certain knowledge is not heeded in local control surveys in two States. The warning is plain in several text books: "Triangulation is strong in azimuth while relatively weak in distance, whereas traverse is strong in distance while weak in azimuth." Our first lines completed showed excellent distance closures and relatively poor azimuth closures. The angles were rechecked in the field but with little improvement in results. Polaris observations were then taken every four miles, the plane azimuths computed therefrom, and angle adjustments made to hold these plane azimuths. When this was done, excellent closures were immediately obtained.

I cannot recommend too strongly observations on Polaris for azimuths at intervals not exceeding six miles. Since all authorities recognize this weakness in the azimuth structure of traverse, it is my opinion that the traverse lines should be divided into sections and adjusted for azimuths observed at regular intervals.

Standard U.S. Engineer Office permanent monuments have been placed in pairs at two-mile intervals throughout the Denison Reservoir Project. These monuments will prove invaluable to the engineer of the future engaged on cadastral surveys, geological mapping, highway location and many other types of surveys.

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HORIZONTAL CONTROL FOR THE TOPOGRAPHIC SURVEY OF DENVER, COLORADO

H. S. Senseney

To provide an accurate topographic map of the city and county of Denver, the Topographic Survey of Denver, Colo., technically known as WPA Project No. 674, was approved and authorized in November 1935 by the Works Progress Administration. The project is sponsored by the department of improvement and parks of the city of Denver, and the work is being done under the direction of the United States Geological Survey. The engineer in immediate charge is Fred Graff, Jr., acting chief of the Rocky Mountain section of the Topographic Branch of the U.S. Geological Survey. The primary object of the project is to obtain an accurate and detailed large-scale map of the city; therefore its major efforts are directed toward the making of topographic surveys and the drafting and reproduction of the various sections of the map. The control surveys established as a foundation for the map, which constitute only a part of Project No. 674, are in charge of the writer, and the following remarks relate particularly to this part of the work.

The fact that the map will be the largest of its scale and kind thus far prepared by the U.S. Geological Survey has aroused considerable interest in the the relative merits of various new methods of procedure. The result has been to introduce into this project many field and office practices not heretofore generally used in standard-scale mapping by the Topographic Branch of the U.S. Geological Survey. It also appeared probable that the resulting survey not only would be widely discussed but that it might have a considerable influence, favorable or otherwise, because of precedents that may be established, on the making of similar maps in the future. The following discussion on the control-survey methods used in this project, therefore, should be of interest to all map makers.

Various scales, contour intervals, coordinate axes, reference datums, sheet areas, and unit boundaries were given serious consideration, and a careful study was made of their relative values in local and general usage before the specifications were finally accepted.

About 60 square miles of territory are included within the corporate limits of Denver. To comply with the requirements of the city engineer's department it was decided to use a horizontal map scale of 200 feet to 1 inch, with a contour interval of 2 feet. On this scale the entire map would require 400 square feet of paper surface. A map so gigantic in size could not, of course, be produced in a single unit, so for the convenience of both the makers and the users of the map it will be assembled in 94 sheets, each representing a ground area measuring 4,000 feet from north to south and 5,000 feet from east to west. Units so shaped offer the greatest map surface on sheets that are not too large to be conveniently handled.

The plane-coordinate system of reference for horizontal control devised by Dr. O. S. Adams of the U.S. Coast and Geodetic Survey, and based on the Lambert conformal projection, was adopted by the U.S. Geological Survey for constructing the Denver map after carefully considering the advantages and possibilities of a number of alternate systems. The use of geodetic coordinates directly was at first contemplated, but as these are of little value to local engineers it was decided instead to use one of the systems employing plane rectangular coordinates. Four such systems were considered. A description of each follows:

1. A rectangular system based on a polyconic projection with either ground or sea-level distances.

2. A rectangular system based on some selected point of origin within the city. Similar systems have been used on a number of previous city surveys, and they are generally acceptable to local engineers.

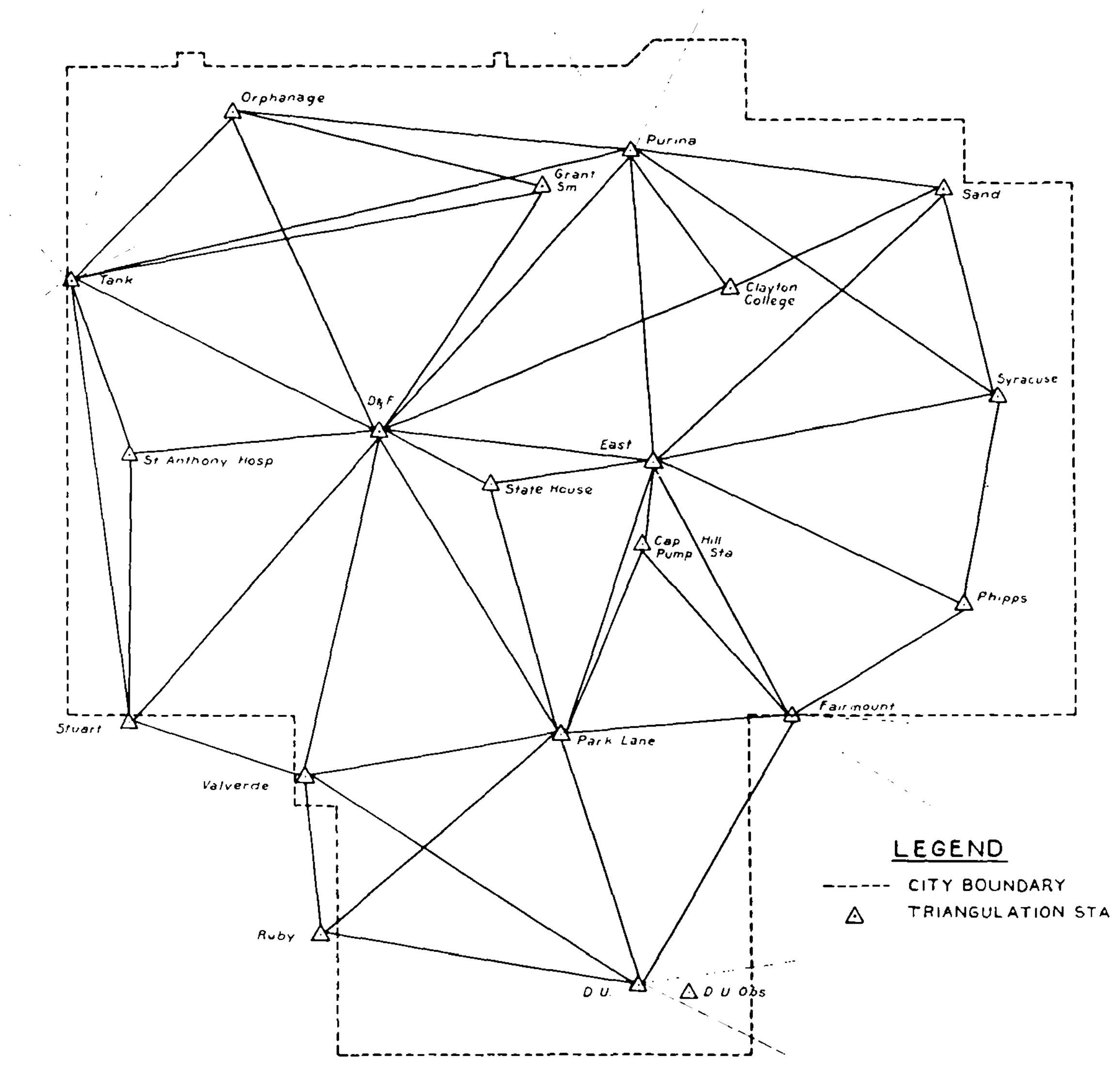
3. A modification of the State system devised by the U.S. Coast and Geodetic Survey so as to use actual ground distances.

4. The State system devised by the U.S. Coast and Geodetic Survey without modification.

The last-mentioned system was the one accepted for the Denver project. In using it, all measured distances are reduced to their grid values in accordance with the Lambert projection, which is fully described in Special Publications Nos. 193 and 194 of the U.S. Coast and Geodetic Survey.

The State system of plane coordinates based on the Lambert conformal projection (No. 4, above) has been given considerable publicity, and has been legally adopted as standard in at least one State. It was adopted as a basis for the Denver map because it satisfies local and general needs and, at the same time, represents the most progressive ideas in modern large-scale map construction. In this State system, Denver falls within the central zone for the State of Colorado. The map angle, or variation between the meridians and grid lines, ranges from 16 minutes 41

U. S. G. S. DENVER SURVEY
TRIANGULATION IN THE CITY OF DENVER



seconds east on the west side of the city projection to 23 minutes 24 seconds east on the east side.

Before work on the project was begun there were available for horizontal control within the city, four auxiliary stations intersected from arcs of first-order triangulation by the U.S. Coast and Geodetic Survey. A number of intersected stations of the U.S. Geological Survey, established several years ago, were also available, but these were not considered as of sufficient accuracy to be included in a second-order control base. For the same reason a loop of traverse around the city, established in 1933-34 by a project of the Civil Works Administration under the supervision of the U.S. Coast and Geodetic Survey, was not used as basic control. Computed points on this traverse line could not be recovered, and no information could be obtained either in regard to its circuit closure or as to the methods used in its computation.

Obviously, this meager distribution of points was insufficient for the accurate mapping of so large an area. Further control was therefore established by combining additional triangulation with new loops of transit traverse.

