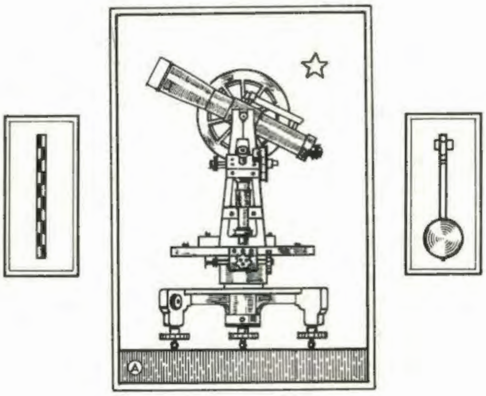
Gaithersburg Obs. See page 1-10

GEODETIC LETTER



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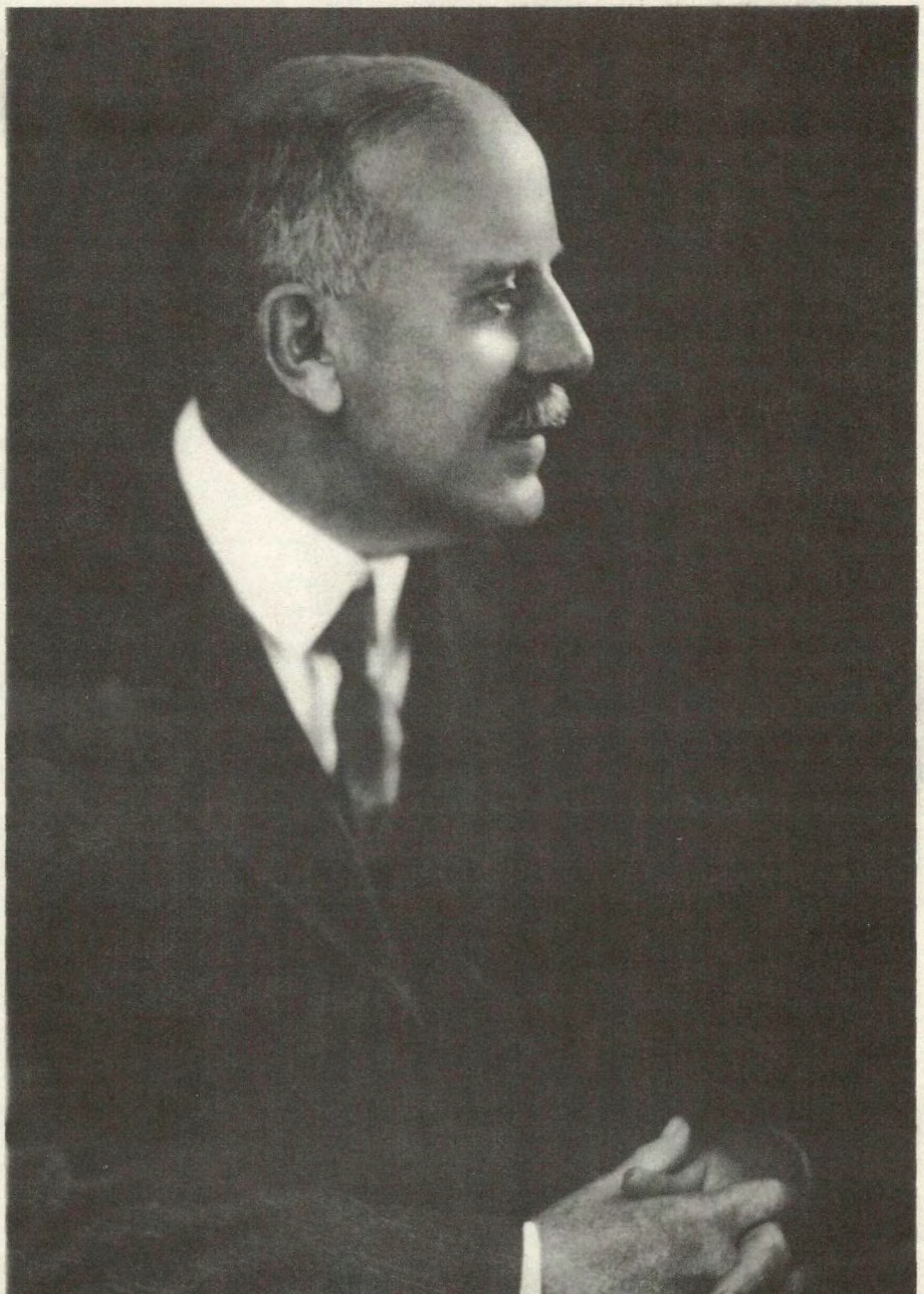

DR. WILLIAM BOWIE

Frontis-

Group attending the opening of the triennial conference of the International Union of Geodesy and Geophysics in Edinburgh, Scotland, September 17, 1936. Front row: Dr. William Bowie, president of the Union; Lord Provost Gumley; Principal Sir Thomas Holland. Back row: Brigadier H. St.J. L. Winterbotham; Sir William Bragg, president of the Royal Society; Professor Chapman, and Professor D'Arcy Thomson.

DR. WILLIAM BOWIE

Dr. William Bowie, Chief of the Division of Geodesy of the Commerce Department's U. S. Coast and Geodetic Survey, was signally honored by the University of Edinburgh on September 17, when the degree of Doctor of Laws was conferred upon him. The Vice-Chancellor of the University who conferred the degree, stated that Dr. Bowie was "best known and greatly respected for his development of the theory -- one might say, now, established fact -- of isostasy." He also expressed his admiration of the scientific work done by the United States Coast and Geodetic Survey.

Dr. Bowie is President of the International Union of Geodesy and Geophysics and is now attending the triennial meeting of that organization in Edinburgh, Scotland. On September 10, Dr. Bowie addressed the physics section of the British Association for the Advancement of Science on the subject "Isostasy" and on September 14, he addressed the section of geography of the same association on the subject "The Need for Maps." On September 17, he made the opening address at the Edinburgh meeting of the International Union of Geodesy and Geophysics.

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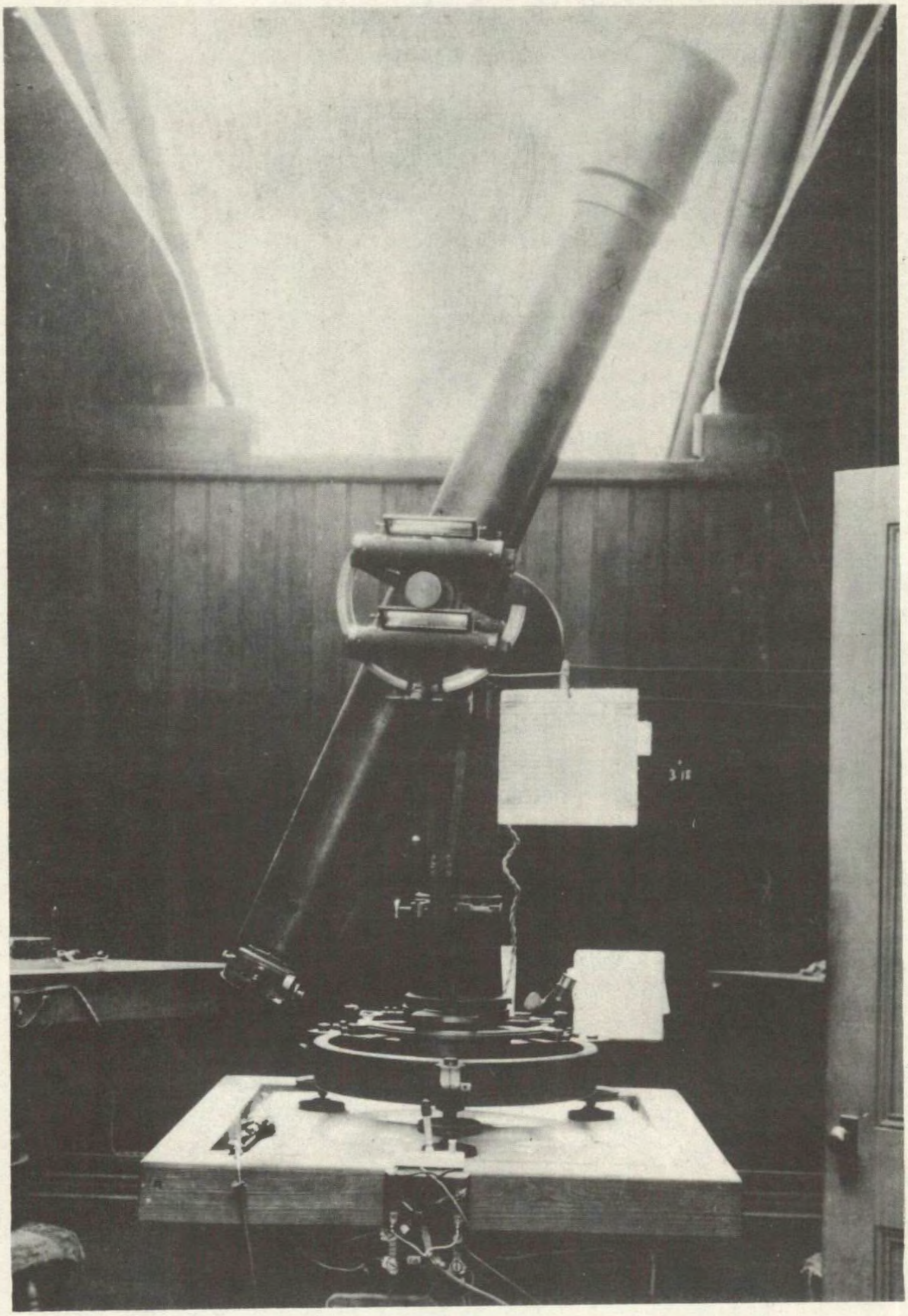


