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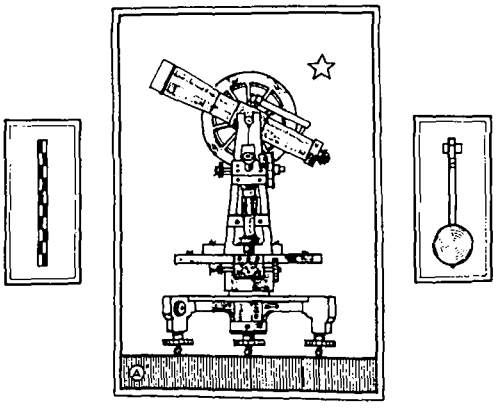

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THE IMPORTANCE OF GEODETIC ASTRONOMY

By C. H. Swick
United States Coast and Geodetic Survey,
Washington, D. C., U. S. A.

(The following article is taken from the Proceedings of the Fifth Pacific Science Congress, 1934.)

In all geodetic surveys, the curvature of the earth must be taken into account. Areas no larger than a small county, or a medium sized city, may be accurately surveyed by the use of plane co-ordinates on the assumption that an equipotential surface, at about the elevation of the area in question, is a plane surface. Surveys over larger areas, such as states or counties, cannot be made without gross error unless the curvature of the earth is considered. The determination of the exact curvature of the earth is, therefore, an essential part of geodetic surveys.

Now the shape of the earth can be ascertained in two different ways, one depending on gravity determinations and the other on astronomical data, but the size of the earth can only be obtained with precision from astronomical data. If the latitudes and longitudes of two points on the earth are determined astronomically, and the distance is then measured between them, the curvature of the earth along the line connecting the two points can be computed.

This simple statement of the problem and its solution must be qualified, however, or it becomes very misleading. If the earth were a homogeneous sphere, or consisted of concentric spherical shells of homogeneous material, and its surface were entirely free of bumps and hollows, then its shape and size could be very easily determined in the simple manner just explained. The real earth, with its mountains, valleys, and ocean deeps, and its heterogeneous crust, presents a very much more difficult problem.

The astronomical observations at any station are necessarily related to the plumb line, or to the level surface at right angles to the plumb line, and here lies the trouble. The positive or negative attractions of topographic features, and of the isostatic compensation of these features, deflect the plumb line away from what may be called its normal position by amounts varying from a fraction of a second to more than half a minute. Therefore, before astronomical data can be used to compute the shape and size of the spheroid which most nearly fits the earth as a whole, either the amount and direction by which

the plumb line is deflected away from its normal position must be computed for each station, or such a large number of stations must be used that the errors from this source tend to cancel each other, or "balance out" as it is sometimes expressed.

In 1909, John F. Hayford, who was then chief of the Division of Geodesy of the Coast and Geodetic Survey, determined a spheroid from data in the United States. Hayford used a large number of stations and computed the effect at each station of the surrounding topography within several hundred miles of the station. What is even more important, he computed the effect of the isostatic compensation of the topography, using a new method devised by himself. This was the first attempt that had ever been made to apply the isostatic effect to computed deflections of the vertical, and it was so successful that the resulting spheroid was adopted about 25 years later as the international standard spheroid.

Hayford used about 750 astronomical determinations in his computations. At the present time there are more than 1,300 additional determinations in the United States that could be used in deriving new and somewhat better dimensions for the spheroid. The computations involved in deriving the best figure of the earth by the isostatic method are laborious and time-consuming, but it is hoped that they may be carried out in the not too distant future, with all the available data in North America taken into account.

After the most accurate possible dimensions for the figure of the earth have been derived, the next important reason for making astronomical observations in connection with geodetic surveys is in order that data may be obtained for controlling the azimuths of the lines of triangulation. Although the specifications for first-order triangulation require that the average closure of the triangles of an arc shall not exceed one second by more than a very small amount, it is found that an arc of triangulation has a tendency to swerve in azimuth and that, after 10 or 12 quadrilaterals have been observed, the azimuths derived from the angle observations may be in error by several seconds.

This swerving in azimuth must be corrected by the introduction of what are known as Laplace azimuths. A Laplace azimuth is an astronomical azimuth which has been corrected for the deflection of the vertical and may, therefore, be considered a true azimuth. It is obtained by making astronomical observations for both longitude and azimuth at a triangulation station and using the longitude difference as a basis for the azimuth correction.

The longitudes carried by triangulation are very close to the true values if the starting azimuths are properly controlled, and, therefore, the deflection of the plumb line in the plane of the parallel through a station may be obtained by comparing the astronomical and geodetic longitudes. This deflection along the parallel may be reduced to the corresponding deflection along the prime vertical, and the latter can then be used in deriving the error in the astronomical azimuth caused by the deflection of the plumb line. A true azimuth (Laplace azimuth) is thus obtained.

The Coast and Geodetic Survey, after more than 25 years' experience with Laplace azimuths, has found that they should be spaced along an arc about eight or ten quadrilaterals apart. When the arcs are adjusted to hold these azimuths fixed, the lines of the triangulation midway between the Laplace stations will not be appreciably in error in direction.

The value of Laplace azimuths for the control of triangulation has been clearly demonstrated in the adjustment of the triangulation net of the western half of the country, completed two or three years ago, and in the adjustment of the eastern half of the country recently completed. In the western adjustment 74 Laplace azimuths were used, and in the eastern half there were 102. The remarkably small closures of the many loops of triangulation involved in the two adjustments show that the lengths and azimuths of the whole net must have been very accurately controlled.

It is seen from the preceding discussion that geodetic astronomy includes three different kinds of astronomical determinations, namely, azimuth, latitude, and longitude. A brief explanation of how the observations are made and the degree of accuracy obtained in the three classes of work may be of interest.

The azimuth observations are usually made by the triangulation party. The same instrument is required for the azimuth determinations as for the angle observations of the triangulation, and the work must ordinarily be done while the observing towers or stands are still in place. Especially, when the steel towers are used, is it very necessary to make the azimuth observations while the triangulation work is in progress, that is, before the towers are moved ahead, because the occupied station and the station used as a mark are generally not intervisible from the ground.

To be acceptable for a Laplace station, the observations for azimuth should have a probable error not greater than 0.3 second. From 24 to 26 determinations of the azimuth are made at each station and the mean is taken. Accurate time is needed for azimuth determinations. Either the chronometer error is obtained from radio time signals or else vertical circle observations for time are made on stars near the prime vertical before and after the azimuth observations.