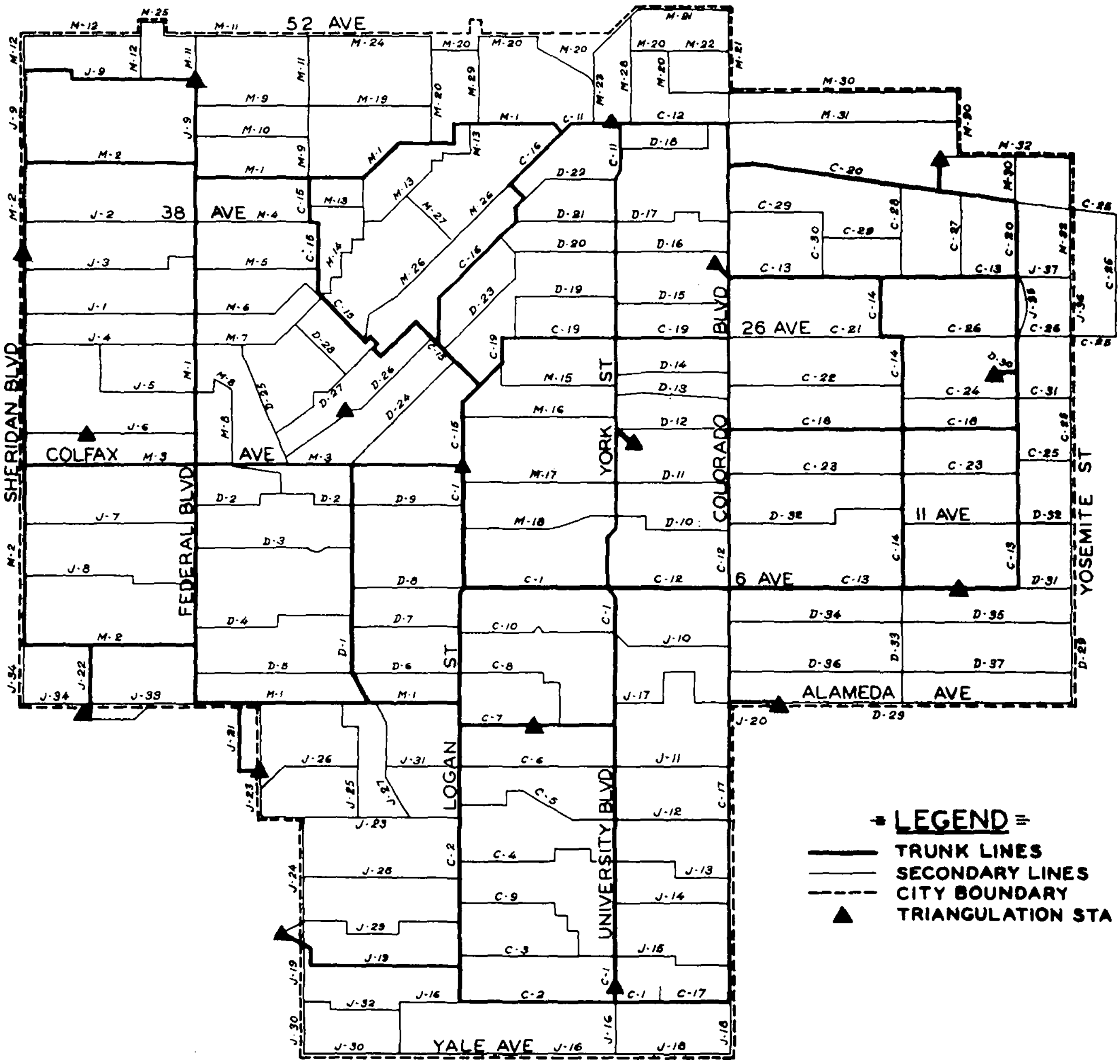
A net of triangulation was first spread over the city starting from two first-order stations of the U.S. Coast and Geodetic Survey, Boulder and Morrison, located about 25 miles west of Denver. The triangulation was carried through to a tie upon two other first-order stations, Indian and Watkins, located approximately 15 miles east of Denver. The resulting net includes 21 occupied and 6 intersected stations, 19 of which are within the city proper. The diagram shows the arrangement and location of the triangulation stations that lie within the city limits. Stations Orphanage, Purine, and Tank are connected through triangulation with the first-order line, Boulder-Morrison, and stations Fairmount and D.U. are connected with the line Indian-Watkins. This triangulation was used as a base from which to extend traverse control and it has been tabulated to give both the geodetic and the plane coordinates of each station. The instrument and signals were centered over the station marks at all stations. Angles were observed with a 10-second vernier theodolite by the repetition method, each angle being measured 20 times. The average closure of 41 primary triangles was 1.70 seconds, and the largest closure was 3.62 seconds. Adjustments were made by the method of least squares. The triangulation was computed first so as to obtain geodetic coordinates, which were then transformed to plane-rectangular coordinates.

The traverse net within the city limits contains 81 miles of trunk lines and 164 miles of intermediate traverse. Routes were first selected so that trunk lines would be spaced about 1-1/2 miles apart. Intermediate lines, generally east-and-west, were then tied between the trunk lines at intervals of approximately 2,000 feet. The diagram indicates the routes followed by the traverse lines.

DENVER CITY TRAVERSE LINES INDEX

U. S. GEOLOGICAL SURVEY DENVER SURVEY CONTROL DIVISION

FRED GRAFF JR., PROJECT CHIEF H. S. SENSENEY, DIVISION CHIEF



Slope distances were measured with 100-foot steel tapes, under 10-pound tension when along the ground and 22-pound tension if on supports. These tapes were checked every week by comparing them with a master tape which had been tested by the U.S.Bureau of Standards. In measuring distances each tape length was marked with a center punch in the head of a tack. The temperature readings and the differences of elevation at the ends of the tape were recorded for each tape length. All distances on trunk lines were determined by two independent measurements made in opposite directions. Mean distances were used for the computation. Intermediate lines were measured in one direction only. All measured lengths were corrected for temperature and inclination of tape, and then reduced to lengths consistent with the accepted projection.

Angles of the traverse were observed with 30-second transits, the deflection angles being measured six times by repetition. Closure errors for trunk and intermediate lines were within the limits prescribed for second-order accuracy.

Traverse stations were established about 1,500 feet apart, each one being marked with a spike and a chiseled triangle. Three reference marks were cut in curbs at each instrument station. Intermediate points at each street intersection along the lines were marked by spikes with chiseled circles around them. These traverse lines tied in and located 70 section corners and 142 quarter corners in the city.

Permanent marks were set along transit lines at intervals of about 2 miles. These marks are standard U.S.Geological Survey tablets in the tops 8 by 12 by 48-inch concrete posts. The posts are usually set either in parks or between the sidewalks and curbs with their tops flush with the ground. In the Denver project 84 of these permanent marks and 3,291 intermediate points were established. It is safe to say that no street corner within the city limits is more than three city blocks from a located control point. The points are distributed in sufficient number over the 94 unit sheets to establish adequate individual control for each map unit.

Three astronomical azimuth stations were occupied and the observed azimuths were reduced to plane or grid azimuths. Plane azimuths at triangulation stations were used as initial or closing azimuths for the traverse lines. Traverses were computed in terms of rectangular coordinates. All trunk-line circuits were adjusted to the triangulation by computing mean values of coordinates at junction points. Intermediate traverses were generally fitted between trunk lines simply by prorating the required corrections according to their mileage. In the few places where junction points occurred among intermediate lines the usual trunk-line adjustment method was used. No attempt was made to adjust excessive errors, and in the 245 miles of traverse only 9.2 miles, or 3.8 per cent, of rerunning was necessary to bring all circuits within adopted limits of closure.

Tabulated results of the horizontal control, giving the x and y coordinates of marked stations, will be available to all engineers who have use for them.

Accurate lines of spirit levels were run over routes nearly the same as those shown on the traverse diagram. Bench marks established by this leveling are being used as reference marks for the vertical control of the topographic mapping. The bench marks will be useful also in determining mean sea-level datum for any local engineering surveys that may be made in the future.

First impressions of the standard State system of plane coordinates are apt to be unfavorable, but a careful analysis of this system will eventually convince those who use it of its many advantages over the polyconic projection or other forms of map bases for projects of the kind just described and its merit as a standard base for all large-scale engineering maps.

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COORDINATE POSITIONS AS COLLATERAL EVIDENCE IN THE RESTORATION OF LOST CORNERS OF THE PUBLIC LAND SURVEYS

Donald B. Clement

The term "public domain" is used broadly to designate those lands vested in the Federal Government by the original thirteen States, and subsequent acquisitions by treaty and purchase; the "public domain" embraces the area west of the Ohio and Mississippi Rivers, and the States of Alabama, Florida, and Mississippi, excluding the State of Texas.

Among the first acts of the Congress after the establishment of our Government was one to make provision for the survey and disposal of the public lands as a means of raising revenue and to reward those who had served in the Army of the Revolution. The present rectangular system of surveying the public lands has been developed from the basic provisions contained in the act passed by the Continental Congress on May 20, 1785, and the act of Congress approved May 18, 1796. The survey of the public lands was commenced near the present city of Marietta, Ohio, shortly after the passage of the act of 1785, and the surveys have progressed westerly to care for the advancing tide of immigration and settlement of the western country. Designed originally to mark, on the ground, the boundaries of lands for purpose of settlement and development of a wilderness, it was and is a marked success; the descriptions and titles to more than 75 percent of the land in the continental United States are based upon the public land surveys.

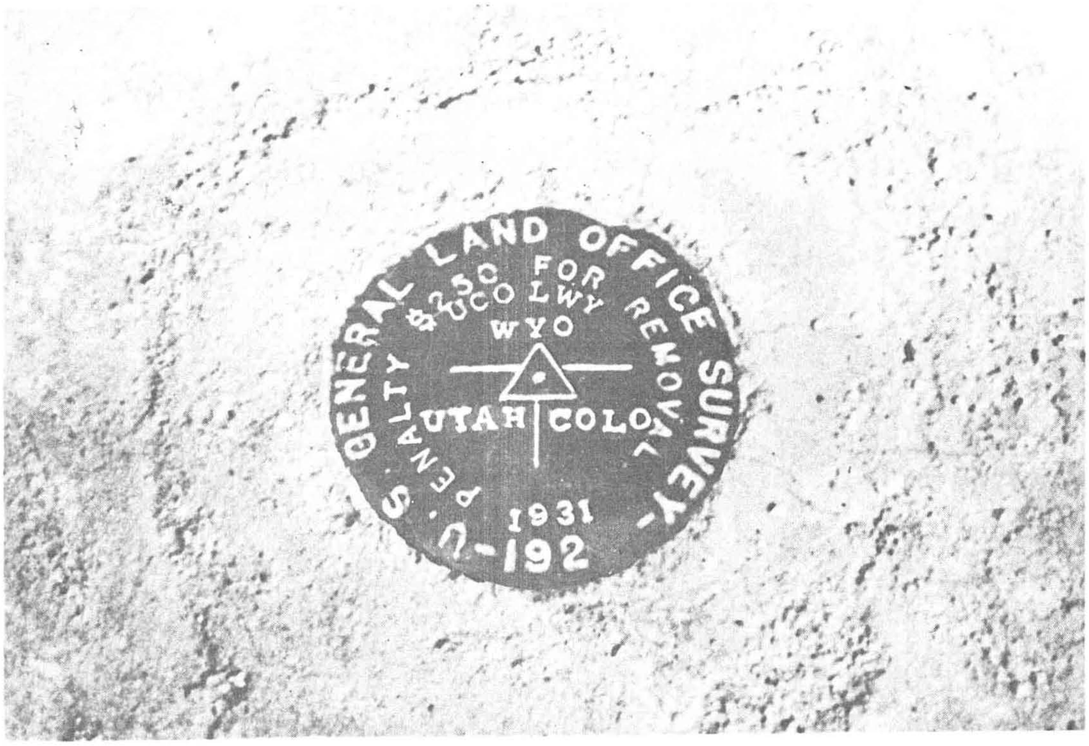
The surveys executed in the earlier part of the program were not of the highest order of accuracy and were made with instruments that today would be considered somewhat crude. Any question as to the binding effect of these surveys is removed, however, by the act of Congress approved February 11, 1805, which provides that the corners marked in the public land surveys shall be established as the proper corners of the sections, or subdivisions of sections, which they were intended to designate; the boundary lines run in such surveys shall be established as the proper boundaries of the sections, or subdivisions of sections, for which they were intended, and the lengths of such lines, as recorded, be held and considered the true length thereof. This is the basic legislative provision that the corners established on the ground mark the boundaries of the lands for which such corners were established; it is still the basic law and must be borne in mind in connection with the original survey of the public lands or in any restoration of previous surveys.