Zenith telescope in use at the observatory, Ukiah, Calif., showing latitude levels.

GEODETIC LETTER

September, 1936

WHO SHOT THOSE PEAS?

W. D. Lambert

The traveler, who from the present city of Washington follows westward the road taken by George Washington and General Braddock before the latter's disastrous defeat by the Indians, may notice just after he enters the town of Gaithersburg, Maryland, a cinder side road coming into the main road from the left. This side road soon becomes a lane leading through a gate to the grounds of the Federal Latitude Observatory at Gaithersburg. The pictures show views of the observatory and surroundings, including the observer's house. There is certainly nothing pretentious or grandiose about them.

In the fancy of the layman -- or the comic strip artist -- the astronomer figures perhaps as an elderly man with long whiskers who spends his nights, eye glued to his telescope, watching the stars go through evolutions like dancers in a ballet. As a matter of cold fact, the astronomer usually spends more time in laborious numerical calculation than in observation and he may indeed look at the stars just enough to orient correctly the photographic apparatus that takes a picture as it follows the stars. He may thus work at second hand from the images on the photographic plate rather than from a direct view of the stars themselves.

The latitude observer at Gaithersburg -- except for the age and the whiskers -- comes nearer than the average astronomer to the figures of the comic strips, for he spends most of the night in observing visually, not photographically, and has comparatively little calculation to do. However, his facilities for viewing the celestial ballet are limited, for his instrument does not range all over the heavens but is narrowly confined to the meridian and his program of observation is made up with a single purpose in view, the study of the vagaries of the earth's axis, or as we generally say, of the wanderings of the pole of the earth.

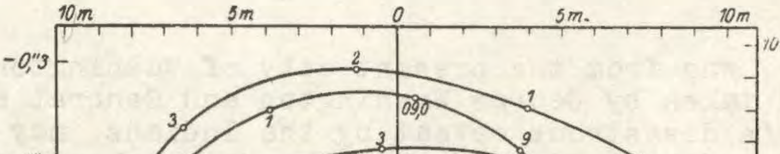


FIG. 1—Observed path of the Pole, 1900-1912. (Taken from Wanach.)

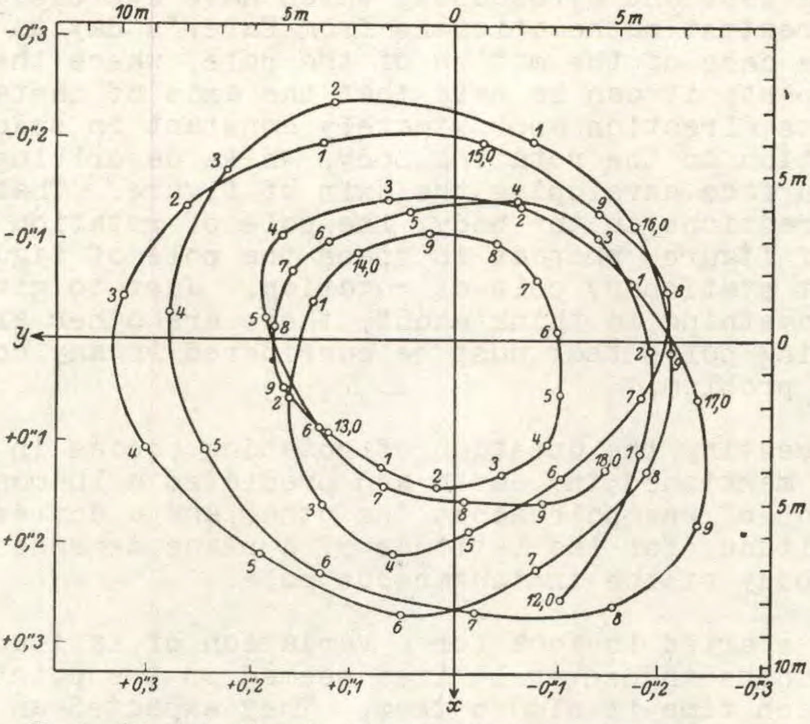


FIG. 2 —Observed path of the Pole, 1912-1918. (Taken from Wanach.)

The wandering of the pole is something that was discovered in theory long before it was actually observed; almost discovered that is; for one part of the theory was incomplete in failing to take account of the physical properties of the earth and this incompleteness confused astronomers by leading them to look for something that did not exist. Often indeed, they really were watching the actual wandering of the pole but when the observed motion failed to conform to the theoretical type, they gave up in disgust.

One very simple remark is necessary before we talk about the wandering of the pole or of the axis of the earth. Every object has an axis of figure. For an approximately symmetrical body this statement is easy to accept but even an irregular body, say a chair and a misshapen chair at that, has an axis of figure, the position of which depends on the arrangement of the masses that go to make it up. Furthermore, any body may be set rotating about any axis, not necessarily the axis of figure, but it does not follow that it will continue to rotate about the same axis.

In fact, the great Swiss mathematician, Leonhard Euler, showed in 1765 that the axis of figure and the instantaneous axis of rotation, if not coincident, will not maintain the same relation to one another. The mathematical problem involved is allied to those of spinning tops and gyroscopes, which have exercised the ingenuity of the greatest mathematicians from Euler's day to the present time. In the case of the motion of the pole, where the two axes are not far apart, it can be said that the axis of instantaneous rotation keeps its direction approximately constant in space but not constant in relation to the rotating body, while describing in the body a conical surface enveloping the axis of figure. That is, if one considers directions in the body, the pole of rotation moves around the pole of figure, whereas in space the pole of figure moves around the almost stationary pole of rotation. Just to give the mathematicians something to think about, there are other axes and their corresponding poles that must be considered in any complete treatment of the problem.

Euler was treating the question of rotating bodies in general, but he specially mentioned the earth and predicted a 10-month period for the motion of one pole about the other and a corresponding variation of latitude, for the latitude of a place depends on the position in the body of the instantaneous pole.

Astronomers started to look for a variation of latitude with a period of 10 months and several times seemed on the point of detecting it but each time it eluded them. They expected an annual variation too, for the pole of figures is not absolutely constant because of changes in the distribution of mass having an annual period, such as changes in the seasonal load of ice and snow, seasonal barometric changes, etc. But so many things with which the astronomer has to deal have an annual period too and have not been determined with absolute precision that the astronomer was much more interested in changes of latitude in a period of 10 months than in possibly spurious changes with a period of a year.

Finally, in 1888, Küstner of Berlin, discussing observations he had made, concluded that there must be a real variation of latitude. The matter was clinched by simultaneous observations for latitude in 1891 at Berlin and other places in Europe and in Hawaii. In these latter, the Coast and Geodetic Survey participated. The longitude of Hawaii differs almost 180° from that of central Europe. It was found that when latitudes in Europe increased those in Hawaii decreased by about an equal amount and vice versa. The obvious indeed, the almost inevitable, explanation was that the latitude had changed because the pole had shifted in the body of the earth; as it shifted towards Europe the latitudes there increased and those in Hawaii decreased.