The latitude and longitude observations are made by a special astronomical party which follows the triangulation party, and may perhaps be several months, or even a year or two, later in occupying the stations. During the latter half of the 19th century many latitude and longitude determinations in the United States were made at points other than triangulation stations. With a more extensive triangulation net available in recent years it has become the practice to have all geodetic astronomical work in this country done at triangulation stations. The results thus become more valuable for figure-of-the-earth computations and are also available for the control of the triangulation net of the country.

The instrument used for longitude determinations is a portable astronomical transit of the broken telescope type. It has an objective with a clear aperture of seven centimetres and a focal length of 67 centimetres. It is provided with a micrometer eye-piece with which the transit of a star can be recorded on a chronograph with almost no effect of personal equation.

All modern longitudes in the United States are determined by the radio method. Since the Naval Observatory time signals are used in deriving the time differences, the longitude differences are all referred to the centre of the clock room at the Observatory. The excellent time service maintained by the Observatory makes it possible to determine very accurate longitudes by this method. The probable error of a radio astronomical longitude seldom exceeds 0.02 second of time (o.3 second of arc), and usually averages less than 0.01 second of time.

During recent years the broken telescope transit has been used for latitude as well as for longitude determinations. It may be readily and quickly changed from a longitude to a latitude instrument by the substitution of another micrometer eye-piece and by the addition of sensitive levels to control the position of the telescope in altitude in the meridian. The Talcott method is used and the observations are made in practically the same

manner as with the zenith telescope formerly employed. A probable error in the result not to exceed 0.1 second is specified for latitude work and is ordinarily obtained.

In the early part of this paper, there are discussed two important reasons why astronomical observations are needed in geodetic surveys. Another important reason must not be overlooked, viz., the adoption of a geodetic datum for a country, although it may now be of only academic interest in a country such as the United States in which the horizontal control surveys are well advanced.

Before the geodetic latitudes and longitudes of the stations of a triangulation survey can be computed, the curvature of the mathematical spheroid which most nearly fits the earth must be determined, as already stated, but in addition the latitude and longitude of some starting station must be known or assumed. When geodetic surveys were first started in the United States, they were made first at the most important harbours along the coast and were in detached pieces, each piece being based on an astronomical determination of latitude and longitude at one of the stations. These separate schemes of triangulation were gradually expanded until finally they touched some of the adjacent schemes and then immediately difficulties arose. The deflections of the vertical at the various astronomical stations caused station errors of different amounts, and each piece of triangulation was, therefore, on a separate unrelated datum.

To remedy this condition, it was finally decided to adopt a single datum for the whole United States. At that time the triangulation of the east and west coasts of the country had been joined by the great 39th-parallel arc and there were several other long arcs included in the control net of the country. Astronomical observations had been made at a large number of the stations along these arcs, and it was desired to adopt such a position for some initial station of the scheme as to make the sum of the residuals (differences between the astronomical and geodetic positions) at these astronomical stations a minimum and yet to avoid, if possible, a recomputation of all the triangulation then in existence in this country. After a very careful study of the available data, a position was adopted in March, 1901, for a selected station in Kansas called Meades Ranch, and the resulting datum, identical with that previously in use in New England, was called the United States Standard datum. The reduction of 765 astronomical stations in 1909 showed that this datum approached very closely the ideal one for which the algebraic sum of the station errors of each class would be zero. The datum

has since been adopted by Canada and Mexico and is now called the North American datum.

When a datum is adopted for a country, the spheroid to be used as a basis for the computations must also be specified. In 1901, when the datum was adopted for the United States, Clarke's spheroid of 1866, as expressed in metres, was considered the best one then available, and it was therefore adopted. Although the new international standard spheroid, previously discussed, is somewhat more accurate than Clarke's, the difference between the two is too small to justify making a change.

North America now has the largest control survey in the world, all co-ordinated on a single datum. The same co-ordination is possible in the other continents of the world, although undoubtedly more difficult to bring about. If the control surveys of the several continents were each on a unified basis, it might be desirable for scientific purposes to put the triangulation of practically the whole world on a single datum by making a connection between the eastern and western hemispheres at Bering Strait. Such a connection is well within the realm of possibility.

Mention should be made of one more use for the results of geodetic astronomy. As explained in the early part of this paper, the deflection of the vertical at any point on the earth can be ascertained with reasonable accuracy by comparing astronomical and geodetic data. If the astronomical data are corrected for the attraction of topographic masses and for the effect of the isostatic compensation of these masses, a close agreement may be expected between the corrected astronomical vertical and the geodetic vertical. The agreement actually is fairly close but not perfect, and it has been found in many places in the United States that the lack of agreement is undoubtedly due to concealed geological structure which could not be taken into account in the isostatic reduction of the astronomical data. The residuals that are found after the isostatic corrections have been applied are, therefore, an indication of buried structure and as such have value in geological studies and possibly in the search for valuable mineral deposits.

In the preceding discussion the four most important uses of geodetic astronomy have been emphasized. These four uses are as follows: to serve as a basis for the determination of the shape and size of the earth, to control the azimuths of long arcs of triangulation, to make it possible to select the best starting point or datum for the control surveys of a country or a continent, and to

serve as an aid in geological studies. Triangulation is often spoken of as bearing a relationship to other surveys similar to the relationship of the steel frame work of a modern office building to its superstructure. May not geodetic astronomy be likened to the foundation of such a building? Without it the control surveys of a country could not have that wonderful precision and rigidity which make them of such great value as a basis for all other surveys and as an aid in some branches of science.

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ASTRONOMICAL LONGITUDES

The possibility of high accuracy in field astronomical determinations with the Bamberg broken-telescope transit is illustrated by the longitude results at a recent station in Iowa. Three determinations were made on two successive nights. The seconds of the final results for the three determinations are as follows: 21.137, 21.135, 21.131. The first and last determinations were made by one observer and the second one by another. Thirty-one stars were observed in all. The largest residual on a single star is 0.048 second. On one set of five stars the largest residual was 0.007 second.

Several factors have contributed to the excellency of these results which are fairly typical of many recent stations. First of all, much credit should be given to the Naval Observatory for their unexcelled time service which includes besides the transmission of the time signals, very careful time determinations to give scientific precision to these signals, and extraordinary care in time comparisons. The star places now published by that Observatory are undoubtedly greatly superior to what they were a few years ago.

Another factor is the instrumental equipment now available for field use, especially the Bamberg transit and the uniquely designed radio amplifier and recorder. The final factor is good observing in the field combined with careful handling of the instrumental equipment and close attention to innumerable details in setting up and adjusting the instruments. It is only when all of the factors mentioned above are uniformly good that results like those above can be obtained.