The corners established in the earlier days of the public land surveys were not permanent and the physical evidence thereof has largely disappeared, by natural causes due to the lapse of time since they were originally established and by causes incident to the development of the country, construction of roads, cultivation of land, etc. It may be considered that no land corner can be so established physically as to be indestructible.

When it is realized that the position of the boundaries of all the lands within the public domain is dependent upon the corners established in the original surveys, the importance of the preservation of such corners and the marking of the points in the most permanent manner possible is readily apparent. It has always been customary to mark physical reference points to witness the position of the corner in the public land surveys; these references usually consisted of native trees to which measurements were taken, large boulders or outcroppings of rock in the vicinity of the corner, or in the prairie States in the digging of pits and building a mound of earth at specified distances from the corner monument. These physical references in many instances can still be identified even after the lapse of 100 years or more, and the position of the corner may thus readily be determined after the identification of the reference object. These reference objects are ordinarily referred to as accessories to the corner and no corner is considered lost if its accessories can be identified.

Nor is a corner considered lost if its position has been perpetuated by the construction of other physical objects to replace the original monument, or if there is reliable record of its position with reference to certain buildings, center lines of roads, etc. But when a corner is lost the problem of restoration thereof frequently requires quite extensive survey procedure; any processes which may reduce the amount of surveying work thus required would be most welcome.

There are certain definite legal rules, developed from the basic law, which govern the restoration of lost or obliterated corners. These rules are based broadly on the proposition that the errors in the original survey should be proportioned along the lines connecting undoubted original corners. In the practical application of these rules it is customary to give proper weight to physical topographic features encountered on the ground which were recorded in the field notes of the original survey, and to other collateral evidence of the position of the original corners.



Above: Triangulation station UCOLWY, a General Land Office mark at the north end of the boundary between Utah and Colorado.

At left: Reference Mark No. 2, to triangulation station UCOLWY.

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During recent years the triangulation net of the Coast and Geodetic Survey has been expanded considerably, and stations established at more frequent intervals throughout the country; in addition, thousands of stations have been established on intermediate traverse lines connecting the points of the triangulation net. The geographic position of each of these stations has been, or can readily be, determined; through such data the plane coordinates of each point, referred to the appropriate State system, are readily available.

It is believed that these stations of the Coast and Geodetic Survey afford unequaled collateral evidence for the restoration of lost corners which had been connected with the triangulation net or local control stations while such public land corners were in existence. It is also believed that when a lost corner has once been restored by proper legal methods, the security of its position would be greatly enhanced if it were connected to the points previously established by the Coast and Geodetic Survey and the proper plane coordinates of the corner determined.

However, it is to be noted that surveying is not an exact science; errors such as are incident to any human endeavor are certain to be found in any line or angle measured on the earth's surface. For this reason it cannot be assumed that a connection from a land corner to only one control station of the Geodetic Survey would be acceptable for the restoration of the missing corner unless such control point be in the immediate vicinity of the corner; the rules governing the distribution of error between original corners should apply equally where the missing public land corner is to be restored by plane coordinates, thus necessitating measurements or connections from at least two control points. An exception may be noted where the control point is in the immediate vicinity of the missing corner and the connecting line measures not over 500 or 600 feet; in such case the control monument might be considered, for practical purposes, as an accessory to the original corner and the corner restored by direct measurement from only one control point.

It may be considered impracticable to make direct connections from each of the corners of the public land surveys now in progress to stations of the Coast Survey. It may be pointed out, however, that if during the original survey of a given township, or at the time of a subsequent retracement of the lines thereof while the corners were still in existence, connections were made from each of the four corners of a township to triangulation or control stations, the plane coordinates of those four township corners might be ascertained without difficulty. Through the connections so made, together with the measurements recorded in the survey or retracement of the lines connecting those corners, the plane coordinates of each intervening point or corner might be computed and determined within the limits of accuracy of the survey or retracement.

Regardless of the method of determining the plane coordinates of a given corner of the public land surveys, such coordinates cannot overcome or outweigh the physical evidence of the corner monument itself; the corner monument is <u>the</u> corner for which it was established, regardless of its position. However, when the corner monument is missing through destruction or decay, it is apparent that the plane coordinates of that corner, properly and accurately determined, may become the best available evidence of the position of the original corner, and thus afford a ready and accurate means for its restoration.

The foregoing is intended not so much as a guide for the restoration of lost corners by coordinate methods as for the purpose of emphasizing the importance to be attached to the original position of corners of the public land surveys and for the need of preserving those positions by the best possible means. No general rules for the use of plane coordinates in the restoration of lost corners can be laid down in a short discussion of this nature, but the need for means of preserving the positions of the corners and boundaries cannot be emphasized too strongly. It is believed that the adoption of the plane coordinate system based upon the control of the Coast and Geodetic Survey stations, affords one of the most certain means of preserving the position of the corners and boundaries in the public domain.

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Survey monument in Rochester, N.Y., after an encounter with a steam shovel. Geographic positions and plane coordinates are immune to such destruction.

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PLANE COORDINATES IN LAND BOUNDARY DESCRIPTIONS

A. H. Holt

The permanence of marks of land boundary -- of "corners" -- the finding of such marks or monuments when they are no longer readily visible, the replacing of them when they have been removed, are matters which have long been of serious concern to land owners and to all others -- engineers, lawyers, abstracters -- who have of necessity, been interested in the occupation, use or ownership of land. No such marks are truly permanent. All are subject to removal or obliteration, wilful or accidental. The only feasible means yet devised of insuring the permanence of position of a land corner, as contrasted with the permanence of the physical object which may once have marked that position, is that for which the Egyptians long ago developed the science of Geometry; viz.: so relating this position to the positions of other monuments, by mathematical means, that if not all are simultaneously destroyed those which remain may be satisfactorily used to recover those which are missing.

Many schemes for employing this means have been devised, and have been used with varying degrees of effectiveness and convenience. To be effective such a system must be so founded as to be practically certain to be workable when needed, and must be capable of restoring the location sought with any required precision. To be convenient it must be simple -- capable of being understood and used by surveyors, and also capable of being sufficiently explained to non-technical persons, without involving any complicated mathematics or abstruse ideas. The necessary data must be capable both of being determined originally, and also made to serve their final purposes, by generally known and commonly used methods of surveying and computation. To meet with general acceptance and use, the scheme must be highly effective and reasonably convenient.

The plane rectangular coordinates of a point offer the most satisfactory answer to these needs. The chief bar to their use heretofore has been the lack of any established system of general availability, and the consequent absence of any means of giving permanent, or legal, significance to their use in a recorded land description. The time and the opportunity have now arrived to remove the bar.

Elsewhere in this Geodetic Letter will be discussed the origin, nature, availability, and permanence of the State-wide systems of plane coordinates which have been set up for the several States by the United States Coast and Geodetic Survey. Let it suffice here to say, by way of review, that the location of any point by means of these systems is fixed by stating one distance east-and-west and one north-and-south, that these distances for ordinary work may be obtained, used in computation, and employed for finding the point on the ground, by the ordinary instruments and methods regularly used in farm or lot surveying. There is nothing new about the use of plane coordinates for surveying field work, mapping or computations. The only new item is the establishment of a general State system, so tied to the national triangulation net as to be available for use, now or at any time in the future, anywhere in the State within reach of a U.S. Coast and Geodetic Survey or other properly-located triangulation or traverse station. Loss of monuments will not prevent the accurate re-establishment of boundary corners whose positions are known in terms of this system. The work of re-establishment will involve nothing more than ordinary surveying unless all monuments over a large area disappear at one time.

An important step toward facilitating the use of this convenient method of recording the locations of property corners is to officially define and name the State system, so that when reference to it is made there can be no doubt as to what is meant, and so as to preclude improper use of it, or ambiguous references to it. It is desirable that this be done by legislative enactment. This has already been done in New Jersey, and is contemplated in several other States. Since it is true that, except for differences which are obvious and easily handled, this matter of legislative definition is much the same in all States, it is thought that a study of the form of such an act might be of some general use.

The following is a proposed act, prepared as for the State of Iowa. Some of the sections will, of course, be different for other States; but it is thought that the form, general content, and some of the detailed provisions may be generally applicable.

THE COORDINATE SYSTEM BILL

A BILL FOR

AN ACT to describe, define, and officially name a system of coordinates for designating the positions of points on the surface of the earth within the state of Iowa.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF IOWA:

1. The system of plane rectangular coordinates which has been established by the United States Coast and Geodetic Survey for defining and stating the positions or locations of points on the surface of the earth within the state of Iowa is hereafter to be known and designated as the "Iowa Coordinate System."

For the purposes of the use of this system the state is divided into a "North Zone" and a "South Zone."

The area now included in the following counties shall constitute the North Zone:

Lyon, Osceola, Dickinson, Emmet, Kossuth, Winnebago, Worth, Mitchell, Howard, Winnishiek, Allamakee, Sioux, O'Brien, Clay, Palo Alto, Hancock, Cerro Gordo, Floyd, Chickasaw, Fayette, Clayton, Plymouth, Cherokee, Buena Vista, Pocahontas, Humboldt, Wright, Franklin, Butler, Bremer, Woodbury, Ida, Sac, Calhoun, Webster, Hamilton, Hardin, Grundy, Black Hawk, Buchanan, Delaware, Dubuque, Monona, Crawford, Carroll, Greene, Boone, Story, Marshall, Tama, Benton, Linn, Jones, Jackson.

The area now included in the following counties shall constitute the South Zone:

Harrison, Shelby, Audubon, Guthrie, Dallas, Polk, Jasper, Poweshiek, Iowa, Johnson, Cedar, Scott, Clinton, Pottawattamie, Cass, Adair, Madison, Warren, Marion, Mahaska, Keokuk, Washington, Louisa, Muscatine, Mills, Montgomery, Adams, Union, Clarke, Lucas, Monroe, Wapello, Jefferson, Henry, Des Moines, Fremont, Page, Taylor, Ringgold, Decatur, Wayne, Appanoose, Davis, Van Buren, Lee.