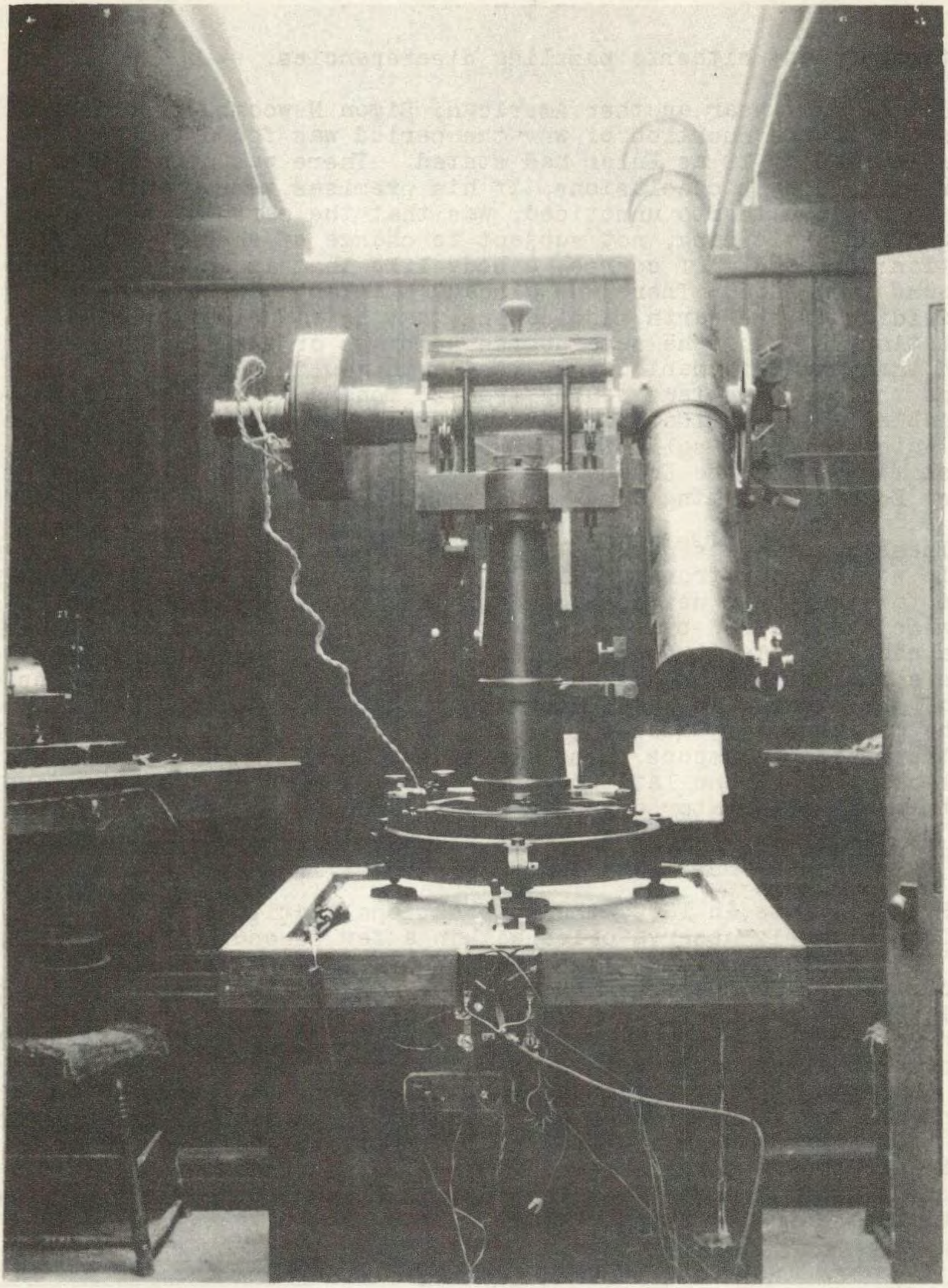
Meanwhile, S. C. Chandler of Cambridge, Mass., had been pursuing his investigations, rediscussing old observations as far back as the eighteenth century, with a view to detecting a variation of latitude, but without any preconceived idea as to possible periods of the phenomena. The next year (1892) he announced his discovery. A variation of latitude with two principal constituents, one having the year for its period and the other 14 months, was found to be the explanation of many hitherto puzzling discrepancies.

In the same year another American, Simon Newcomb, supplied the answer to the question of why the period was found to be 14 months instead of 10 as Euler had stated. There was nothing the matter with Euler's conclusions, if his premises were granted. A tacit premise, hitherto unnoticed, was that the earth is absolutely rigid and unyielding, not subject to change of shape by the application of force. Of course, a body like that is an abstraction, not found in nature. There was already available an estimate of the yielding of the earth, indicating that as a whole it resisted deformation in about the same degree as brass or steel. Newcomb showed that the deformability of the earth would lengthen the period and the observed lengthening from 10 months to 14 was perfectly reasonable. Part of the deformability comes from the fact that the ocean waters are not solid in any sense of the word and when the pole shifts -- and the Equator with it -- they tend to flow towards the new Equator, forming a new equatorial bulge.

These discoveries naturally aroused great interest in the scientific world and astronomers in different parts of the globe cooperated to study this new phenomenon. They found, however, that they were handicapped by the imperfections of their star catalogues. When a change of latitude was noted it was not always certain whether it was a real change or was due to small errors in the assumed position of the stars. The most accurate method of observing latitude and the one generally adopted, is the Horrebow-Talcott method, which uses the zenith telescope. The stars used depend on the latitude of the place. If all the latitude observatories were on the same parallel, then all observatories could use the same star program and it would be easier to disentangle real changes in latitude from spurious ones caused by small uncertainties in the star catalogues.

Finally, late in 1899, the International Latitude Service was organized with six observatories within a few seconds of the parallel of 39° 08' north latitude. Three of these stations were in the United States. Gaithersburg, Md., and Ukiah, Calif., were specially established after careful consideration of the particular sites chosen. The observatory of the University of Cincinnati happened to be on the chosen parallel and agreed to cooperate. The other three were in Mizusawa in Japan, Carloforte on a small island off the large island of Sardinia in the Mediterranean and Charjui* in Russian Turkestan. Now, as in 1900, the observations of the International Latitude Service are visual, though perhaps some day they will be photographic. The instrument used, the zenith telescope, is shown in the figure. It happens to be the instrument at Ukiah.

Note: * Spelled Tschardjui, in German, which needs the extra letters to transliterate the sounds of Russian characters according to the German pronunciation of the Roman alphabet.



Zenith telescope in use at observatory, Ukiah., Calif. Pier is protected from accidental disturbance by a wooden casing.

Of the six original observatories, Ukiah, Carloforte and Mizusawa, constituting a bare minimum of stations necessary to determine the displacement of the pole, have continued to function through all vicissitudes. As a measure of economy, Cincinnati and Gaithersburg were discontinued in 1914 and 1915. During the World War all trace was lost of Charjui but it was found that it had functioned until 1919. Once the station had to be moved a few miles because a river which was formerly several miles off, changed its course and threatened to undermine the observatory. Kitab, near Samarkand, was finally substituted for Charjui and in 1932 the Gaithersburg station was reopened, so now there are five stations on the parallel of 39° 08'.

There are also two stations on the same parallel in the Southern Hemisphere, La Plata in Argentina and Adelaide in Australia. Greenwich Observatory in England, the Naval Observatory in Washington and an observatory near Batavia in Java, though of course, not on the same parallel with any of the other stations nor with each other, are making special studies of the variation of latitude. Some of these use photographic instruments.

Observations from all these stations are sent into a central office to be reduced and discussed so that the observers, contrary to the practice of their brother astronomers, have comparatively little calculation to do. The first central office was at Potsdam, Germany, and was connected with the Prussian Geodetic Institute. After the World War it was moved to the latitude observatory at Mizusawa and since January of this year (1936), to a special organization with headquarters at the Observatory of Capodimonte, near Naples in Italy.