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HITCHING POSTS FOR THE FIXED STARS

The Survey now receives a new bi-monthly astronomical magazine called "The Telescope", published by the Bond Astronomical Club of Harvard. The December, 1934, number of this magazine contains a note under the above heading in which occurs the following paragraphs:

"Although from the beginning of civilization the stars to the unaided eye have appeared to occupy exactly the same positions, when careful measurements are made of their positions in the sky, slow and steady changes are noted. No star, no object, not even our own sun, is stationary; every celestial body is in -- what would be called terrestrially -- rapid motion, from a few miles per second for the slowest to tens of thousands of miles per second for the most rapid of which we have knowledge. Only the enormous distances of these bodies cause their motions to have but little effect upon their positions as seen by the earth-bound observer. Yet very careful measurements of their celestial coordinates at intervals of five to a hundred years do reveal slight changes and give the information on stellar motions that is so essential to the proper interpretation of the structure of the galaxy.

"To define these changes requires the use of stationary or nearly stationary points of reference. External galaxies, huge stellar aggregations hundreds of thousands of light years distant, provide such a set of points, for despite any exceedingly rapid motion through the cosmos they may possess, their distances are so great that they remain apparently fixed in position. Despite the fact that the nebulae present on the photographic plate images of considerable size, which creates difficulty in measuring the location of stars relative to their hazy centres, they furnish, nevertheless, one basis for the estimation of stellar motions."

It is quite remarkable that the great astronomical observatories of the world have been able to analyze the motions of the stars so precisely that an observer with a modern star catalog such as the American Ephemeris and Nautical Almanac published by the U. S. Naval Observatory, and with a portable field instrument can determine his so-called astronomical position on the surface of the earth with an error usually less than 25 feet. This is shown by the average probable errors obtained by the astronomical party of the U. S. Coast and Geodetic Survey during the latter half of the calendar year 1934. The average probable error of the longitude determinations at 25 stations is $\pm .01$ second of time, corresponding to about

12 feet on the earth. The latitudes have not all been computed as yet but the probable error will be about the same or slightly less than that for the longitudes. The azimuths at the same stations have a mean probable error of ± 0.28 seconds.

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STATION MARKS NOT DESCRIBED BY STANDARD NOTES

By Gale Murphy

In preparing descriptions of stations for publication, it has been necessary to pass over and slight a number of essential points of information. One of the reasons for this is the incomplete description of station marks which are not described by standard notes.

The exact geographic position of a point on the earth's surface is of value to an engineer only if he can positively identify it when he wishes to use it for his local surveys. The field parties of the Survey establish a great many stations, the descriptions of which are usually adequate enough to provide for their recovery; but a large number of stations and monuments of various other surveying organizations are recovered and tied in, the descriptions of which, in a great many instances, are decidedly inadequate.

The descriptions of stations marked by standard disks of the Survey is greatly simplified by the use of standard notes as given on page 108 of Special Publication No. 120, "Manual of First-Order Triangulation"; but these notes should not be used to attempt to describe special types of marks of other organizations. If a bronze or aluminum tablet of the U. S. Geological Survey is recovered, it should be described as such, together with the character of its setting; and a complete record of all letters and figures stamped on the tablet should be put on the description card. These stampings should be copied exactly as they appear on the tablet and should be put in quotation marks. In some states, the U. S. Geological Survey's work is done in cooperation with the state, and a special tablet which states this fact is used. Whenever this is the case, it should be so recorded on the description card.

A common cause of confusion in identifying positions of recovered stations is the fact that a reference mark was recovered instead of the true station. Unfortunately the

station and reference marks of some of the early stations were almost identical, but usually there was some slight difference in marking so that by careful inspection each mark might be properly identified. It should be remembered, however, that the local engineer does not have ready access to the detailed information by which he can recognize these differences, and it is, therefore, of the utmost importance when one of these stations is recovered that the recovery note states exactly what was recovered and its present condition. If we are to believe the records some station marks established prior to the use of bronze tablets have shown remarkable changes. Not only have they changed in shape and dimension, but also in composition. Granite monuments have frequently become marble, and limestone changes to cement with astonishing regularity. Stones which according to original notes were marked with cross lines when recovered have been marked with triangles, circles, or quite frequently not marked at all.

These discrepancies naturally raise the question as to which data should be published, the original description or the recovery note. Usually the practice in the Office has been to accept the recovery note as being correct. Cases have arisen, however, which showed, when later data were available, that this policy was sometimes the result of misplaced confidence.

The distances of stations from center lines of roads, fence corners, trees, buildings, and other nearby references will aid in their recovery, but it should be remembered that next year some or all of these points may be obliterated. In such a case, the recovery of a station would become largely a matter of luck and intelligent guesswork, but would be materially aided by the knowledge of exactly what kind of mark was being searched for. The exact dimensions, shape, material, and markings of old marks of the Survey and of county, state, and other public or private monuments should be given in sufficient detail to enable engineers to identify these points 25 years or more hence. In the case of irregular-shaped monuments, the exact spot used as the station should be stated.

A determined effort is being made by the Survey to encourage the local public and private engineer to use the triangulation stations of the Survey for his horizontal control. The movement is making progress, as evidenced by letters which are being received every day requesting information, but lack of confidence caused by discrepancies between data published as compiled from incomplete descriptions and actual conditions in the field may seriously

retard its further growth. Therefore, we in the Office who assemble these descriptions feel that we should have all the facts.

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ADDITIONAL INFORMATION TO BE ENTERED ON FORM 45

In order to expedite the computation of the orthometric correction, to facilitate the handling of information requests, and to make it unnecessary to have both descriptions and field computation in use by one person at the same time, in handling the above features of the work, it has become necessary to add certain information on Form 45, which has, in the past, not been required on that form.

A circular letter was sent to the Chiefs of all leveling parties, under date of December 18, 1934, which read in part, as follows:

In preparing field computations (Form 45) enter in "Remarks Column" the distance and direction from the nearest town opposite each permanent bench mark thus:

"Niobrara, 2.8 miles east of"
or "Niobrara, at"

The cooperation of all field officers in seeing that this additional information is entered on the forms will very greatly aid the members of the office force who are charged with handling computations, etc., after they are received from the field.

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INTEREST IN THE STATE SYSTEM OF PLANE COORDINATES

The following abstract of a letter to the Chief, Division of Geodesy, U. S. Coast and Geodetic Survey, is typical of the interest shown in the State System of Plane Coordinates by engineers throughout the country.

My dear Mr. Bowie:

I wish to thank your Division for the cooperation and information furnished me recently, and also to express my appreciation of your very courteous and interesting letter of Nov. 30th.

I have always been an enthusiastic advocate of relating all surveys to national datums, both horizontal and vertical, and it has been the policy of this bureau to do so whenever the control was available. Thanks to the recent activity of the U. S. Coast and Geodetic Survey, Richmond and vicinity now have an abundance of excellent control and it is already proving of inestimable value.