2. As established for use in the North Zone, the Iowa Coordinate System shall be named, and in any land description in which it is used it shall be designated, the "Iowa Coordinate System, North Zone."

As established for use in the South Zone, the Iowa Coordinate System shall be named, and in any land description in which it is used it shall be designated, the "Iowa Coordinate System, South Zone."

3. The plane rectangular coordinates of a point on the earth's surface, to be used in expressing the position or location of such point in the appropriate zone of this system, shall consist of two distances, expressed in feet and decimals of a foot. One of these distances, to be known as the "x-coordinate", shall give the position in an east-and-west direction; the other, to be known as the "y-coordinate", shall give the position in a north-and-south direction. These coordinates shall be made to depend upon and conform to the plane rectangular coordinates of the triangulation and traverse stations of the United States Coast and Geodetic Survey within the state of Iowa, as these coordinates have been determined by the said Survey.

4. When any tract of land to be defined by a single description extends from either of the two coordinate zones into the other zone, the positions of all points on its boundaries may be referred

to either of these two zones, the zone which is used being specifically named in the description.

5. For the purpose of more precisely defining the Iowa Coordinate System, the following definition by the United States Coast and Geodetic Survey is adopted:

> The Iowa Coordinate System, North Zone, consists of a Lambert conformal Projection of the Clarke spheroid of 1866, having a central meridian 93° 30' west of Greenwich. The intersecting cone of this projection cuts the surface of the spheroid in parallels of latitude 42° 04' and 43° 16' north of the equator, along which parallels the scale shall be exact. The origin of coordinates for this zone is at the intersection of the meridian 93° 30' west longitude and the parallel 41° 30' north latitude. This origin is given the coordinates: x = 2,000,000 feet; y = 0 feet.
>
> The Iowa Coordinate System, South Zone, consists of a Lambert conformal projection of the Clarke spheroid of 1866, having a central meridian 93° 30' west of Greenwich. The intersecting cone of this projection cuts the surface of the spheroid in parallels of latitude 40° 37' and 41° 47' north of the equator, along which parallels the scale shall be exact. The origin of coordinates for this zone is at the intersection of the meridian 93° 30' west longitude and the parallel 40° 00' north latitude. This origin is given the coordinates: x = 2,000,000 feet; y = 0 feet.

The position of the Iowa Coordinate System shall be as marked on the ground by triangulation or traverse stations established in conformity with the standards adopted by the United States Coast and Geodetic Survey for first-order and second-order work, whose geodetic positions have been rigidly adjusted on the North American datum of 1927, and whose plane coordinates have been computed on the system here defined. Any such station may be used for establishing a survey connection with the Iowa Coordinate System.

6. No coordinates based on the Iowa Coordinate System, purporting to define the position of a point on a land boundary, shall be presented to be recorded in any public land records or deed records unless such point is within one-half mile of a triangulation or traverse station established as prescribed in section 5 of this act.

7. The use of the term "Iowa Coordinate System" on any map, report of survey, or other document, shall be limited to coordinates based on the Iowa Coordinate System as defined in this act.

8. Nothing contained in this act shall be interpreted as requiring any purchaser or mortgagee to rely wholly on a description based on the Iowa Coordinate System.

9. This act, being deemed of immediate importance, shall be in full force and effect from and after its publication in two newspapers of this state, as provided by law.

* * * * * * * * * * * * * * * * *

The following comments on the several parts of this proposed act indicate some of the reasons why, after considerable discussion, this form is presented.

The statement of the purpose of the act is probably of general application.

The enacting clause will conform to the style regularly used in the State in which the act is presented.

Section 1. The number of zones will vary in different States, and their names will accord. It seems desirable to make the specific statement that the area "<u>now</u> <u>included</u>" in certain counties shall "<u>constitute</u>" a given zone, to guard against change or uncertainty resulting from possible future changes in county names or boundaries, -- by consolidation or otherwise. It is thought that the date of the act and the known division of the State into counties at that date will at any time in the future make certain what area is included in a given zone. The counties may be named in either a geographical or an alphabetical order. For a State in which the county arrangement is as regular as it is in Iowa, the former seems to be rather more convenient. Each arrangement has its advantages.

Section 2. This section formally assigns the names by which the component parts of the State system shall be designated, The terms "north", "south", "central", etc., seem descriptive, and hence useful, where practicable. Other names may have to be devised in States where there are several zones.

Section 3. This section formally ties the plane-coordinate system of the State to the national triangulation net, and makes the United States Coast and Geodetic Survey responsible for the determination of the coordinates of the controlling stations.

Section 4. The purpose of this section -- to provide for the bounding of a tract of land lying within more than one zone -- is obvious. A slight rewording will be necessary for those States which have more than two zones.

Section 5. This section has been the subject of a good deal of discussion and revision. A first reaction might be to put these precise definitions of the system and the zones into the first section of the act. It is recognized, however, that these mathematical definitions will be understood by relatively few people; and it has been thought best to make the statement in Section 1, simple and non-technical, holding the necessary mathematical definition for a later section. The definition is purposely labeled a "definition by the United States Coast and Geodetic Survey", and the expression "<u>adopted</u>" is a selected one. The intent is to emphasize that the definition is vouched for by an out-of-State, disinterested, technical organization, nationally known. The insetting of the definition in the printing is to continue the emphasis. It is thought that these points may help a legislator who might otherwise hesitate to favor a measure whose provisions he could not ordinarily be expected to understand, by assuring him that they have the endorsement of the United States Coast and Geodetic Survey. The definition of each zone is made complete in itself, even though that involves some repetition. The necessity for doing this is more obvious in States whose division into zones must be less regular than in the instant example. The final paragraph of the section regulates the source from which the coordinates of a point are to be determined. It imposes the requirements of at least second-order precision and "rigid adjustment", according to the U.S. Coast and Geodetic Survey standards, in locating control stations; but does not require that the work be done by the U.S. Coast and Geodetic Survey.

Section 6. The intent of this section is to prevent official records of land boundaries, such as deed records, being made a repository of inaccurate data. The provisions of the section prohibit the recording of coordinates obtained by a survey of less than second-order precision which has been carried more than a half-mile to reach the point whose coordinates are in question, -- the half-mile being taken as the straight-line distance from the control station. The burden of compliance with the law is placed upon the surveyor or other person who might seek to have the data recorded, rather than upon the recorder, who would have no feasible way in many cases of determining whether the data had been so obtained as to entitle them to be recorded.

Section 7. The intent of this section, to prevent the use for any improper purpose of the terms defined by the act, is obvious. It supplements Section 2.

Section 8. This section is intended to reassure any person who may be somewhat ultra-conservative, - to make clear to him that there can be nothing implied from any provision of the act to require him to accept a land description expressed in terms of coordinates in case of a transfer of title or interest in land. Obviously there is no such requirement in the bill, but a plain statement to this effect may result in forestalling opposition to the act on the part of some who might be unduly apprehensive.

Section 9. The presence, and the form, of this section will depend upon the customs of the State concerned.

The mention, under the heading of Section 8 above, of the desirability of reassuring some persons concerning the use of coordinates in land descriptions, calls to mind a point which apparently needs strong and frequent emphasis in order to remove misunderstanding and forestall opposition in the matter of the legalizing of the State systems. To some persons, and among them a few engineers, the suggestion of using plane coordinates in land descriptions seems to connote the abandonment of the older methods of description. To this they object, and their objections might make them oppose or at least fail to support such an act as is herein proposed. This fact should be clearly understood: THE USE OF PLANE COORDINATES IN LAND DESCRIPTIONS DOES NOT MEAN THE ABANDONMENT OF THE OLDER METHODS OF DESCRIPTION, either by platted subdivision or fraction of subdivision, or by metes and bounds. It is intended to supplement either of these methods, and to facilitate the finding, or the checking of the location of, any of the corners implied or described in the older forms of description. It is simply a matter of increasing the certainty and facilitating the future field use of the old descriptions,-- not of superseding them. With the coordinates available, one may well still find that the best way to describe the tract to be conveyed is to say: "A certain tract of land consisting of the east half of the northwest quarter and the north half of the northeast quarter of Section so-and-so"; but it will be wise to add to this description, "the coordinates of the corners of which tract, referred to the Iowa Coordinate System, North Zone, are - - -", and to proceed to give the coordinates of the corners, in order, around the tract. If it be said that the subdivisions of the Public Land Surveys are already, in theory, located in accordance with a coordinate system, let it be mentioned -- and it is believed that no experienced surveyor who has retraced public land surveys made by contract will gainsay the statement -- that all the data available from these Surveys will not ordinarily assure the replacing of a lost (not merely obliterated) corner within a long way of where it originally stood. So, while the description by fraction of section is excellent from the point of view of the abstracter or the examiner of title, it does not, without outside help from some source, give any assurance that the parcel which is so easily, and apparently clearly, thus described can be located on the ground. And, after all, that is where the land will finally have to be found.

Most people will probably agree that a metes and bounds description is less desirable than one of the type mentioned above,-- when conditions are such that a description of this type can be written. But occasionally the situation just about requires a metes and bounds description. It is not the purpose of this brief article to discuss methods of surveying; but the statement may be safely made that in this situation, field work (either an original survey or a survey to restore missing corners), computation, platting, and description will ordinarily be materially aided by the use of plane coordinates. Such a description can readily be written so as to involve the coordinates of the corners, and so as to include, also, without confusion, all the data which should normally appear in such a description. As part of the closing discussion of a paper which was printed in the Transactions of the American Society of Civil Engineers, Volume 99, pages 1155 et seq., the present writer suggested such a description. It was reprinted in the May 1935, issue of the Geodetic Letter; but, for convenience of reference, it is given here, with a few minor modifications which have been suggested by developments since it was first proposed.

"A parcel of land situated in Blank County, Iowa, and described as follows. The coordinates used to define the positions of corners are referred to the Iowa Coordinate System, South Zone. Bearings used are referred to the meridian of that zone.