After hearing of all the trouble taken to determine the variation of latitude, the reader will probably suppose that the variation is large, large enough to "hit the observer in the eye", but it is not. The figure (page 2) shows the wandering of the pole from 1900 to 1912 and (page 3) for 1912 to 1918.* The entire wanderings of the

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Note *--The single figures like 1, 2, 3 indicate the positions for tenths of a year. What year it is must be determined by following backward or forward the continuous line representing the path of the pole till the last two figures of the year followed by the decimal zero are found. The general direction of motion is counterclockwise. For example, take the numbers 1, 2, 3 at the top of Figure 1 and follow backwards (clockwise); we come to the number 10,0 in the upper left hand corner of the figure. This means the beginning of 1910. Follow the line counterclockwise, taking care not to be diverted to adjacent lines representing the path for other years and we pass through 4, 5, 6, etc., till we come to 11,0 in the middle right hand edge of the figure. This represents the position for the beginning of 1911.

pole are contained in a square 20 meters (66 feet) on a side, as shown on the figure. In angular measure the extreme change of latitude ranges between $-0''.3$ and $+0''.3$ and is often much less. Why then all this fuss, and what have we found out by our thirty-five years of systematic study?

Chandler announced an annual period, which surprised no one, and a 14-month period, which Newcomb explained. That announcement had stood the test of time, but superposed on these regular motions are unaccountable irregularities. It is like the weather. In these latitudes, April is usually warmer than March, but not always. We can count on July as a whole being very much warmer than January, but by picking and choosing we may find a July day and a January day that are about alike in temperature. All attempts at long-range forecasting of the weather have failed and no more can we tell in advance just what the pole will do. The irregularities, the unexpected changes of amplitude and phase of the annual and 14-month motions, are such that we do not even yet know the exact length of the 14-month period, although it has repeated itself -- after a fashion -- some 30 times since 1900.

The 14-month oscillation is the free oscillation or oscillation in the natural period of the system. A swinging pendulum has its own natural period. Though the pendulum may be subject to transient disturbances, nevertheless, between disturbances it takes on its natural period. The pendulum or any oscillating system may be forced to move by external compulsion in any other period. This is called the period of forced oscillation. The annual part of the motion of the pole -- as far as the seasons of one year resemble those of another -- corresponds to a forced oscillation. The motion of the pole has been compared to the motion of a pendulum subjected to a forced oscillation but always tending, except as it may be disturbed, to oscillate in its natural period. These disturbances of the motion of the pole have been likened to the effect of peas shot at a pendulum by mischievous boys armed with pea shooters. We want to know: Who shoots those peas and when and how and why? The Elephant's Child which Kipling told of, was afflicted with a "'satiable curiosity", and so are we.

The unpredictability of the motion of the pole has been compared to the unpredictability of the weather. It is not pretended that the motion of the pole has the immediate and personal interest for each and every dweller on this terrestrial ball that the weather has. But the problem of the motion of the pole has many and various ramifications and is certainly of enough interest to warrant the small sum spent in studying it. Mention has already been made of the determination of the elastic properties of the earth from the prolongation of Euler's theoretical 10-month period into the observed 14-month period discovered by Chandler.

We can get a hold -- not so accurate -- on these same elastic properties by subjecting the observed latitudes to the same harmonic analysis that is used for the tides, for the latitude is affected by the tide-producing forces of the moon and sun and by the elastic properties of the earth as a whole.

Is the earth tri-axial? That is, is it more nearly an ellipsoid of three unequal axes than it is an ellipsoid of revolution, which has two of its axes equal? Some scientists contend for triaxility, both on the basis of gravity observations and on the basis of deflections of the vertical. A study of the variation of latitude may enable us to check their conclusions by different and entirely independent data. The answer to this question, whatever it may be, involves interesting consequences as to the physical properties of the earth.

Are the irregularities in the rotation of the earth, which some astronomers suspect to exist, connected with irregularities in the variation of latitude? Maybe both are caused by the same pea. What is the relation, if any, between frequency or intensity of earthquakes and the variation of latitude? Attempts have been made to trace such a connection. Again, perhaps both phenomena come from the impact of the same pea.

The geodesist observes latitude, longitude and azimuth. The motion of the pole affects all these, and to put all these determinations on a uniform basis it is necessary to reduce to some mean pole. The observations and calculations of the International Latitude Service, to which the observatories of Gaithersburg and Ukiah contribute, have recently put geodesists in a position to reduce their astronomical observations to a common basis.

Is the pole shifting progressively? Some geologists think that a large displacement of the pole would come in very handy in explaining the ice ages of the past and other geological phenomena. For a while it looked as if the average position of the pole were moving progressively towards the continent of North America but at a rate too slow to be of any use whatever in explaining the last ice age. Now even that progressive motion, small as it was, appears to have ceased, though there has been no very recent investigation of this particular point.

The variation of latitude does not concern only those who deal with the earth. The astronomer who is compiling a catalogue of stars must know the changes in his latitude and the International Latitude Service helps to answer this question. Moreover, the International Latitude Service uses stars taken from some recognized catalogue or catalogues. The observations for latitude contribute to the determination of systematic corrections to these catalogues. It is from the proper motions of the stars which are affected by these systematic corrections, that the astronomers try to answer the question, "Whither are we drifting?" This question has for the astronomer a wider import than when it is asked by the political orator. The astronomer means: Whither are the sun and all its attendant planets drifting? The observations of the International Latitude Service help to answer the question.

Thus, though the actual variation of latitude is a small matter, it ties in with many important geophysical questions, most of them not yet answered and contains mysteries enough to excite the curiosity even of those less inquisitive than the Elephant's Child.

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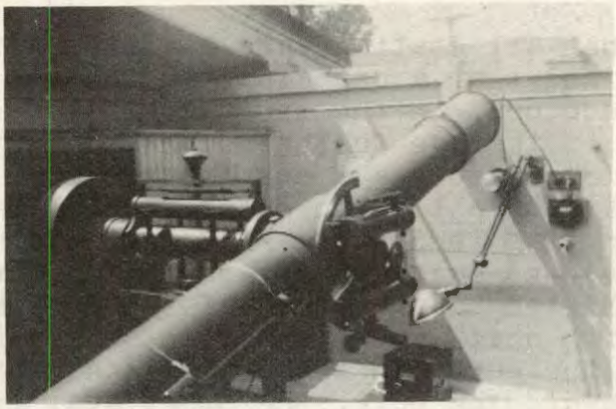
I LIVE AN UPSIDE-DOWN LIFE

Earl L. Williams

I am the variation-of-latitude observer at Gaithersburg, Md. As such it can hardly be said that I lead a normal existence. My outlook on life is largely "uplook" at stars. I work while the rest of the world sleeps, with only the mournful hoot of a distant owl or the incessant call of the whip-poor-will to keep me company. When the world begins to teem with activity I am just starting my slumber. One nice thing though, I can sleep into the day as far as I please. No raucous alarm clock disturbs my slumbers, calling me unwillingly to a workaday world. But I must begin my labors at the end of the day when others have given themselves to lighter things. Others work and then play; I violate this well-advocated precept by playing first and then working. Then, too, my meals are topsy-turvy, for I eat my breakfast at noon and often wind up the day by eating at three or four o'clock in the morning.

Although thousands of miles from it, I help keep track of the wanderings of the pole. But on a cold windy night in winter, I can tell you, I feel as if I were watching Mr. Pole's activities in person on the spot. In summer, though, it is quite pleasant, as I work during the coolest part of the day. Yet even at this season too, my equilibrium is often disturbed by some bounding insect bent on reaching his destination by the shortest possible path wholly regardless of the position of my nose.



Telescope at Gaithersburg, Md.

One might think that observing the same stars in the same manner night after night, would be a wholly monotonous affair. Many times, however, unusual things break in upon it. I often see brilliant meteors. My work has been interfered with twice by earthquake tremors which were still strong enough after traveling some 3000 miles, to rock the telescope foundation and cause the level bubbles to move to and fro. One night I discovered a fire burning on a distant farm and reported it.

My work is part of a program carried on by five stations, distributed more or less evenly in longitude around the earth and all quite closely on the same parallel of latitude. This work has for its purpose the continuous plotting of the position of the geographical pole on the surface of the earth. Or, for my station, to determine the angular distance from Gaithersburg to the pole. To do this, reference points not on the earth are necessary, so stars are employed. What I do is to observe how the earth's rotation on its axis causes certain stars to pass my zenith, all observations being taken when they cross the meridian. Variations in the star's passage, that is, in the distance from a star to the zenith, may be due to three causes; a motion of the star on the celestial sphere (called proper motion) due to the motion of the individual star through space, to a motion of the observer's station (the variation of latitude) or to a motion of the station and the axis together (precession of the equinoxes, nutation, etc.).