I was particularly interested and pleased to note in one of your recent publications (Plane Coordinate Systems, Serial No. 562) that you are advocating the establishment of plane coordinate systems on a comprehensive scale. It seems to me that this should be the ideal we should strive toward in providing an adequate, yet simplified, control to be of the greatest practical value to all engineers, whether engaged in private or public enterprises.

You may be interested in the fact that this Bureau has recently, in co-operation with the National Park Service and Civilian Conservation Corps, established first-order traverse control for a battlefield park area around Fort Harrison, about eight miles southeast of Richmond, and at present is establishing similar control for a national park in Chesterfield County, about fourteen miles southwest of Richmond. In each case the traverse was connected to triangulation stations whose geographic positions were transformed to plane coordinates referred to the City of Richmond's origin and meridian. Thus, we are already establishing the nucleus of a system for this vicinity.

* * *

Yours very truly,
(Signed) Geo. J. Parrish
Division Engineer of Surveys.

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THE FOURTH QUADRENNIAL CONGRESS ON PHOTOGRAMMETRY

PARIS Nov. 24., Dec. 2, 1934

By O. S. Reading

The formal opening of this congress at the Sorbonne was a bit of a surprise to one accustomed to the little attention mapping and photogrammetry receives in the United States. The ceremonies were conducted by the Air Minister and attended by the President of France. A military band played the Marseillaise as the officials came in and there was the usual blinking of photo flash lamps and arranging of broadcast microphones which accompany events which the press thinks of some importance.

There were 372 delegates from 32 countries registered at the Congress. The scientific papers were presented during sessions of six committees: Terrestrial photogrammetry; Aerial photography; Mapping from aerial photographs; Architectural, medical, crime detection and other applications; Instruction in photogrammetry; and Bibliography and vocabulary.

There was an excellent exhibit of cameras, photo-mapping machines and maps held in connection with the Congress. One could go from booth to booth and compare the leading machines. In general each country seems to be developing cameras and machines of its own, perhaps on account of possible military exigencies. But the international congresses seem to be forcing all of them to adopt and adapt the leading advantages of the others. Nearly all countries are now making multi-lens cameras and adapting the photo-mapping machines to their use. The photo-mapping machines are rather expensive, costing in this country, with our 45% duty, from forty to sixty thousand dollars. The output of each machine seems to be limited to eight to twelve sheets per year and the machines will probably become obsolete in five to ten years.

The nations of Europe seem to be much more map minded than the United States. All of the leading nations are making large scale maps of their countries and are convinced that they are improving their efficiency and saving money thereby, as well as preparing for national defense. Three times as many government maps are sold to the public per capita in England as in the United States.

One of the most interesting lessons from the European work was that suitable stereoscopes with wandering marks or grids would add considerably to the accuracy with which common points in pastures, forest, marshes, and similarly featureless areas could be identified on the photographs for the use of the radial line method as practiced in the United States.

It was the general opinion at the 1934 Congress that great progress had been made in instruments, methods and maps since the 1930 Congress. There was universal testimony that, not withstanding all its handicaps, photogrammetry has proven more economical and much more satisfactory than the older methods for all large mapping projects.

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LOCATING PROPERTY BOUNDARIES

By Professor S. S. Steinberg
University of Maryland

It is generally admitted that the widespread ownership of land is one of the important factors making for the stability and well-being of the nation. It is likewise generally known that boundary disputes between nations have frequently led to wars, and such disputes between private owners of property have led to ill-feeling, confusion, litigation and loss of money. Therefore, anything which contributes to the security of land tenure, reduces its costs and makes for cordial relations between neighbors, whether they be nations, states or individuals, merits careful and sympathetic consideration. Land being one of the most important things that the human race owns, it is essential that the custodian of a piece of property, whether public or private, should know where the boundary lines are.

Land surveying, the art of measuring land and of delineating its boundaries on a map, is generally supposed to have had its rise among the ancient Egyptians, due to the river Nile's destroying and confounding all their landmarks by its annual inundations. This put the Egyptians to the necessity of inventing methods and measures to enable them to distinguish and adjust the limits of their respective grounds when the waters were withdrawn. The Egyptians, in addition to being the first to measure the earth, likewise were the first to determine the relations between the heavenly bodies. Their knowledge of these matters was engraven on columns and by that means delivered to posterity. It is interesting to note that the modern engineer or surveyor makes astronomic observations for use in all important mapping as did his predecessor in early Egypt.

The present system of locating property boundaries is based on the belief that a point on the earth's surface can be perpetuated by placing on it some physical object for a marker. Many centuries ago the Egyptians learned the fallacy of that theory, but we still adhere to it. In a recent city improvement, a boundary monument of massive concrete was lifted out of the ground by a steam shovel even before the engineer could reach a tape to it to locate its former position. If a monument like this is impermanent, what hope is there of an enduring future for the stake, the pile of rocks or the blaze on a tree, which commonly mark farm boundaries?

It might be of interest to cite from an old deed the description of the starting point of a tract of land which read, "Beginning at a point on Powder Mill Run where Bill Jones killed the Indian." Needless to say, that corner could not be found. Also, there are many cases where excellent surveys have been of only temporary value because the surveyors making them left no permanent monuments.

There is nothing that causes more trouble to an owner of a piece of property than to have doubt raised as to the exact location of his land. He may wish to sell the land and give clear title to it, or he may wish to raise money on it. In either case he must be certain that the exact locations of his boundaries are known. His boundaries will be known if he has placed substantial monuments at their turns, setting the monuments in such a way that they are not likely to be disturbed by man or nature. A small amount of concrete, properly placed, will make an excellent mark, and to establish such a landmark will cost an insignificant amount compared with the cost of doing the survey work over again.

Landmarks have been the subject of legal action for thousands of years. Back in the time of Moses, in 1500 B.C., the laws protected survey monuments. One of these laws read: "Cursed be he that removeth his neighbors' landmarks, and all the people shall say Amen." Job, in speaking of the wrong-doing of his people, listed the removal of landmarks as one of the reprehensible acts they committed. Solomon, in his Proverbs, said, "Remove not the ancient landmarks which thy fathers have set."

In the United States, during Colonial times, with land plentiful and population very scarce, only the crudest kinds of surveys were made on the outlines of a grant from the King or the Colonial governor. After the Revolution, with the western area of the country opening up for settlement, a method of laying out the public lands in squares approximately one mile on a side was adopted. The land there was plentiful and it was not feasible to use exact surveying methods in establishing these township range and section lines. To have done this work in an exact way would have made the cost excessive as compared with the value of the land.