"Beginning at a point marked by an iron pin set in concrete whose coordinates are: x = 2,461,271.3 feet, y = 571,001.4 feet, and which is on the north line of Section 00, Township 00 North, Range 0 West of the Fifth Principal Meridian, three hundred one and six tenths (301.6) feet east of the northwest corner of said section; thence south seventy-two degrees and forty-seven minutes east (S 72° 47' E) one thousand eighty-three and four tenths (1083.4) feet along a fence line to an iron pin set in concrete, whose coordinates are: x = 2,462,306.2 feet, y = 570,680.7 feet; thence south sixteen degrees and twelve minutes west (S 16° 12' W) fifteen hundred eighty-nine and three tenths (1589.3) feet, along and in prolongation of a fence line, to an iron pin, set on the center line of Blank road, whose coordinates are: x = 2,461,862.8 feet, y = 569,154.5 feet; thence south sixty-six degrees and five minutes west (S 66° 05' W) twelve hundred ninety-two and one tenth (1292.1) feet along the center line of said Blank road to an iron pin whose coordinates are: x = 2,460,681.6 feet, y = 568,630.7 feet; thence north thirteen degrees and fifty-eight minutes east (N 13° 58' E), to and along a fence line, twenty-four hundred forty-three and one tenth (2443.1) feet to the point of beginning; containing forty-eight and thirty-six hundredths (48.36) acres, more or less."

The introduction of the coordinates increases the bulk of this description, and that is objectionable; but it is believed that the data are worth including. Extra care will be required in transcribing such a description to avoid an error in stating a number; but, again, it is believed that the data are worth the extra care required.

From the standpoint of an abstracter or of an attorney examining an abstract to determine where the title lies, metes and bounds descriptions present a serious problem. It is difficult to tell whether such a description, later than another in matter of time, calls for the same parcel of land as the earlier one. It is difficult to tell whether two tracts, supposed to be adjoining, and both described by metes and bounds (unless the description of the common boundary is the same in both), actually do have one common boundary, whether they overlap, or whether there may be a gap between them. This difficulty is increased, when magnetic bearings are used, by the changes in direction of the needle. If coordinates of points on a supposedly common boundary are given, the above uncertainties can be very quickly removed.

The extent to which these State Coordinate Systems can be used for property description now or in the early future is very limited. Control stations with coordinates determined are available within reach of only a very small fraction of the area of the land to be described. However, it is very desirable that an "enabling act", defining and naming the system for a State, should be a part of the statute law of the State well in advance of any such use. This should insure, from the very beginning, uniformity of terminology, with resulting certainty of meaning of terms used. It should also impose reasonable limitations on the use of the coordinates for descriptions of boundary when those descriptions are to become a part of the public records. This last matter is an exceedingly difficult one to control. In this connection, be it noted that corresponding matters under current schemes of description are in most States quite uncontrolled. It is possible that a satisfactory solution of this situation, and of other allied matters that are quite beyond the scope of this paper, may be found only in the establishment of a State Land Court, with competent legal and engineering personnel, and with the authority as well as the ability to exercise control of surveys and descriptions to be recorded. The way to these Land Courts will undoubtedly be long and rough but may we have the courage and the persistence to follow it. In the meantime, the adoption of acts legalizing the State Coordinate Systems, and the use of these systems wherever practicable, will be steps in the right direction.

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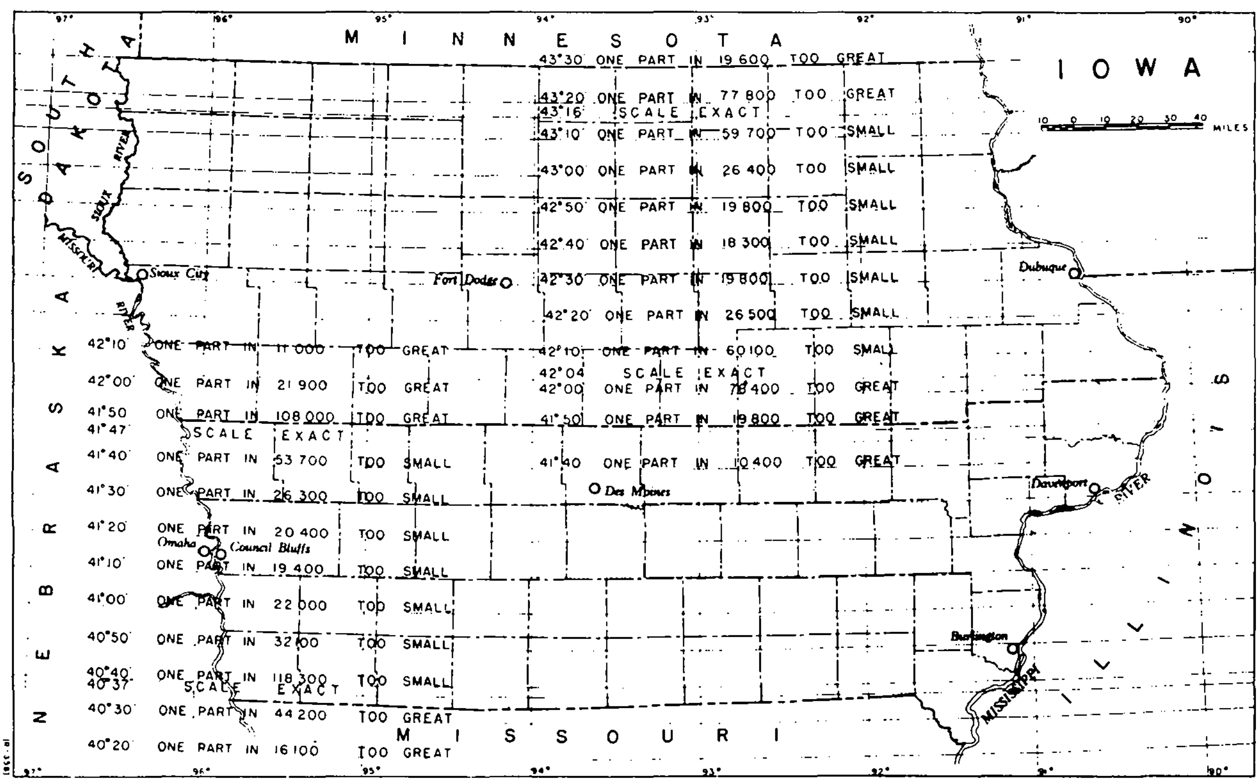

Map of Iowa showing State coordinate system and lines of departure from true scale.

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MASSACHUSETTS GEODETIC SURVEY

E. C. Houdlette

Those interested in the progress made in the use of geodetic control in Massachusetts may refer to the contribution made by Clarence B. Humphrey, Engineer for Court, Massachusetts Land Court, to the Geodetic Letter for May, 1935 (No. 5, Vol. 2, page 26) from which the following chronological abstract is drawn.

1846: First triangulation in Massachusetts made by Mr. Simeon D. Borden who devised 5 separate origins based on a plane tangent at each point of origin.

1890: Publication of town boundary atlases and topographical maps based on recomputed values of Borden points and addition of many others by the U.S. Coast and Geodetic Survey, all based upon the Clarke spheroid of 1866.

1898: Massachusetts Land Court established.

1915: A system of plane coordinates was adopted for each registration district to the number of twenty-one districts.

1933: April 1. The increasing use by the Department of Public Works of the twenty-one Land Court systems of coordinates developed a need for simplification. Through conferences and cooperation between the Land Court and the Department of Public Works, made effective on the above date, geodetic control in the State was established on eight coordinate systems, three of which remained as before, while five systems replaced the remaining eighteen systems.

1935: "Since December 1933 ..... much work has been done which will be of inestimable value in the future. The result of this work has been that in Massachusetts, at least unofficially, the 1927 North American datum has been adopted, and furthermore, a rectangular system adopted based on the Lambert Conformal Conic Projection ....." This abstract is completed by further quotation from the same source.[1] "Everybody understands the value of a plane rectangular system covering the whole State, and its great potential value, if those in charge of engineers

[1] Note: Geodetic Letter, May 1935.

working for State departments or other political subdivisions of the Commonwealth would gradually adopt the system and have all of their surveys connected with it."

In December 1933, the then Local Control Survey was requested to facilitate adoption by the Court of the Lambert projection by computing the coordinates of the corners of the 72 subdivisions into which the Court divides each of the 54 topographic sheets, which are then developed on the scale of 300 feet to the inch. Later the Court requested a retriangulation of Nantucket and the determination of coordinates on the 1927 datum of all its stations on the island.

In May 1935, subsequent to the above article in the May Geodetic Letter, Mr. Humphrey submitted a memorandum to Mr. Houdlette upon the subject of legislative action. There followed a conference at which it was decided to postpone this contemplated step until the arcs of first-order triangulation now in progress across the State along the north and south borders and through the western counties were completed, and adjusted to the North American datum of 1927. Then with all traverses within the State tied to this adjusted system the picture would be complete upon which to base legislative action.

1936: To bring the record up to date the Land Court has adopted the single system of plane coordinates developed for the State on the Lambert projection and requires that the survey accompanying each new case be tied to the nearest Lambert control point if located within a reasonable distance of the property.

The Massachusetts Department of Public Health has adopted Statewide vertical control based on mean-sea-level datum. Its Chief Engineer has requested a special project, now being executed by the Massachusetts Geodetic Survey, to establish bench marks at all sources of water supply, reservoirs, wells, standpipes, elevated tanks, and pumping stations in Worcester County and all counties east of Worcester County. This survey will include the determination of water levels in all open water bodies, with date of observation, and the elevations of crests of dams, spillways, and overflows and of intake pipes.

The Massachusetts Department of Public Works, which includes the Division of Water Ways, the Division of Highways, and the Division of Bridges, has also adopted this control for all future surveys. The field work required in reconnaissance and final location of new highway routes is greatly lessened since it is no longer necessary to run back traverses to establish control.

Public interest, both private and official, is continually increasing. Many communities made appropriations for material needed for monuments and towers to further the work of the Massachusetts Geodetic Survey in establishing local control points.

The reproduction department has published a variety of documents pertaining to geodetic work in the State in the form of special reports, lectures, and manuals on procedure in the field, procedure in computation, and procedure in preparing the text of special reports. The Massachusetts Institute of Technology has loaned lecture rooms for use by classes of men drawn entirely from the personnel of the Massachusetts Geodetic Survey receiving instruction from Mr. H. J. Shea, formerly observer in the U.S. Coast and Geodetic Survey, now instructor in Geodesy at the Institute. The course of sixteen lectures is to be repeated this winter.

The Kirstein Public Library, 20 City Hall Avenue., Boston, Mass., the Business Branch of the Boston Public Library accepted a window display as an educative exhibit in April 1936. A relief model of a portion of the Worcester Turnpike (Mass. Route 9) through Southborough and Westborough, presented the topography of 9.5 square miles of territory at the horizontal scale of 1 to 5400 and the vertical scale of 1 to 1440. Miniature towers indicated triangulation stations, while labelled flags were placed at traverse stations, bench marks, and highway markers. Surrounding the glassed-in model were models of towers, and photographs of field parties and of instruments, including first-order triangulation and leveling instruments. The exhibit remained three weeks. Later it was set up in the Park Square Building and again at the Brockton Fair.