Our problem is to separate these various effects. Three observing stations are essential, and more are desirable for greater accuracy and for detecting any errors arising in a single station, such as errors which would result if that station were to be moved by earthquake or drifting land masses, or if for any reason its instrumental set-up should be unstable.

Let us assume that all stations are exactly on the same parallel of latitude and that a certain star tonight passes directly overhead of each one, in the zenith. If the star's own proper motion causes it to move to the southward on the celestial sphere it will be observed, say, one month hence, to pass to the south of the zenith by <u>all</u> of the stations. If, however, the earth shifts position with respect to an unmoved axis (unmoved with respect to space) and Gaithersburg shifts northward the star would again appear shifted to the south of the zenith of Gaithersburg, but such an earth shift would carry an observing station on the opposite side of the earth in the opposite direction (one side of the earth moves toward the pole, the other away from it) so that the star for the Japanese station would pass to the north, and not to the south of the Japanese station. A similar direction of shift takes place for all stars (after correction for individual star motions) at any given station, with an opposite direction of shift for all stars at a station located on the other side of the earth. Now in the case the earth's axis moves with respect to space carrying the earth along with it, the oppositely located stations will not only get oppositely directed shifts but there will also be an opposite direction of drift as between all stars in one section of the sky and stars on the opposite side of the sky as well, all stars not acting the same at any one station as in the case of station motion only (without axis motion).

Because of these differences, with the use of enough stations all observing the same stars under as nearly similar conditions as possible, it is possible to untangle the variation-of-latitude from other earth motions.

Of what value such knowledge is to us is discussed in another article in this issue entitled "Who Shot Those Peas?"

The meridian mark

The observer's home

Gaithersburg, Md.

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COMPUTATION OF A PLANE-COORDINATE TABLE FOR A ZONE ON THE LAMBERT GRID

- - -

Oscar S. Adams

(The adoption of the systems of plane coordinates as devised for the various states by the Coast and Geodetic Survey has brought several inquiries as to the utility and method of preparation of such tables as are discussed in the following articles. Since some of the states are on the Lambert Grid and others on the Mercator Grid, the methods to be used for each system present certain distinctions and are considered separately. Such tables have been, or are being prepared in Massachusetts and New Jersey, and it is our hope that as a result of the following articles, other states may become interested in such an undertaking.
--Editor.)

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The computation of the plane coordinates on one of the state grids from the geodetic position of a station would be much simplified if a table of the minute intersections of the meridians and parallels were computed and tabulated. Direct interpolation in such a table would give the coordinates with all required accuracy. Also the reduction of coordinates to geodetic positions could be made in the same way.

The reader is referred to the method of computing plane coordinates as illustrated in Special Publication No. 194, "Manual of Traverse Computation on the Lambert Grid." The form used is shown on page 3. The projection tables for the State of Nebraska used in the illustrative text for that publication are shown on pages 174 to 193, inclusive. Similar projection tables for other states are available from this office, upon requisition. These projection tables will be needed in the preparation of the contemplated table.

If a ten-bank calculating machine were available, the computation of such a table of intersections would not be a very great undertaking. If the central meridian is located in the exact center of the zone, it would be necessary to make the multiplications for only one side of the meridian since the y's at equal distances out from the central meridian are the same for any given parallel, and the x's differ only in that the x' value is added to the constant to the eastward and it is subtracted from the same to the westward.

In starting the work, a list of the natural sines of the θ angles should be made to ten places and thoroughly checked. Then a computation should be made for the formula $2 \sin^2 \frac{\theta}{2}$. It should be noted that half of the values of $\sin \frac{\theta}{2}$ are found in the list of sines already prepared; that is, the sine θ for one minute of longitude out from the central meridian is the $\sin \frac{\theta}{2}$ for two minutes of longitude from the central meridian and so on for the other values. In this way only half of the values of $\sin \frac{\theta}{2}$ would have to be taken anew from the table of natural sines. It would be well to make a list of the values of $\sin \frac{\theta}{2}$ and have it thoroughly checked before computing the list for $2 \sin^2 \frac{\theta}{2}$. This last list would be the one that would thereafter be used in the computations. After these two lists have been prepared the remainder of the work would consist in multiplying these values by the various radii that are listed in the state plane-coordinate table and the combination of these products with the proper constants. The x' values would have to be added to and subtracted from the constant of 2,000,000 in all states except Massachusetts and Connecticut in which 600,000 is used. The y'' values would have to be added to the y' values listed in the state table. The y' value is constant for any given parallel but changes from parallel to parallel.

In the actual computation, one man could manipulate the calculating machine and two recorders could tabulate the results, one east of the central meridian and the other west of the same. With this method of operation it would be best to set the value of sine θ on the machine and multiply by the successive radii of the parallels and then the same procedure for $2 \sin^2 \frac{\theta}{2}$. This would mean the computation and tabulation of the values up a given meridian with the longitude and hence the θ angle constant. In this way the x' values and the y'' values would change comparatively slowly and no trouble would occur due to a misplaced decimal point.

In cases where the central meridian is not located in the exact center, extra values would have to be computed for the one side that extends farther from the central meridian. These would then have to be tabulated only on the one side of the central meridian.

If calculating machines are not available, the computation would have to be made by use of logarithms. A list of the logarithms of the radii would have to be prepared and the lists of sine θ and $2 \sin^2 \frac{\theta}{2}$ would have to be prepared as logarithms also. The computation from that point would not be as rapid as with the natural functions. It is possible that the five minute intersections could be computed and tabulated and the remainder of the values computed by interpolation. The x coordinates could no doubt, be best interpolated along the parallel and the y values along the meridian. If second differences are used, there is no doubt that satisfactory results could be secured in this way.

With calculating machines it is believed better progress can be made by computing all of the values direct rather than by computing the five minute values and then interpolating. With the logarithms the difficulty lies in the fact that two logarithms have to be added and then the product obtained as the anti-log from the table.

It should be noted that such a table for a zone in a state would be no small affair. We have calculated that for Massachusetts 27,600 coordinate values would have to be tabulated. We figured that 40 minutes of latitude and 3 minutes of longitude would about fill a page. This would list 120 values per page or the complete table would fill 230 pages. The north-central zone of Texas would require more than 1000 pages for such a tabulation. This is probably the largest of any in the whole country.

Some states are making such a computation under the Works Progress Administration program. It is true that such a table would be very useful if it is once comouted and published in a usable form. Of course, the most desirable form would be an ordinary printed book but other less expensive methods of reproduction might be satisfactory. The photo-lithograph process such as used for the state tables published by this Bureau could be used with much less expense than would be required for a regular printed book.

After the table is completed, the whole of the work should be thoroughly checked by taking the differences and seeing that they run regularly as they should do in any accurate table.

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COMPUTATION OF A PLANE-COORDINATE TABLE FOR A ZONE ON THE TRANSVERSE MERCATOR GRID

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Oscar S. Adams

The reader is referred to the method of computing plane coordinates as illustrated in Special Publication No. 195, "Manual of Traverse Computation on the Transverse Mercator Grid". The form used is shown on page 7. The projection tables for the State of New York used in the illustrative text for that publication, are shown on pages 86 to 97, inclusive. Also, those for the State of New Jersey are given on pages 133 to 139, inclusive. Similar projection tables for other states are available from this office, upon requisition. These projection tables will be needed in the preparation of the contemplated table of minute intersections.

On this system of projection, the procedure is not as simple as we have found to be the case on the Lambert Grid. It is not possible to make such direct use of the calculating machines in the computations since all of the elements are given in terms of logarithms. The most rigid method for the preparation of such a table would consist of the direct computation of all of the minute intersections. This would entail much work and would therefore be almost prohibitive. Of course, many of the logarithms and factors would be used over and over so that when they are once taken from the table it would only require a recopying in the further work.