The early surveys were notoriously inaccurate. Practically all the surveying was done with the compass and the chain. Measurements of angles and of distance were made by methods that were crude and unreliable, and frequently no account was taken of the magnetic attraction

of the earth on the compass needle. Finally, it was the common practise not to close the circuit of the property boundaries. There are many deeds on record in which a description encircles the greater part of a tract and, having run to a spot somewhere in the vicinity of the starting point, closes with the charitable phrase, "and thence to the place of beginning."

Because of these inaccuracies, it has come to be the well-established court practise that the actual positions of the boundary marks on the ground, if they can be established with reasonable certainty, will control rather than the metes and bounds as given by the surveyor.

Conditions, however, have changed with the years, and land that was originally worth a few cents or a few dollars an acre may now be worth a hundred or even a thousand dollars an acre. In some of the large cities, lots are worth thousands of dollars a square foot. This increase in the value of land necessarily calls for an increase in the accuracy with which the boundaries of the land are surveyed. The engineer's transit and the steel tape have replaced the compass and the chain.

In addition to the thousands upon thousands of conflicting private property boundaries, there are scores of state boundaries in the United States which have been subject to controversies in the past or may at some future time require redetermination. It is a general legal principle that when a boundary is once accepted by the custodians of abutting properties, it is the boundary for all time to come. But the question arises: "How can a boundary be so located that it might be easily recovered in the future?"

An answer to this question is furnished by the Geodetic Control Surveys that were conducted in Maryland during the past winter under the auspices of the United States Coast and Geodetic Survey and in cooperation with the College of Engineering of the University of Maryland. Similar projects were undertaken in the other states. They were financed by the Civil Works Administration as a means of employment for engineers and for the performance of a work of great economic value to the people of the states. Some 420 Maryland engineers, surveyors and assistants, operating in all sections of the state, were engaged in establishing control lines and elevations which provide a basis for accurately tying in land surveys in the future. In addition these points serve as fundamental control for all engineering projects that might be undertaken in any community.

In conducting the control surveys the general practise is to follow the improved highways, since the aim is to establish points in places readily accessible. The monuments used are three-foot concrete posts which are set flush with the ground at the edge of the road right-of-way. The monuments set west of Frederick were four feet in length, due to lower frost line. The top of the monument has a bronze cap on which will eventually be stamped the number of the marker and its elevation above mean sea level. Monuments are set in pairs one quarter of a mile from each other, with each pair about two miles apart. They are established in every town on the circuit and at important crossroads, so that engineers will have these reliable points for referencing any survey or engineering project in that vicinity.

In establishing these monuments extreme accuracy of measurement is required. Distances are determined with a steel tape which has previously been compared with a master tape standardized by the National Bureau of Standards. The tape is stretched carefully between special chaining tripods, and in stretching it a spring balance is used at one end to make certain that the required tension is given. At the time of each tape measurement a thermometer reading is taken so that correction may later be made for increase or decrease in length of the tape due to temperature. All distances and elevations are determined to the nearest thousandth of a foot.

These control surveys have a real value to every owner of land, whether of a farm or a city lot, because a land survey which has been tied into such geodetic control is indestructible. Should every point of such a survey be lost or destroyed, the property boundaries can be retraced and the old points relocated. This is possible because the geodetic control is part of the triangulation network which has been established throughout the country by the United States Coast and Geodetic Survey in the past hundred years of its operation. Any survey so referenced becomes tied into the geography of the United States, and as there is only one point on the earth's surface that has a given latitude and longitude, that point can be recovered at any time in the future.

To facilitate surveying of counties and other local areas, computations have begun, as part of the Civil Works Administration project, on a system of referencing points in Maryland which will eventually permit coordination of land or engineering surveys in the state. At present at least three separate and unrelated groups of surveys are in use in Maryland; namely, those in Baltimore, in Annapolis and in suburban Washington. When the single coordinated

system for Maryland is fully computed it will be a comparatively simple matter to have these three different units referred to the state-wide system and thereby facilitate surveying operations between those three cities and, also, its extension to the remainder of the state.

It would be advantageous for each state to have a land court, in which all disputes over property boundaries could have a hearing. Since laws relating to the ownership of property are very complicated, it is reasonable to expect that such a court, concentrating on boundary matters, could render decisions more expeditiously than one not so expert. Massachusetts has had a land court for some years. There the law requires that private property boundaries be connected with the control system of the state. The township lines were definitely located and tied into the Coast and Geodetic Survey network and monuments were set upon these lines, thereby making them available in that state to any engineer or surveyor who undertakes a boundary survey.

One of the newest developments in land surveying is the use of the airplane for taking aerial photographs. With geodetic control monuments on the ground serving as a "yard-stick," maps can be constructed with little difficulty from the assembled photographs. This method, which speeds the work and reduces the cost, has been found very useful in locating boundaries of large tracts of land, in city planning and in mapping inaccessible areas. The land areas in Baltimore and in the vicinity of Annapolis have been surveyed from the air, and the resulting maps have been found extremely valuable in defining property boundaries and for many engineering purposes. By means of aerial photography in certain states, parcels of land have been discovered that were not previously listed on the books of the tax assessors.

All Europe, Mexico and many countries of South America have accepted geodetic control, and in those countries it serves as a foundation for all surveying, whether public or private.

As a result of the impetus given to this work last winter under the Civil Works Administration, it is hoped that sufficient funds will be forthcoming for the extension of this project in all the states to a point where geodetic control would become generally available for use by engineers and surveyors in their work, and particularly in so locating boundaries as to avoid over-lapping of adjacent properties. Boundaries that are connected with geodetic control are really tied to the stars; and, as the motions

of the heavenly bodies are immutable, so, by the use of this system, will property boundaries become definitely established for all time.

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REPORT ON INSPECTION OF LOCAL CONTROL SURVEY WORK

STATE OF SOUTH CAROLINA

By Albert J. Hoskinson, Lieut.,
Coast and Geodetic Survey

In accordance with instructions dated November 14, 1934, several days were spent in South Carolina during the month of December inspecting field work in the state and methods of computing the traverses of the Local Control Survey work. This work was started as a C.W.A. project and later taken over as a state relief project. Mr. T. C. Hamby, Consulting Engineer, has been in charge of the work from the start of the project. At present there are about 180 men employed on the work. About 4500 miles of second order traverse have been completed in the state to date and the position and elevation of about 6000 permanent monuments determined. The work has been well distributed over the entire state so that there is a rather complete network of traverse lines spaced from 10 to 30 miles apart. The unit cost of the present work is running about $40.00 per mile. The earlier work was somewhat more expensive so that the average cost per mile of the entire project will be nearer $50.00.

Reconnaissance and Monuments.