Since its organization, the Massachusetts Geodetic Survey has steadily pursued its objective of making horizontal and vertical control available throughout the State despite the "stop" and "go" signals, the readjustments of field and office personnel, and fluctuations in available funds. The work accomplished within the State is summarized in the following table.

PROGRESS STATISTICS - MASSACHUSETTS GEODETIC SURVEY

Monthly averages for the years	1934	1935	(10 mos.) 1936	Total to date
Field force	200	276	291	
Office force	41	80	140	
Total men employed	241	356	431	
Traverse mileage	63	73	50	2128
Second-order levels, mileage	61	130	154	3835
First-order levels, mileage	15	18	44	776
Arcs of triangulation, mileage	130	227	206	6339
Traverse stations established	151	131	74	4117
Triangulation stations established	30	28	11	810
Bench marks established	169	230	260	7385
Average traverse closure	16,700	23,025	23,390	

About 50 per cent of the noticeable increase in the office force is attributable to the Reproduction Division established in August 1935 and later expanded to prepare, reproduce, and assemble the manuals, special reports, computation forms and other material needed in the operation of the project and for special reports of the W.P.A. Planning Board of the State, and also to the publication of a special volume of hitherto unpublished bench marks, approximately 800 in number, established in this State by the U.S. Geological Survey.

A special report "High Water Data - Flood of March 1936 in Massachusetts", just off the press and now being bound, is based upon some 1400 observed points which required about 800 miles of levels to determine the elevation of each. As this work was not a regular part of the control program, neither the points nor the level mileage are included in the above summary.

SURVEY MARK OF THE MASSACHUSETTS

LAND COURT

Made of bronze and cast in cap form for use on pipes or as a disk for use with concrete and masonry monuments.

Remedying Our Archaic System of Land Descriptions

by Thomas P. deGraffenried
Of the New York City Bar

IT has been said that the transfer of real property involves difficulties out of all proportion to its value, as compared with the transfer of any other form of wealth. In large part the trouble is due to the methods heretofore used in America in preparing the descriptions of land in deeds and other instruments affecting the title to realty. These methods have been aptly described by Professor Kissam of Princeton University as "inadequate, archaic and inaccurate and the cause of untold economic loss and damage." The frequency and ill effects of defective descriptions are indeed appalling, and there are few brokers who have not in some way suffered as a result of them.

While it is the privilege, as well as the duty, of a purchaser to insist upon a sound description of the land which he intends to buy, it is well known that the seller, as well as his attorney, is as a rule loath to depart from the description by which he has received title. This difficulty has often proved insurmountable.

Not infrequently another obstacle is encountered, arising from a total lack of means by which an adequate description may be obtained. Competent surveyors often differ as to the location, as well as the dimensions, of the same piece of property. In fact, under present conditions and methods, surveying in many localities is admittedly an unscientific and inaccurate art.

Our haphazard, loose, rule-of-thumb, trial-and-error methods of description are a heritage from England, as an examination of the very earliest proprietary grants and patents will demonstrate. In and about New York, and throughout a long stretch of the Atlantic coast, they have caused from colonial days to the present a mass of litigation and incalculable loss, and the end of the sorrows engendered by them has not yet been reached.

The writer only recently, while examining the title to a large and valuable parcel of acreage within fifty miles of the New York City Hall, met with a record description which read: "Beginning at a point where an old hickory tree once stood." He was at once reminded of that favorite exclamation of auctioneers: "Sold to the lady in the vacant seat!"

It was Rufus Choate, arguing a question of interstate boundary, who uttered the words which may be fittingly applied to a multitude of land descriptions which may be found in the registries of America: "It is as vague as the imagination of man. It is as though you should say, "Beginning at a blue jay perched upon a leafy bough in summer, and running thence five thousand feet to a hive of bees in swarming time."

Fortunately, the courts have developed many salutary and remedial rules of construction. These are of great benefit, but can only mitigate, not eliminate, the long-standing evil of careless descriptions. Like the disease itself, these remedial rules came to the American colonies from England, and in view of the important part played by them in our outmoded system of conveyancing, some familiarity with them is desirable.

COURTS generally, when interpreting ambiguous and imperfect conveyances, have endeavored as far as possible to put themselves in the position of the parties at the time of the execution of the instrument, and to ascertain their intentions in the light of all the surrounding circumstances. When necessary to effectuate the intention of the parties, the courts have not hesitated to substitute north for south or east for west, or to stretch or diminish distances in order to conform to established monuments or boundaries, or to reject surplusage in descriptions or interpolate missing terms; but to this process there are well-defined limits and it is a primary rule that nothing passes by an instrument of conveyance except what is described therein, whatever the intention of the parties may have been.

The intention of the parties, the courts hold, may be ascertained not only by the language of the description but by reference to extrinsic facts. These may be found in prior deeds relating to the same property or prior deeds in the chain of title, or writings contemporaneous therewith or circumstances relating to the premises described in them, and evidence of undisturbed use of the property on the one hand and of acquiescence in such use on the other is competent and important.

Again, it is cardinal that every instrument of conveyance must be read in the light of the facts and circumstances existing at the time of its execution and must receive the same construction which would have been given it immediately after its execution, and it has long been the rule that every reasonable intendment is to be made in favor of the grantee and against the grantor. It is, of course, presumed that every grantor intended to convey that which he owned and not that which he did not own.

It is well settled that a conveyance is to be construed with reference to its distinct, locative calls, as marked or appearing upon the land, in preference to quantity, course, distance, map or other references. Ambiguous or patently erroneous descriptions have often been rejected and the land located by other calls. Visible or definite objects, fixed upon by the terms of the grant as the boundary or locative call of the premises, such as a marked tree or clearing, the corner of a lot, or the land of another person, which is certain and notorious, must be adhered to in the location of the land, although they do not correspond with the courses, distances or quantity specified in the deed, all of which must give way to such known boundaries or calls. The

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locations made upon the ground and the acquiescence of the parties following such locations have often been held conclusive and binding upon the parties.

As a rule, any description by which the identity of the premises sought to be conveyed can be readily established is sufficient, since the office of a description is not primarily to identify the land but to afford the means of identifying it. A description which enables a surveyor to locate the land, or affords any other means of identifying it, is not to be rejected. A conveyance does not fail by reason of uncertainty in the description if the premises can be identified by descriptions in other conveyances or by reference to plats, lines or records well known in the neighborhood or on file in public offices.

FROM the foregoing summary it is obvious that while the courts extend a helping hand wherever possible, there remain many cases in which careless, inaccurate descriptions have placed purchasers beyond hope of remedy.

In approaching the consideration of a cure for this evil, it should be borne in mind that our country is very poorly surveyed and mapped. In fact, Dr. William Bowie, Chief of the Division of Geodesy of the United States Coast and Geodetic Survey, has said that "it is one of the most backward in this particular of all the highly organized countries of the world."

Much, it is true, has been accomplished by the municipal topographical bureaus of our larger cities, notably New York and Chicago, toward the permanent establishment of monuments, locations and boundaries, but even in Greater New York, where a very active and progressive topographical bureau has been at work for a long time, the topographical maps for many local areas are yet in a formative state, being tentative only. At best, the work of these municipal agencies is local. The problem is national, and as a result of the plan devised by Dr. O. S. Adams of the United States Bureau of Coast and Geodetic Survey, it is now being treated as such.

The great difficulty with most surveys is the lack of a basic starting point, or basic line, permanent in character, or if not fully permanent, capable of being easily and accurately restored in case of accidental destruction. At present, the particular point chosen for a starting-point or monument must necessarily, in many instances, be of a temporary nature, such as a tree, the center line of a stream, an unmapped road line, a neighborhood corner, a poorly constructed monument, or the like. Often the location of an entire parcel, even in well settled areas, is a matter of considerable conjecture, giving rise to disputes between surveyors. The magnetic or arbitrary bearings now customarily used are quite inadequate and old surveys are frequently misleading as to the magnetic or true north, as the magnetic point is constantly shifting in a very irregular manner.

The plan projected by Dr. Adams is not only national in scope but is designed to provide permanent starting points for surveys throughout the country and by the use of them to make possible, within the limits of present surveying practice, an accurate survey of land in any part of the United States. He has devised a method whereby a large strip of territory may be projected upon a plane and the geographic co-ordinates in such a strip converted into plane rectangular co-ordinates, maintaining in that projection an accuracy well within the limits required or obtained in ordinary land surveying.

While the system is new in this country, it is said to have been adopted years ago in France, and with such success in practical application that in areas where every landmark was destroyed during the war, it has been possible to re-establish property lines exactly as they existed prior to the destruction of the marks. The chief principle in this system, Professor Kissam remarks, is the establishment of carefully monumented and referenced points over the entire country, interconnected by precise surveys so that the relative position of each point with respect to the entire system of points is known to a nicety. Marks of this kind, called "control points," should for proper use be established at distances of not more than a few thousand feet from each other. Once established, they are in principle indestructible, because, even if many thousands of them should be destroyed, they may all be replaced, provided but two remain.

The United States Coast and Geodetic Survey, in pursuance of this system, has established or is establishing in every state monumented triangulation stations, spaced at intervals of approximately twelve miles and interconnected by the most precise type of surveying ever developed. Mr. Hugh C. Mitchell, a senior mathematician of that Bureau, in a recent letter to the writer, explains that the various state systems of plane co-ordinates, as prepared by the Bureau, are the means of putting the data obtained from the National Geodetic Survey in such form that they may be used by any land surveyor without resorting to anything more involved than ordinary formulas and methods of plane surveying.

Prominent engineers and others throughout the country, after careful study of the plan, have given it their unqualified approval and support. Through the co-operation with the Bureau of Professor A. H. Holt, Associate Professor of Engineering at the State University of Iowa, a practical surveyor as well as a distinguished engineer, and a member of the state bar, an act has been prepared for presentation to the legislature of Iowa, providing for the establishment of the system of plane co-ordinates in that state.

In New Jersey the method was officially adopted by an act of the legislature in 1935, and although the official use of the system in that state is yet in its infancy, good results are said to have been obtained.

A similar act has been drafted for presentation to the legislature of Florida and the State Planning Board of Pennsylvania has requested that an act be prepared for that state.

A proposed act, prepared by Mr. Mitchell for the State of New York, divides that state into four zones, three north and south zones and one east and west zone, with technical descriptions of each of these zones and of the projections placed over them given in the act.

Other states for which, pursuant to requests received from them, the Bureau has prepared acts are Texas, Tennessee, Virginia and South Carolina.

In short, the plan now bids fair to be generally adopted throughout the country. The consequences of ancient blunders will, of course, be with us for years to come, but the establishment of the Bureau's system will make possible simple and definite descriptions of land in the future.