To get all the accuracy required, it would not be necessary to perform all of the computation indicated. It would be sufficient to compute certain values and then get the other values by interpolation. We have found the following scheme satisfactory for the work:

A computation of the even five-minute intersections of longitude on every even ten-minutes of latitude has been found to be sufficient for the work. With this scheme, all of the coordinates of the intersections can be found with an uncertainty not greater than two-hundredths of a foot. This uncertainty has no significance for practical work and can be tolerated in such a table. To get this result, it would be necessary to use second differences in the interpolation work. This does not require any great amount of computation if a calculating machine is available. The second difference would merely be multiplied by a small factor and then applied to the result of the application of the first difference.

In the scheme that we are outlining, the following table would give the interpolation along the parallel:

Let the first and second differences be donated by Δ_1 and Δ_2 , respectively. These Δ's must have their respective signs carefully determined. Then, to the starting value given by direct computation, we may derive the first, second, third and fourth value by adding algebraically the following computed quantities:

1. $1/5\,\Delta_1 - 0.08\,\Delta_2$
2. $2/5\,\Delta_1 - 0.12\,\Delta_2$
3. $3/5\,\Delta_1 - 0.12\,\Delta_2$
4. $4/5\,\Delta_1 - 0.08\,\Delta_2$

Then the process starts over using the second computed value as the basis to which we are to add algebraically the above values expressed in symbols. It is evident that the signs of Δ_1 and Δ_2 must be carefully preserved for these enter into the effect of the whole on the final values of the coordinates.

By this method all of the values along the ten-minute parallels can be obtained. The general layout of the whole table should be prepared beforehand so that these values can be entered in their proper places in the complete table. After this much of the work is completed, a set of differences can be made along any given meridian. By denoting these differences by the same symbols, we find the following nine additions to be applied to the starting value to obtain the nine intervening values.

1. $1/10\,\Delta_1 - 0.045\,\Delta_2$
2. $2/10\,\Delta_1 - 0.08\,\Delta_2$
3. $3/10\,\Delta_1 - 0.105\,\Delta_2$
4. $4/10\,\Delta_1 - 0.12\,\Delta_2$
5. $5/10\,\Delta_1 - 0.125\,\Delta_2$
6. $6/10\,\Delta_1 - 0.12\,\Delta_2$
7. $7/10\,\Delta_1 - 0.105\,\Delta_2$
8. $8/10\,\Delta_1 - 0.08\,\Delta_2$
9. $9/10\,\Delta_1 - 0.045\,\Delta_2$

Again the signs of the Δ's must be carefully noted so that the symbols may have their proper effect on the final coordinates. By applying this process to each meridian in succession, the whole table can be filled up with the proper values. As an additional check it might be desirable occasionally to compute directly some intermediate value to make sure that the interpolation has been properly made.

This gives an outline of the way in which such a table could be computed. In fact, a table for New Jersey is at present in process of computation and we understand that already much of it is completed. As in the case of a similar Lambert table, the complete work would be of considerable size. However, it would be useful in many ways and its computation would no doubt be justified by the aid that it would give in further computations.

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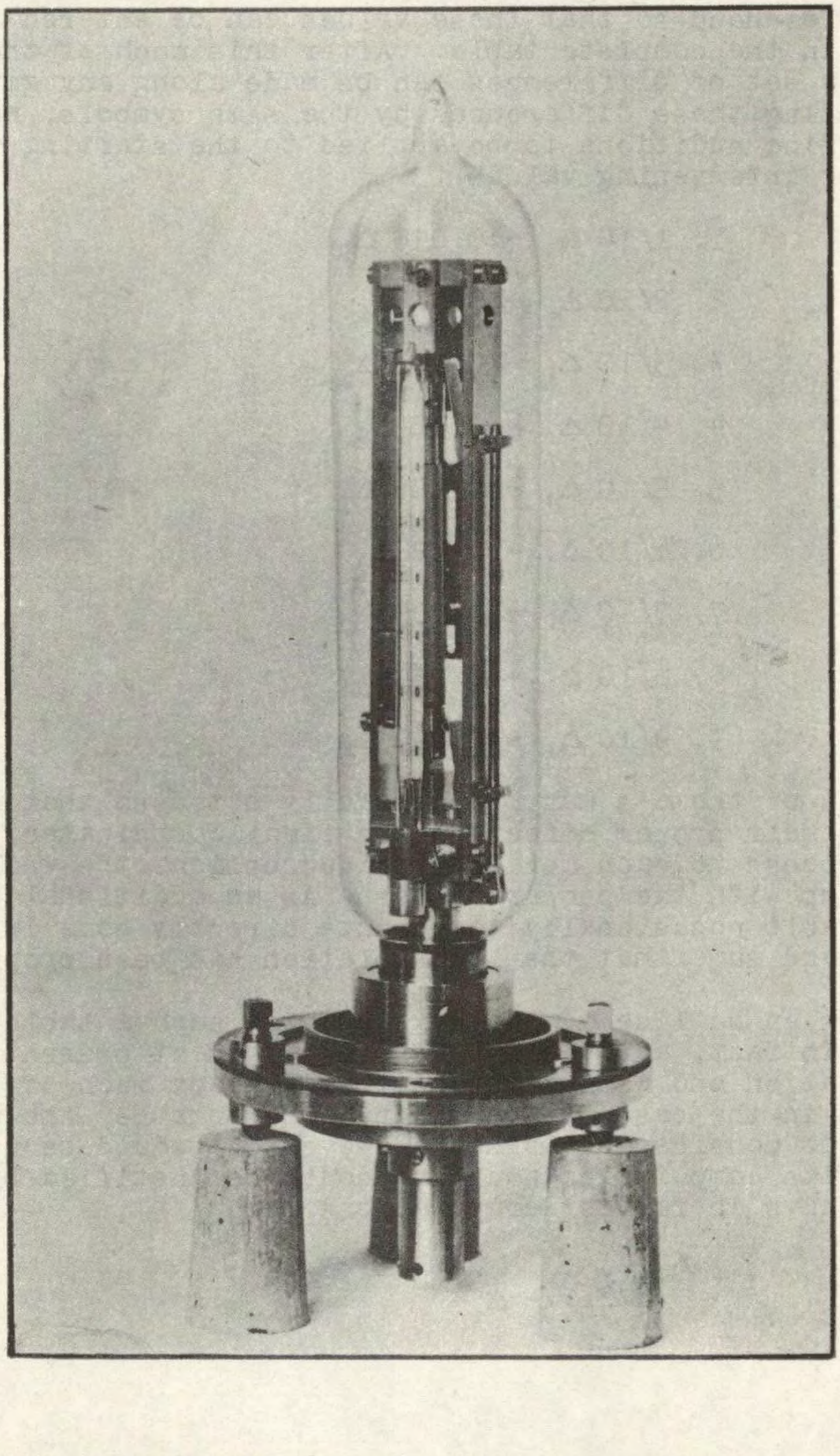

Holweck-Lejay gravimeter with protecting shield removed.

RECENT DEVELOPMENTS IN GRAVITY*

Albert J. Hoskinson

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Instruments

A few years ago a gravity anomaly was something which a specialized scientist used in determining the shape of the earth and in related studies, but today it has become one of the most useful tools in geophysical prospecting and in geological studies. A demand has thus been created for many additional gravity stations throughout the world and practically every major nation on the globe is today making gravity observations and doing research work to perfect instruments that will give more accurate results and at the same time do more rapid work.

The Coast and Geodetic Survey made a big step forward in 1932 when the new Brown instrument was put into operation. During the last year two new instruments of this type have been constructed and will be available for field work in the near future. Considerable research work has also been done to increase the accuracy of our recording devices, so that a shorter time interval might be used in making an observation. At the present time the pendulum is swung at each new station for a period of six hours, which gives a value of gravity with an accuracy of about one part in a million. We now have time intervals broadcast nearly every hour by the Naval Observatory which are accurate to about one thousandth of a second. It should, therefore, be possible, in theory at least, to get the same accuracy that we now obtain in a swing of two or three hours, providing we can perfect our recording instruments, so that they have an accuracy equal to or greater than the signals themselves. Our amplifier and receiving instruments have recently been redesigned and rebuilt so that we believe they have this accuracy, and test runs now being conducted in our laboratory will soon prove whether we have achieved this goal or not. If it is desired in the future to shorten the time of observation even more, then the most logical step is to compare two pendulums directly, one swinging at the base station and one at the field station. This can be done by putting the beats of one pendulum on the air and recording these against the beats of the other at the field station or more simply by recording each pendulum against some arbitrary signal such as a time signal. This system has been used quite extensively by some of the larger oil companies when the base station and the field stations were close together so that the two observers could talk directly with each other by short wave radio phones. I hope that we may be able to try out this system between some distant stations and our base station at Washington during the coming year. Up to the present time we have not had the necessary instrumental equipment for such experimental work.