A rather careful reconnaissance of each line is made by a supervisory engineer before the monuments are set so that good locations are selected for the stations. All monuments are cast in place, the side walls of the earth hole being used as the form for the concrete mass except for about 12 inches at the top where a metal form is used to give a smooth, well shaped monument. A rich concrete mix with plenty of good crushed stone or gravel is used so that adequate strength is obtained in the structure. Bronze tablets of Coast and Geodetic Survey design are used as the center mark in all monuments. Trucks with large bodies are used by the monument party and most of the mixing of the concrete is done while the truck is in motion between the station locations, thus saving considerable time at each station. Adjacent monuments are intervisible, so that local engineers desiring to use them have a position and an azimuth for starting any local survey.

Chaining.

The chaining parties are well organized and are making very good progress, chaining from 3 to 5 miles per day in both directions. Most of the chaining is done on tripods, it having been found by experience that better checks were possible in this way than when the taping was done directly on a road surface or on the rails of a railroad. A very rigid light tripod has been constructed of wood and is giving excellent results. The legs are fastened rigidly to the head of the tripod and also to each other thus making a very rigid structure but one that is not adjustable. However, most of the taping is done on rather uniform grades so that no serious difficulty is encountered from the fact that the head of the tripod is not exactly level. The difference of elevation of the tripod heads for inclination corrections is determined by the use of a hand level, the levelman standing near the center of the tape in most cases so that short sights are possible and the forward and backward sights are balanced. The elevations of the monuments are determined by Wye Levels run in both directions and tied into first or second order lines wherever possible.

Horizontal Angles.

The angular measurements, to determine the directions of the traverse lines, are slightly behind the rest of the field work due to a shortage of instruments at the start of the work. However, very good progress is now being made by these parties and this phase of the work should soon be up to the rest of the survey work. Most of the work is being done with one-minute instruments, three sets of 6 D. and R. being taken at each station. Two 10-second instruments, which were borrowed from the University, have been available some of the time when not being used for instruction purposes at the University. The longer and controlling traverses where better accuracy was desired have been run with these instruments as far as possible. Good angular closures are being obtained on all of the traverses that have been computed to date. All angle parties are using a diamond shaped target of metal for the object to sight upon at the stations. These are very carefully centered over the mark by a light tripod or by a well braced center pole. A light portable tripod has been designed by the field parties to support the target and provides a rigid support as well as a very quick means of centering the target directly over the mark. The tripod and target can be set up in about half of the time required to center and brace a center pole with target attached.

Computations, Descriptions, and Closures.

Most of the work to date has been computed by the geodetic method but all future work will be computed using the Lambert system of plane coordinates as laid out for the State. All permanent monuments have been referenced to nearby objects as well as possible so that the location will be established and recovery easily made for future work. Adequate descriptions have been written for each mark on forms provided for that purpose. A satisfactory closure, within the limits for second-order accuracy, has been obtained for all of the traverses computed to date. Some of the earlier field work had to be rechained to locate blunders that occurred before the parties were well organized.

The work in South Carolina has been very well laid out and executed, and at the present time lines of traverse have been run over nearly all of the hard surface highways of the State. These lines are spaced from 10 to 30 miles apart. To complete the second-order work with a spacing of 5 to 7 miles about 5000 to 7000 additional miles of traverse will be required. The spacing of 5 to 7 miles furnishes all of the second-order control required in any area for topographic or general mapping purposes for either plane table or air-photo methods, and also furnishes the permanent control for subdivision work such as: County and municipal boundaries, parks and recreation centers, flood control and sanitary districts, townships, school districts and other subdivisions for political or taxation purposes. When the second-order control areas are further divided by third-order work spaced about 2 miles apart, there will then be adequate control for all local surveys and for farm and local real estate boundaries.

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SOME REMARKS ABOUT REJECTIONS FOR HORIZONTAL ANGLE OBSERVATIONS

By J. A. Duerksen

A few years ago the Division of Geodesy adopted an arbitrary rejection limit of 4 seconds from the mean, for first-order horizontal angle measurements with a first-order theodolite. This limit of rejection seems to be a very reasonable limit, especially in the light of the recent circle tests made by Lieut. H. C. Warwick and other experienced observers. The method for analyzing these tests, recently developed by C. A. Whitten of this Office, showed that after eliminating the graduation errors of the circle,

the probable error of a single observation by a good experienced observer was of the order of 0".4, making two pointings direct and two reverse for each of the sixteen positions. This would indicate that the probable error of a single observation, making only one direct and one reverse pointing for each setting, would be of the order of ± 0".5 or ± 0".6. It was found, further, that the probable error of a single observation for standard practice and using a circle having graduation errors less than one second was about ± 0".8 or ± 0".9. This shows conclusively, according to the theory of least squares, that a value more than 4 seconds from the mean is a blunder and could not be classed as an accidental error, and, therefore, should be rejected.

But to use a four-second rejection limit for a circle having a maximum graduation error of two seconds is somewhat questionable. This point was brought up at the meeting of the American Geophysical Union last spring.

In computing the graduation errors of a circle, a mean position of the circle is taken in such a way that the sum of the graduation errors in the positive direction is equal to the sum of the graduation errors in the negative direction from the true value. So if the circle has a maximum graduation error of two seconds, (and this is the limit specified for a first-order circle), there is a certain part of the circle where the graduations are 2 seconds in error in either the positive or negative direction, and another part where the graduations tend to approach 2 seconds in error in the opposite direction. If the initial and the mark happen to fall on these two graduations, the measured horizontal angle will approach 3 seconds in error. Similarly, by using another part of the circle where the effect is in the opposite direction, the measured angle will tend to approach 3 seconds in error in the opposite direction. If there were no observational errors with such a circle, the circle errors would vary roughly between -3 and +3 seconds from the mean. Now it is impossible for any observer to make perfect observations. There are pointing errors on the initial and on the mark, atmospheric disturbances, errors in reading of the micrometer, etc. As stated before, the probable error of a single observation by a good experienced observer, using a circle having no graduation error larger than one second, is about ± 0".8 or ± 0".9. If the observer makes one second error on each of the two observations, which are about 3 seconds out already because of circle error, then there are three possibilities:

First, the v's (errors of observations from the mean) of each may be increased by one second, they will both be rejected, and the mean of the remaining 14 observations will still be about correct.

Second, both v's may be reduced by one second, no rejection will be made and the mean will still remain correct.

Third, one v may be increased and the other decreased by one second, then one will be rejected and the other will be retained, and the true measured angle is changed by 0".25. The above example is a very conservative one, because a probable error of 0".8 implies several errors of about 2 seconds and an average error of about 1 second.