LAND SURVEYING IN HAWAII

L. M. Whitehouse

The transition of the government of the Hawaiian people from the feudal system which had prevailed for many centuries prior to the discovery of the islands by Captain Cook in 1778, to that of a constitutional government under a Christian civilization which took place about sixty years after the discovery, was accompanied by a radical change in the system of land tenure. However, the ancient subdivisions of land, for geographic and other convenient reasons, have remained unchanged to the present day.

The Hawaiians had no written language of their own and the manner in which the boundaries and names of lands were perpetuated was by word of mouth passed down from generation to generation by certain persons who were selected as the repositories of this information. Boundaries of the land sections constituting the domains of the chiefs were identified by geographical features, such as streams, mountain ridges, hills, capes and other prominent points, and where no such features existed, by stone walls, large rocks, cairns of stones or other material and other artificial monuments. All these features were generally given names indicative of some physical characteristic or historical event connected therewith.

The smaller parcels of land held by the common people were identified by the extent of their cultivation; wet land patches for the cultivation of the taro, the Hawaiian staff of life, were bordered by narrow banks and the areas under dry cultivation were marked by low and narrow ridges of hard-packed earth to delimit the occupation of the individuals. House lots, not always located in the cultivated fields, were enclosed by stone walls or wooden fences of cut saplings. In almost every instance each land division down to the smallest unit had a distinctive name of its own.

In the peaceful revolution from the absolute monarchy of Kamehameha I to the constitutional monarchy under Kamehameha III, in which also the system of land tenure underwent a change, the common people who previously had only a permissive use of the lands on which they lived, were given an opportunity to secure allodial titles to their holdings.

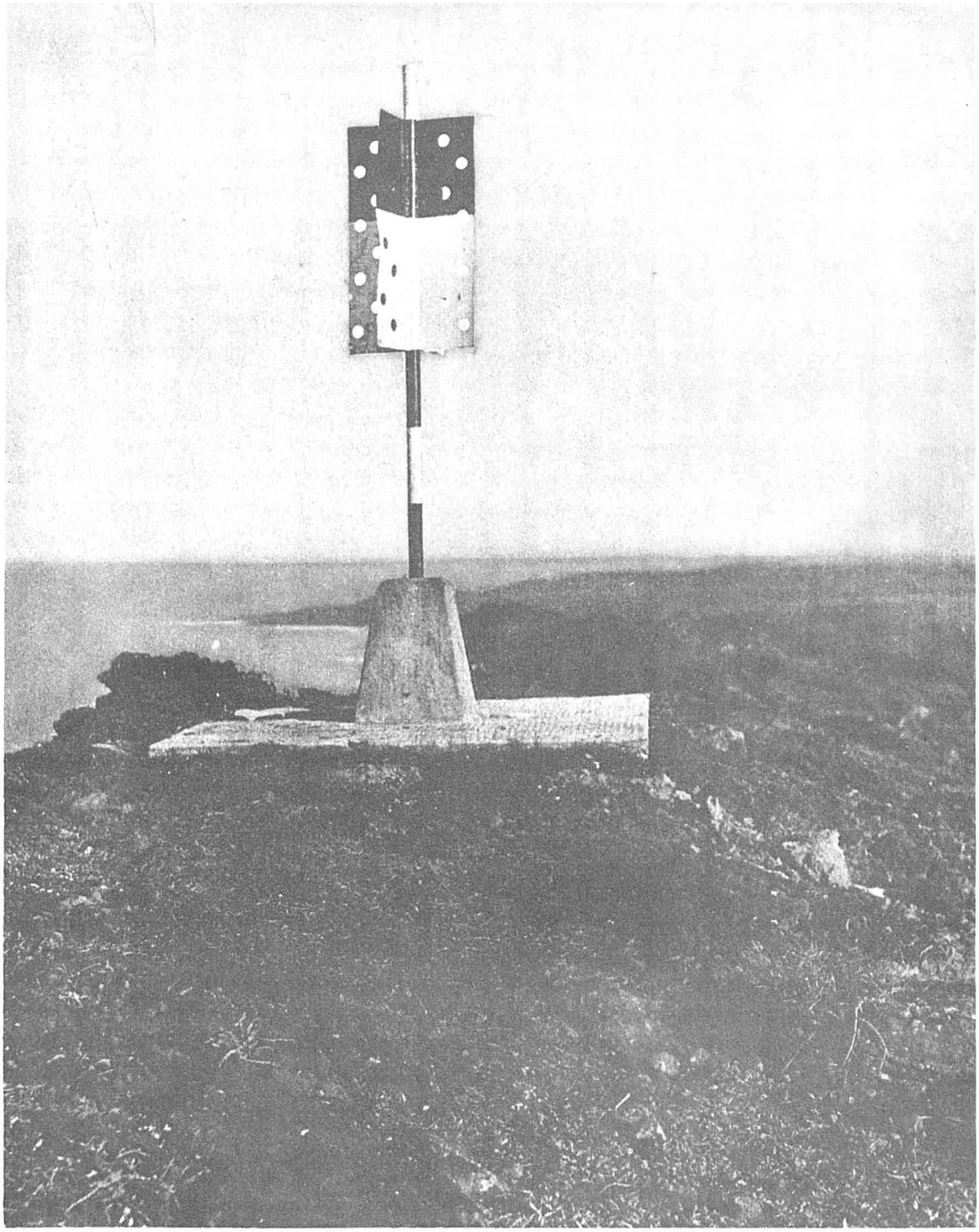
The king and his feudatory chiefs, in a grand division which took place in 1848, divided between themselves the large land sections. The king, who received the largest individual share, then transferred a portion of his lands to the government as a part of the public domain and retained the remainder for himself as an appurtenance to the crown.

In these transactions it was provided on the part of the common people that all claims should be accompanied by a metes-and-bounds description of survey and map. In all these early surveys the magnetic compass - an inadequate and unreliable instrument - was used in measuring the bearings of the land lines and usually, but not always, the Gunter's chain for the measurement of distances. The chiefs were not required to submit surveys of their lands, their claims being awarded by the names of their particular land sections according to their ancient boundaries. Further provision was later made by which these boundaries, at the option of the land owners, could be defined by survey before a boundary commission, and when these lands were surveyed the practice was no different.

No real attempt was made to correlate these surveys with one another or to exercise any method of control. Perhaps as many as 40,000 parcels of land, large and small, were surveyed in this manner between the years 1846 and 1870. The crown and government lands generally remained unsurveyed, except in the instances where the king sold some of his lands and the government granted lands out of the public domain. These latter surveys were generally magnetic, but sometimes true bearings were used, the north line being established at the site of the survey.

No base maps were ever made and by 1870 it was quite impossible to determine the area and extent of the crown and government lands. This led to the inception of the Hawaiian Government Survey. The first steps taken were to determine the latitudes and longitudes of initial stations, to measure base lines and to extend a chain and network of geodetic stations over the whole group of islands, as a foundation to which all existing surveys could be coordinated and to which all subsequent surveys could be connected.

The United States Coast and Geodetic Survey was consulted for the best practice and methods and besides practical advice, also helped by lending the Hawaiian Government a base-line apparatus and other instruments of precision. The true azimuth system was adopted and thereafter all government surveys were based on this method of surveying. This did not by any means correct the errors of the old surveys or provide for the compulsory surveying of the privately owned land sections. Perhaps as many as two-thirds of the lands of the kingdom were in private hands - lands for the most part remaining unsurveyed or at the best but poorly surveyed - so that there still remained much to be done to bring about a system of land and boundary control.



KILAUEA

A triangulation station on Kauai Island, T.H. Note permanent observation platform and demountable target.

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It is easy to imagine that this condition would cause much litigation affecting boundaries, and such is the case, as the Hawaiian courts have had innumerable lawsuits involving land boundaries.

The situation became so acute that thoughtful men acquainted with these problems and familiar with what had been done in other communities conceived the idea of applying the Torrens System of land registration to these islands, the use of which would be optional.

A lawyer well versed in land matters, the then head of the territorial survey department and the chief of the bureau of conveyances, took a leading part in initiating the move to enact proper legislation and in 1903 an act was passed creating a Court of Land Registration, the name being later changed to Land Court.

The Land Court is a court of original jurisdiction and is presided over at stated periods by one of the Circuit Court judges and this court decides questions of titles as well as of boundaries.

Respecting surveys submitted in the Land Court, the rules require that a precise surveyor's transit shall be used for measuring angles and that the azimuth shall be used in all descriptions of surveys with zero or 360° at true south and that the initial point of the survey shall clearly show its connection with the government triangulation. Distances shall be measured in feet and decimals of a foot with a steel tape certified to be accurate by the U.S. Bureau of Standards.

At the present time, a surveyor can readily tie-in his work either directly to a government station or to a reference point which has already been tied in to the triangulation net. For all ordinary purposes the plane rectangular coordinates [1] are used and are much easier to apply. Where the cadastral survey is over a large area and it becomes impracticable to have a single plane reference for the entire area, the coordinates can then be referenced to the nearest geodetic station and the spherical difference between two or more stations will automatically adjust itself within a reasonable degree of error. In the case of the city surveys, coordinates and azimuths can be taken from a nearby street monument which latter is connected with the government triangulation.

The territorial surveyor is ex officio surveyor of the Land Court and before an application for the registration of title to land comes before the court for hearing, the survey and map is examined by him and must receive his approval. The examination is thorough and goes into all the elements of good surveying, the prescribed standards being of the highest. All boundary points, if practicable, must be marked in a durable and substantial manner, there being no special type of marker designated, but it must be of a quality best suited to the ground conditions. The nature of the mark must be embodied in the description of survey and indicated on the map.

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[1] Note: On a local system of plane coordinates.

The economic value of a Land Court title is great, although difficult to measure in dollars and cents. The best recommendations are: that it is constantly growing in favor and very few transactions of valuable property now take place until a Land Court title is obtained; that no private title and guaranty company could successfully compete with the existing system; and that no one would seriously think of abolishing the Land Court.

As no attempt was made to compel the registration of all the land in the Territory in the Land Court, so in the first years of its existence not many applications were filed, most of the cases covering small holdings, but as its value has become better known, advantage has been taken of its services. Owners of large tracts of land such as corporations and trustees of trust estates find particularly valuable the provisions stating that adverse possession and easements cannot run against a registered title.

It is not uncommon at the present time for tracts of land of from 20,000 to 80,000 acres - big areas in these islands - to come under the operation of the Land Court system. Operators in real estate, especially of tract subdivisions, arė relieved from conveying by warranty deed as the government already has guaranteed the title.