The growing demand for gravity data has naturally caused the invention of many new types of gravity instruments that will measure changes in the gravitational attraction in a shorter interval of time than required for pendulum observations. Some of the more successful of the recent European gravimeters are the Holweck-Lejay, the Tyssen and the Haalck. In the United States we have the Wright instrument and one recently perfected by the Gulf Oil Company as well as many others, some of which are closely guarded secrets of the oil companies.

The Holweck-Lejay instrument is an inverted elastic pendulum which I will describe in more detail later. The Tyssen instrument is a spring instrument in which the lever arm of the mass increases with increased gravitational attraction.

The Haalck instrument may be called a static gravimeter in which the center of mass of a floating tube changes with gravitational changes thus causing the floater to stand at different levels. This instrument has been used quite successfully for both land and sea observations. The Wright instrument, as you probably know, is a coil spring instrument in which the angular deflection of a small mass is measured. The instrument of the Gulf Oil Company is also a coil spring type.

The Coast and Geodetic Survey selected the Holweck-Lejay as the most promising of the spring instruments, and purchased one late in 1935. About 1000 observations have been made with this instrument to date and the variations are considerably larger than we had expected, but the instrument which we received was extremely sensitive to temperature changes and also had a very poor thermometer inside the vacuum chamber so that some of the inaccuracies are no doubt caused by this imperfection in the construction of the instrument. We hope to have this difficulty remedied in the near future and then perhaps more reliable results may be obtained. This instrument has many of the desirable features of a modern gravity instrument. It is very portable, weighing less than ten pounds. The time of a single observation is about four minutes, and ten or fifteen such observations should give a good value of gravity at any locality. If the necessary accuracy can be obtained, then it should be a very successful instrument. Some of those present are no doubt quite familiar with the construction and operation of the instrument, but for the benefit of those who are not, I will describe it quite briefly. The instrument is an inverted elastic pendulum in which the mass moment of the pendulum is opposed by the restoring moment of a small spring. The pendulum is a rod of fused quartz 4 mm in diameter and 6 cm in length. The lower end of the quartz rod is fastened to the upper end of a small elinvar spring .02 mm in thickness, the lower end of the spring being fastened rigidly to the base of the vacuum chamber which surrounds the instrument. The entire vacuum chamber is about the size of a small radio tube.

It is obvious that the period of the pendulum and the sensitivity of the instrument to gravitational changes may be made, in theory at least, as great as desired, by making the mass moment and the restoring moment approach equality. The manufacturers found by experiment that a period of six or seven seconds for the pendulum was the most desirable one for practical use. This produces an instrument which is so sensitive to gravity changes that a change in the gravitational attraction of 1 milligal will cause a change in the period of the pendulum of .001 of a second. Thus if 100 oscillations of the pendulum are timed, the total time interval need not be more accurate than 1/10 of a second. This accuracy can easily be obtained with an accurate stop chronometer which is easily transported. The timing device furnished with the instrument may be read to hundredths of seconds which is quite satisfactory for the work required.

The pendulum apparatus is probably today the most dependable of the various types of gravity instruments but whether the apparatus of the future will be of this design or of the spring or static types or of some modification of either or both or whether some entirely new design will be perfected, only time will tell and the best that we can do is to try and improve and perfect our own instruments to the best of our abilities and hold an open mind regarding all new developments until they have been very thoroughly tested and either accepted or rejected. It must also be borne in mind that the problems of all organizations are not exactly the same. One may be interested in the small changes over a relatively small area while another may be more interested in the larger changes over an area of considerable extent. It is thus entirely possible that the instrument that is most satisfactory for one organization may not be the best for another whose aims are quite different.

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* NOTE: Paper read by Lieutenant A. J. Hoskinson before the Section of Geodesy of the American Geophysical Union at the April-May meeting, 1936.

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Triangulation party, Coast and Geodetic Survey, occupying top of Washington Monument, 4:00 p.m., Monday, November 19, 1934, access to which was obtained by using the scaffolding constructed to clean this historic structure. The theodolite is placed on a specially constructed stand over the apex as shown.
-World Wide Photos.

OUTLINE OF GENERAL QUALIFICATIONS AND DUTIES OF SEVERAL CLASSES OF EMPLOYEES OF THE DIVISION OF GEODESY OF THE U. S. COAST AND GEODETIC SURVEY

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C. D. Meaney

In response to many inquiries regarding the qualifications and duties of field employees of this Bureau, the following brief outline has been prepared to illustrate the training and experience required of surveyors, observers, rodmen, chainmen, truckdrivers and lightkeepers.

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A man in excellent physical condition who, according to reports on file in the Coast and Geodetic Survey, did entirely satisfactory work while employed in any of the classifications listed above, is eligible for emergency reemployment in the same classification.

Assistant Geodetic Engineer (Surveyor)

Minimum qualifications:

Training equivalent to that represented by graduation in engineering from a college or university of recognized standing, with major work in courses supporting civil engineering.

Not less than two years of postgraduate study which has involved the completion and preparation of reports on acceptable research work in some branch of civil engineering, or, not less than two years of successful experience on geodetic surveys of the grade and character required of a Junior Engineer (Observer).

Demonstrated aptitude and capacity for increasingly difficult and responsible assignments.

Interest in geodetic surveying.

Duties and responsibilities:

Under general supervision with limited latitude for independent or unreviewed action or decision.

To keep instruments in adjustment.

To be in charge of a subdivision of a field party executing geodetic surveys.

To execute second-order triangulation, primary traverse and primary levels.

To make observations for azimuth.

To make preliminary computations of triangulation, primary traverse and levels.

To assist in the preparation of notes and reports for publication.

To execute reconnaissance for triangulation.

Junior Geodetic Engineer (Observer)

Minimum qualifications of a new employee:

Training equivalent to that represented by graduation in engineering from a college or university of recognized standing with major work in courses supporting civil engineering; general knowledge of the fundamental principles of surveying, physics and mathematics and of the ordinary sources of general engineering information; ability to prepare field notes or data for plans and reports; familiarity with the use of drafting instruments, surveying instruments, and mathematical tables required; accuracy, alertness and adaptability.

Duties and responsibilities:

Under immediate supervision and with little opportunity for independent or unreviewed action or decision, to perform elementary professional work in investigation and development of geodetic surveying and related work as assigned.

To make simple control surveys as assigned by the chief of party.

In the office to assist in the computation of the data secured in the field.

To make observations for first- or second-order triangulation.

To observe with a first-order level.

Leveling party, Mauna Loa, Hawaiian Islands, 1926.

Rodman, Chainman, Truckdriver

In general, rodmen and chainmen are also required to drive trucks. Men whose major work is truckdriving are called upon to act as emergency rodmen or chainmen. Consequently, these positions are grouped.

Minimum qualifications of a new employee:

Excellent physical condition.

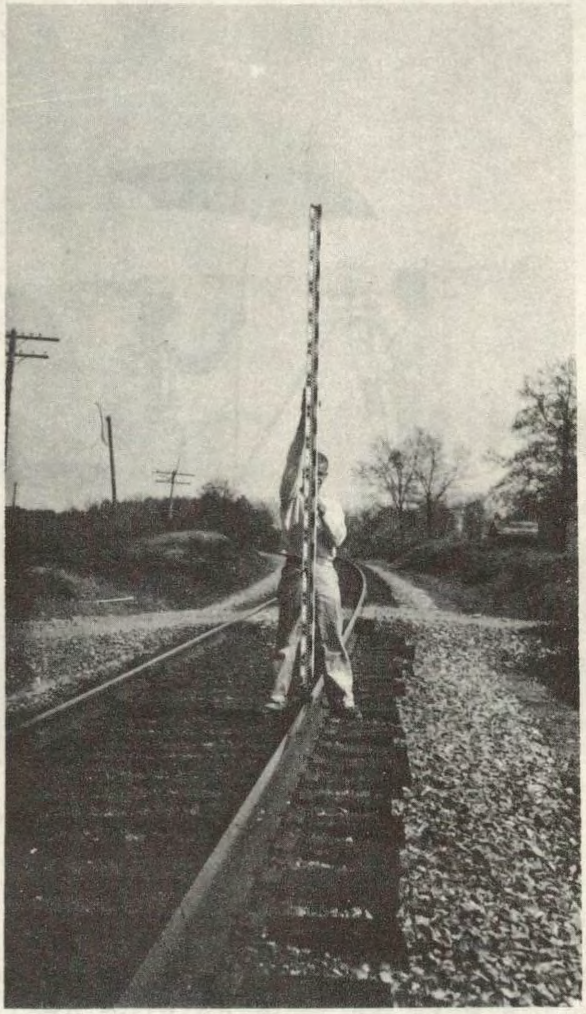
Equivalent of a high school education.