Consequently, it seems to be erroneous and contrary to the theory of averages to use a 4-second rejection limit for any circle which has a maximum graduation error of 2 seconds, because it will mean that good acceptable observations will be rejected and some poor observations may be retained.

Theoretically, a good experienced observer should have on the average not more than about 1 rejection, and probably less, for every set of sixteen positions observed. If there are frequently 3, 4 or more rejections for a set of 16 positions, it would seem that there is a very strong indication that either the observer is not using sufficient care or that the circle is poorly graduated.

If the 4-second rejection limit is to be retained, it would seem to be no more than fair to the observer that the specifications for graduation of circles should be made more rigid, and the maximum allowable graduation error should be reduced to about 1-1/4" instead of 2". Otherwise, the observer will frequently introduce an error into his angle observations by rejecting a good position, which should have been retained to compensate for graduation error in another part of the circle.

Discussion by Captain William Bowie, Chief, Division of Geodesy.

I have read with a great deal of interest the article entitled, "Some Remarks about Rejections for Horizontal Angle Observations."

It is quite evident that there should be a rejection limit for each theodolite or each group of theodolites. Where the circle graduations are of the highest degree of perfection and the graduation error is less than one second, a rejection limit of 4 seconds is reasonable. On the other hand if the errors of the circle are as great as 2 seconds or more then a higher rejection limit should be prescribed.

There are two kinds of errors in the graduation of a circle, - one the accidental error of the spacing of the contiguous marks and the other, the systematic error. A large section of the circle will have errors of one sign while perhaps the opposite side of the circle will have errors of the opposite sign. In addition, the graduations may be made on an elipse instead of a circle. In each of the latter two cases the reading of the microscope spaced 180 degrees apart will tend to eliminate the effects of the errors in graduation. It is possible that the field records for the different theodolites could be analyzed and the degree of excellence of the circle determined. Should this be done the rejection limit that would be reasonable could be determined for each instrument.

We may, however, arrive at a reasonable solution by merely having the observers keep track of the number of rejections for each direction for a large number of stations. If only occasionally a position has to be rejected on the 4-second limit then we may assume that the limit is a reasonable one. If, on the other hand, there are several rejections for each one of the directions then the error limit for rejections should be raised or the circle should be re-graduated.

The Bureau of Standards is now re-graduating circles for us and is doing its work well. I should like every circle that is not high grade to be re-graduated.

Where a circle is poor it is rather dangerous to leave a station with only 10 or 12 positions observed. There is always certain to be a characteristic error for each 4 positions of the 16. Unless we observe all of the 16 positions around a circle there would be an error introduced into the observations that were actually made. The instructions now permit the observer to leave the station and consider it completed if he has as many as 10 positions. This procedure would be one of doubtful expediency if the instrument used had a poor circle.

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CIRCLE GRADUATIONS

In Geodetic Letter No. 1, Vol. 2, there appeared an article entitled "Notes from the U. S. Bureau of Standards".

The Bureau of Standards has finished and delivered to us 40 circles. These circles with only one exception, which was later corrected, have been well within the acceptable limits of accuracy. Tests and comprehensive analysis show that the graduations of these circles are far superior to those of other circles, graduated by foreign commercial instrument makers, which the Coast Survey has been using in recent years. Furthermore the graduating of the circles seems to be improving all the time. Those more recently received are superior to the first. In fact the 6-1/2 inch second-order circles recently received are graduated to an accuracy well within the limits of the first-order circles. This naturally leads us to believe that eventually our instruments will be smaller, lighter, and more compact.

The credit for these increasingly more accurate graduated circles is largely due to the unceasing, tireless efforts, research and study of Dr. L. V. Judson and Mr. B. L. Page of the Bureau of Standards. The whole hearted co-operation shown by these gentlemen is greatly appreciated.

Three circles from some of our older second-order instruments with inferior graduations have been sent to the bureau for regraduation. It is hoped that when these circles are returned and installed in their instruments that it will be possible to produce first-order results with them. This will enable the Office to replace some of the large twelve-inch instruments now in use in the field with these smaller instruments. Whereas both Dr. Judson and Mr. Page were reluctant to say whether or not the regraduation of these old circles would be successful, due to a combination of circumstances, they were willing to attempt the work, and it is quite certain that their best efforts will be put forward to produce circles up to their present standard of accuracy.

It is the purpose of this Bureau to continually strive to improve our instrumental equipment and it is with this in mind that many replacements of circles have been made in our theodolites. Comment from the field is invited in regard to the accuracy of these new circles under field conditions.

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BANKER FACILITATED GEODETIC SURVEYS

During recent years one of the triangulation parties operating in the southern states and in the middle west encountered considerable difficulty in cashing U. S. Treasurer's checks without the payment of exchange as was required by the local Banking Association. In an effort to clarify this trouble the chief of party called on one of the bankers in the area in which his party was operating and after some discussion of the question at hand, found that this banker was very much interested in the surveying work that was being carried on. He was invited to accompany one of the observing parties to a station, and at the appointed time he appeared with a large basket full of fine melons. After the observations were completed the entire observing party enjoyed these melons, and also had a very interesting discussion with the banker on control surveys in his locality.

It was quite a surprise to the chief of party to find out that this banker was so interested in the technical details and the results of the work. He proved to be a great friend, and when the party left the town this banker furnished the chief of party with letters of introduction to a number of prominent bankers along the proposed route which practically eliminated the check-cashing troubles experienced in the past.

In using these letters of introduction the chief of party was further surprised to find that almost all of the bankers he met were similarly interested in the surveying operations.

This incident is mentioned as a possible source of help to other chiefs of parties in similar difficulties.

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LOCATING THE WASHINGTON MONUMENT

On November 19, 1934, work was begun to permanently and accurately locate the Washington Monument, latitudinally and longitudinally speaking. A triangulation party in charge of Lieut. John Bowie, Jr., taking advantage of the scaffolding erected around the Monument for the purpose of repairing and cleaning it, ascended to the 500-foot level in the scaffolding-elevator and then climbed by ladder the additional 55 feet to the wind swept top of the monument. Here they set up their theodolite and proceeded

to observe and record the various angles to other triangulation stations by means of which the position of the monument might be computed. Directions were also taken to various prominent structures such as the Capitol, church spires, etc., in order that they, too, might be located.

These records were then submitted to the triangulation section of the Division of Geodesy where the final computations were made. As a result the position of the Monument is now determined to be exactly 38° 53' 21".681 in latitude and 77° 02' 07".955 in longitude and no longer need be referred to merely as being near 15th Street and Constitution Avenue, N.W.

The historic structure now takes its place in the national network of triangulation stations which covers the United States.