The knowledge which a landowner carries with him that his boundaries have been accurately determined, that his title has been perfected, and that the area is mathematically correct, cannot but be a continual source of satisfaction in the peaceful possession of his property.

We have followed the evolution of the definition of boundaries of lands from ancient times to the present, first by their names and references to certain landmarks, passed down from generation to generation solely by word of mouth; next, by magnetic bearings with unequal variations in the declination in different localities and with unstandardized chains, these surveys being unrelated one to the other; next, the setting up by the government of a triangulation system with geodetic stations to which surveys may be referenced, but no legal means by which precise surveys could be substituted for the old inaccurate and imperfect surveys; and lastly, the Land Court system by which anyone can come into court and have his title to land definitely quieted for all time, guaranteed by the government and at the same time have his boundaries precisely defined by the most modern methods of surveying.

The Land Court method of registering boundaries and guaranteeing titles has been found well worth while in Hawaii, and although the initial cost in many cases has been great, subsequent charges have been found to be in the majority of cases considerably less than costs incurred in the transfers of title of unregistered lands.

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THE HAWAII LAND COURT SYSTEM

P. H. Mulholland

Thirty-three years ago there was introduced into the Territory a new method of dealing with land which its sponsors hoped would prove a solution to the problem of dealing with Hawaiian land titles with facility and safety. Difficulties had been experienced in real estate transactions which it was hoped the method would overcome. In thirty-one years Land Court registration has assumed an important place in the life of the community. To such an extent has it been accepted that a Land Court title today is looked upon as the last word in security and strength. The new system is based on the Torrens land registration acts and is usually referred to as the Hawaiian Torrens System or Land Court System.

The Hawaiian act is designed to create a system of dealing with land which is simple, rapid, inexpensive and secure. To this end a governmental register is established which consists of a number of certificates of title bound together. These certificates contain the following information:

(1) The person in whose name the land is registered;

(2) A description of the land, title to which is so registered;

(3) A summary of the encumbrances to which the land is subject, if any.

An examination of these certificates, original or duplicate original, is all that is necessary to determine the status of the title therein set forth. The Territory guarantees the accuracy of its register and compensates those who suffer losses through reliance thereon.

Land and easements or rights in land held and possessed in fee simple within the Territory may be registered. The provisions relative to the registration and conveyance of registered land shall apply to the registration and conveyance of easements and rights. Interests in registered land less than an estate in fee simple are noted as encumbrances on certificates of title affected. They are not the proper subject matter of separate certificates.

The act is administered by the Land Court which has jurisdiction throughout the Territory. A judge of the Circuit Court of the First Circuit designated so to act by the chief justice acts as judge of the

Land Court. The judge appoints a registrar and such assistants as may be allowed by law. He may also appoint one or more examiners of title who have been declared by the Supreme Court to be qualified.

The form of application is prescribed by statute. It may be filed by any person authorized by law, or by a non-resident through his agent or by a trustee unless expressly prohibited by the instrument creating the trust.

The application is filed in duplicate, accompanied by a plan of the land and a complete abstract of title.

The court upon receiving the application refers a certified copy thereof and the abstract of title to an examiner and refers the map to the territorial surveyor for check.

Immediately upon the filing of an examiner's opinion favorable to the applicant or the filing of applicant's election to proceed in case of an unfavorable report, as the case may be, and the filing of the report of the surveyor, notice of the filing of the application is published in a newspaper of general circulation.

Any person claiming an interest, whether named in the notice or not, may appear and file an answer on or before the return day, or within such further time as may be allowed by the court. The answer must state all objections to the application; must set forth the interest claimed by the party filing the same; and must be signed and sworn to by him or by some person in his behalf. A trial is then had before the judge of the Land Court to dispose of the issues involved.

If no person appears and answers within the time allowed, the court may at once, upon motion of the applicant and no reason to the contrary appearing, order a general default to be recorded and the application to be taken as confessed. The applicant then presents proof of ownership and title. If the court finds that he has not title proper for registration, his application will be dismissed. If the evidence produced is satisfactory, a decision is rendered in his favor.

In contested as well as in non-contested cases, the decision of the court must be filed in writing. An appeal may be taken from a decision of the judge of the Land Court to the Circuit Court sitting with a jury on questions of fact only. In all cases a writ of error from the Supreme Court shall lie to the final decree of the Land Court.

Final decree may be entered at any time after the expiration of ten days from the date of the decision. On entry of the decree a certified copy thereof is sent to the assistant registrar of the Land Court who transcribes it into a book called the registration book. This transcription is the original certificate of title and is signed by him and sealed with the seal of the court. The assistant registrar then makes an exact duplicate of the original certificate including the seal, but putting on it the words "owner's duplicate certificate" and delivers it to the owner or his authorized agent.

As soon as the decree is transcribed, the land described therein becomes registered land. The land, though registered, is in all respects subject to the same burdens and incidents of proper conveyancing and law which attach by law to unregistered land.

The decree of registration is an agreement running with the land, and binding upon the applicant and all his successors in title, that the land shall remain forever registered and subject to the act or amendments thereto. Prescription or adverse possession does not run against registered land.

The certificate of title is the owner's evidence of ownership. He holds it free from all encumbrances except those noted on it and certain statutory encumbrances which may be existing, a list of which is printed on the back of the document.

If an owner's duplicate certificate is lost or destroyed he may secure a new duplicate by filing a petition with the Land Court stating the facts. The court, after notice and hearing, will direct the issuance of a new one to take its place. No certificate of title can be altered or amended without order of court.

Once land is on the register and a certificate issued, it may be dealt with as though it were unregistered. There is no limit to the transactions which may be entered into concerning it. With respect to documents affecting land under the act executed after decree issues, there is this requirement: that such papers must be registered in the Land Court in order to effectuate any change in ownership or to encumber any registered interest.

The system has achieved that which its friends in the islands had hoped would be accomplished. It has promoted security in transactions which had formerly been marked with so great an element of risk and speculation. It has added to this element of security the further element of speed in transfer, which under certain circumstances and in particular cases may be the most important feature of a real estate transaction. Other benefits have proceeded naturally and logically from these two great elements of speed and security, rendering important contributions to the commercial life of the community. Loans on registered property are obtained with much less difficulty than loans on unregistered property.

On June 30, 1933, the system had completed its thirtieth year of service to the people of the Territory. On that date there had been registered in the Land Court 1012 titles involving lands assessed for taxation purposes at a sum in excess of twenty-seven millions of dollars. In addition, there were pending registration sixty-four titles involving lands assessed at over six millions. From various sources we learn that steps are being taken for the registration of practically every large estate in the Territory. Outstanding corporations in the islands have adopted a policy to register all their real property. Local banks and trust companies are insisting on land registration as a prerequisite to loans on properties which have no clear paper title.

One island of the group, Lanai, is entirely within the system, the whole having been registered, a few years ago, under one application.

Of the island of Oahu's area of 604 square miles, eleven per cent is registered. If the applications which are now pending are completed this percentage will be increased to approximately one-third of the whole.

On the other islands of the group progress has not been so rapid, although it has been very encouraging. Molokai leads with four per cent. Of the island of Hawaii's area of 4030 square miles, three per cent is registered; on Maui, two per cent, and on Kauai, one-half per cent is under the provisions of the Torrens Act.

These are impressive figures, but the future holds possibilities of a still more amazing record. The factors which brought the system into being in the Territory and which are responsible for its success and popularity will strengthen rather than diminish with the passage of years, and the experience both of those who use the system, and those who, on the side lines, have watched its progress and effects, has produced a public state of mind appreciative of its benefits and receptive to a continued use of its facilities.

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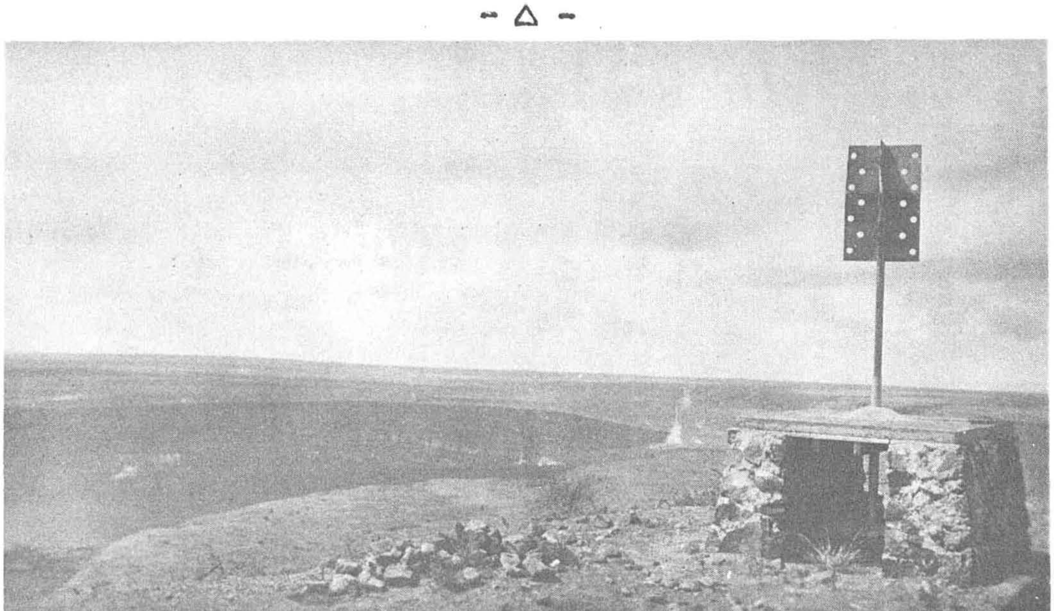

UWEKAHUNA

A triangulation station on edge of Halemaumau Pit, Kilauea Volcano, Hawaii Island. Note permanent observation platform and demountable target.

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OUR CONTRIBUTORS

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THE FEDERAL BOARD OF SURVEYS AND MAPS (Plane coordinate systems, page 8, and Discussion of plane coordinates, page 68) was

> "created by Executive Order of December 30, 1919, and was designed to furnish the means of coordinating the activities of the bureaus and independent organizations of the federal government engaged on surveying and mapping, and to avoid duplication of effort between these organizations, also to make the results of greatest usefulness to the map using public." [1]

While the powers of the Board are advisory, not mandatory, its determinations are adhered to closely by its member organizations, which number 24 at the present time. Assisting the Board is an Advisory Council with a membership of 22

> "consisting of the representatives of map users and publishers outside of the federal government which are interested in the surveying and mapping done by the federal government." [1]

The Board maintains a Map Information Office in the Interior Department Building, Washington, D.C.

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1 From the report of William Bowie, Chairman of the Board, to the President of the United States, dated March 5, 1923.