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ADJUSTMENT OF MISSISSIPPI RIVER TRIANGULATION

The Army Engineers have detailed several computers to the Coast and Geodetic Survey for the purpose of making a readjustment of the triangulation along the Mississippi River. This work is being done under the supervision of experienced mathematicians of the Coast and Geodetic Survey. A few years ago a first-order scheme of triangulation was run by Lieut. H. W. Hemple from New Orleans, La., to St. Paul, Minn. This arc and the more recent arc from New Orleans to the Delta by Lieut. C. I. Aslakson, have been used as control for the readjustment of the older second and third-order triangulation and traverse by the Coast and Geodetic Survey, the Mississippi River Commission and the United States Lake Survey.

The work from the headwaters of the Mississippi River to Cairo, Ill., was readjusted first. Three thousand nine hundred second-order triangulation stations and third-order traverse stations were computed in this area. One traverse line of about 150 miles in length was adjusted with a maximum correction of 0.3 second to an angle. The control was exceptionally good. Most of the connections to the first-order work were by triangulation ties.

From Cairo, Ill., to Memphis, Tenn., there were two second-order and one third-order triangulation arcs. This set contained 1,750 positions. The control stations were

connected by traverse to the first-order triangulation. The traverse connections did not have the close agreement that was found on the upper part of the river. A number of these traverse ties had to be rejected.

The third part of the adjustment was from Memphis, Tenn., to Vicksburg, Miss. The same conditions existed here that were found in the second part. Three thousand five hundred positions were required to cover this area.

The fourth section yet to be adjusted runs from Vicksburg to New Orleans. The third-order scheme stops at Donaldsonville. About 3,500 stations cover this area.

The fifth section from New Orleans to the Delta has the 1934 arc for control. The old triangulation is all Coast and Geodetic Survey work from 1858 to 1922. This part is complex, having different arcs over the same area in places. About 1,000 stations will have to be adjusted.

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GUATEMALA - HONDURAS BOUNDARY SURVEY

Lieut. J. P. Lushene has been detailed to duty in cooperation with the Guatemala-Honduras Boundary Commission for the purpose of extending first-order triangulation and making astronomical observations along the boundary between these two countries, which is being settled through a commission appointed for that particular purpose. The Chief Engineer of the Commission is Mr. Sidney H. Birdseye, who has made the reconnaissance for all of the triangulation, extended some second-order work and measured two bases along the boundary. He will also have the triangulation stations prepared for occupation by the party of Lieut. Lushene.

Lieut. Lushene will be assisted by Mr. Philip L. Welker, at present a computer in the Division of Geodesy. Instruments for the work are being loaned by the Coast and Geodetic Survey and it is expected that Lieut. Lushene and Mr. Welker, by operating two observing parties, will be able to complete the total arc along the Guatemala-Honduras Boundary, consisting of some 40 stations, in about two months' time. The triangulation is controlled by two bases located reasonably near the ends of the triangulation. There will be at least one astronomical station at which latitude, longitude and azimuth observations will be made.

The party plans to complete field work during the winter months of January, February and March, which is the dry season and the only time of the year suitable for observations in the mountains of that region.

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GRAVITY SURVEY

During the past several years the U. S. Coast and Geodetic Survey has cooperated with Government officials, scientific organizations and private agencies in extending gravity observations in the southeastern section of the United States and on outlying islands nearby as a means of obtaining a more complete gravity survey of that region. Gravity observations are becoming increasingly more valuable and are used not only for isostatic investigations but also for the location of inequalities in the crust of the earth, and in the study of surface structure and geology, particularly with respect to the search for oil. This winter the party of Mr. H. E. McConnell has been assigned to about three months work on the island of Cuba in cooperation with the Atlantic Refining Company of Cuba and with the Committee on Ocean Basins and Their Margins of the National Research Council, of which Dr. Richard M. Field is Chairman. During the three months in Cuba it is expected that Mr. McConnell will determine gravity at some 80 stations. This is the second Cuban gravity expedition and when completed will provide approximately 150 gravity stations well distributed over the island.

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UMBRELLAS

Mr. S. Y. Symns, Surveyor, offers the following comments in discussing the article on instrument covers and umbrellas in Geodetic Letter No. 10.

"Much has been said about the umbrellas in use at this time. From my experience it seems to me that Lieut. G. R. Fish has very accurately covered the subject in Geodetic Letter No. 10.

"The cost of an umbrella or two is quite often a small item compared to the cost of time that is lost by the observing party during the day when they have to stop and repair the umbrella. I have an umbrella frame which was sent out from the Office in January 1933 and was used

in the field for more than a year without causing any loss of time. The frame is in excellent condition now but the covers on the present umbrellas are too small to fit it. I think umbrellas of this type are a better investment than the $2.11 variety.

"The life of the present umbrellas can be increased from two to three times by lowering the catch on the pole from 1-1/2 to 2-1/2 inches. This will decrease the strain on the clevis on the outer end of the spreaders, which seems to be the weakest point in the structure."

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DEATH OF PROFESSOR GEORGE LEONARD HOSMER

Readers of the Geodetic Letter will regret to learn that Professor George L. Hosmer a member of the civil engineering department of the Massachusetts Institute of Technology for 37 years until his retirement last October, died at his home in Woburn, Massachusetts, January 10, 1935.

Professor Hosmer had a wide variety of scientific interests but he was best known to members of the Survey through his work in surveying and geodesy.

As a member of the American Society of Civil Engineers he took an active part in the formation of the Division of Surveying and Mapping being, at the time of his death, a member of the Executive Committee of the Division.

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NOTICE

The attention of all personnel is called to Paragraph 16a of "Regulations and Instructions of the Coast and Geodetic Survey":

"All official mail from any officer or employee in the field or any field station addressed to the Director shall be forwarded through the chief of party, or officer in charge of field station, as the case may be, or from any officer or employee in the office through the chief of division, and all communications thus forwarded shall be so noted upon their face with indorsement of approval or disapproval or other recommendation, with signature and date."

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REPORT OF PROGRESS

Triangulation:

Lineal miles of triangulation through axis of schemes completed during November, 1934:

First-order - - - - - - - - - - - - - - - -	1,281
Second-order - - - - - - - - - - - - - - - -	-----

Total miles of triangulation completed to November 30, 1934:

First-order - - - - - - - - - - - - - - - -	51,824
Second-order - - - - - - - - - - - - - - - -	3,321

Levels:

Lineal miles of levels completed in November 1934:

First-order - - - - - - - - - - - - - - - -	593
Second-order - - - - - - - - - - - - - - - -	11,860

Total miles of levels completed to November 30, 1934:

First-order - - - - - - - - - - - - - - - -	99,300
Second-order - - - - - - - - - - - - - - - -	82,470

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