Interest in geodetic surveying.

Possession of automobile driver's license when required.

Duties and responsibilities:

The performance of routine tasks and related work as assigned under immediate supervision and following specific instructions as to methods and working details.



Rodman - Leveling

Type of work performed:

Driving and making minor repairs to trucks.

Acting as forward or rear chainman on a traverse party.

Aiding in the setting up and moving camp.

Acting as forward or rear rodman on a level party. (Rodmen walk more than ten miles during a day's work.)

Keeping level rods, tapes and other equipment in good condition.

Holding an umbrella so as to shade a level.

Moving and setting up a first-order level.

Observer and lightkeeper.

For purposes of demonstration the upper section of a steel tower was placed on the ground. Above the observer is a lightkeeper on the seat near the top of the outer structure operating a signal lamp.

Lightkeeper

Minimum qualifications of a new employee:

Excellent physical condition.

Equivalent of a high school education.

Knowledge of Morse code.

Interest in geodetic surveying.

Possession of automobile dirver's license when required.

Duties and responsibilities:

The performance of duties assigned verbally or by schedule under immediate supervision and following specific instructions.

Type of work performed:

Driving truck and making minor emergency repairs.

Aiding in setting up and moving camp.

Climbing stands, wooden or steel towers up to 160 feet in height and from such structures showing lights to observing parties stationed on towers, hills or other positions.

Communicating with observing parties and other lightkeepers by using signal lamps.

Clearing obstructions interfering with visibility to or from observing parties.

Keeping lights and other equipment in good condition.

Bench Mark Setter

Minimum qualifications:

Excellent physical condition.

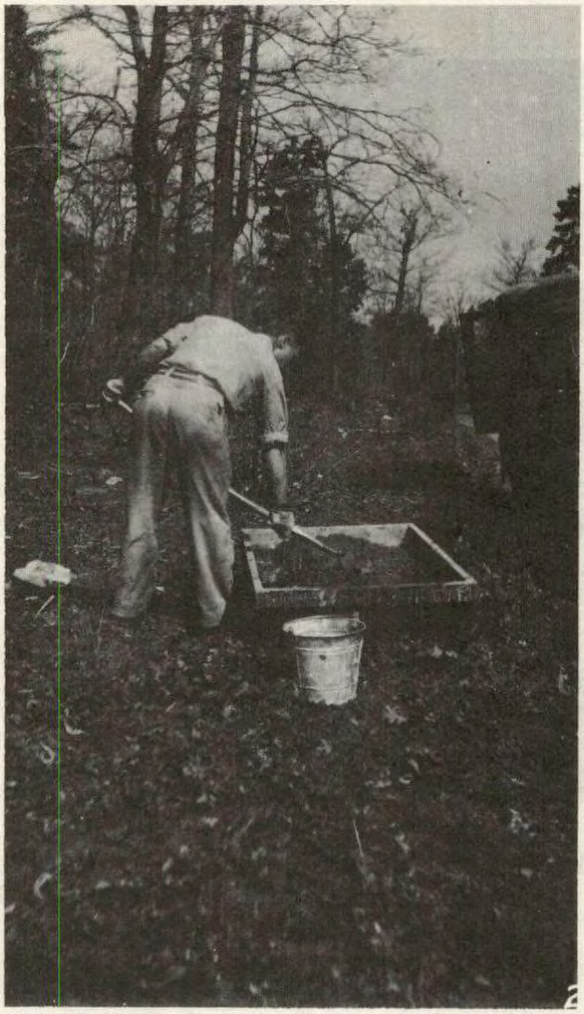
Training equivalent to that represented by graduation from High School.

Two years' practical experience performing technical duties on surveying or similar work or two years of college training in engineering.

Interest in geodetic surveying.

Possession of an automobile driver's license.

Ability to make minor truck repairs.



Bench mark setter at work

Duties and responsibilities:

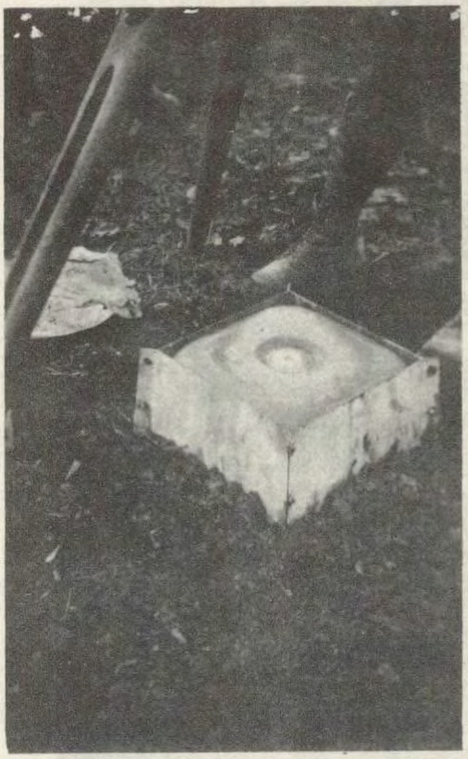
Under immediate supervision, to drive a truck; maintain it in clean and serviceable condition; to follow detailed or general instructions regarding establishing bench marks; making necessary arrangements with property owners for the placing of such marks; mixing and pouring concrete in place or setting precast monuments; writing descriptions of marks established and submitting reports to officer in charge.

Recorder

Minimum qualifications:

Excellent physical condition.

Training equivalent to that represented by graduation from High School, with courses in mathematics and physical science.



Surface mark, triangulation station showing sheet iron forms in which the upper part is modeled.

Two years' practical experience performing technical tasks on surveying or other engineering work or two years of college training in engineering.

Good general knowledge of surveying; demonstrated ability to make ordinary observations, computations and notes with care and accuracy.

Interest in geodetic surveying.

Note: Graduate engineers have proved best able to handle the position of recorder and have the necessary training to take additional responsibility when openings develop in the positions of observer and surveyor.

Examples of work:

Driving a truck.

Acting as emergency rodman or lightkeeper.

Keeping an accurate record of observations and measurements on geodetic and other surveying parties.

Making necessary field computations.

Aiding in moving and setting up camp.

Aiding in preparing accounts.

Duties and responsibilities:

Recorders are employed on triangulation, leveling, traverse, gravity and other geodetic parties. The duties of this position are general. A recorder must be versatile and able to do several classes of work. His duties are not limited to accurately recording observations. In general, he works under immediate supervision with limited latitude for somewhat independent work in carrying out more routine details.

Steel hauling truck.

Steel Hauler

Minimum qualifications:

Excellent physical condition.

Common school education.

Possession of automobile driver's license.

Not less than six months' experience driving trucks over country and mountain roads.

Knowledge of steel tower parts acquired from work as a steel builder.

Care in operating motor vehicles and ability to make minor engine repairs.

Duties and responsibilities:

Under immediate supervision to drive a trailer truck loaded with a knocked down steel tower; maintain truck in clean and serviceable condition; make minor emergency repairs; sort, load and unload steel towers; follow complicated directions in delivering tower to a prearranged location and make necessary arrangements for outdoor storage.

Examples of work performed:

According to a prearranged schedule to proceed to a triangulation station with trailer truck, sort and load a steel tower on the trailer and deliver the tower to another triangulation station, railroad car, ship, or to storage.

Keep truck and trailer in excellent condition.

Arrange with property owner for outdoor storage when necessary.

Move and set up camp.

Perform other related work as assigned.

Steel Builder

Minimum qualifications:

Excellent physical condition.

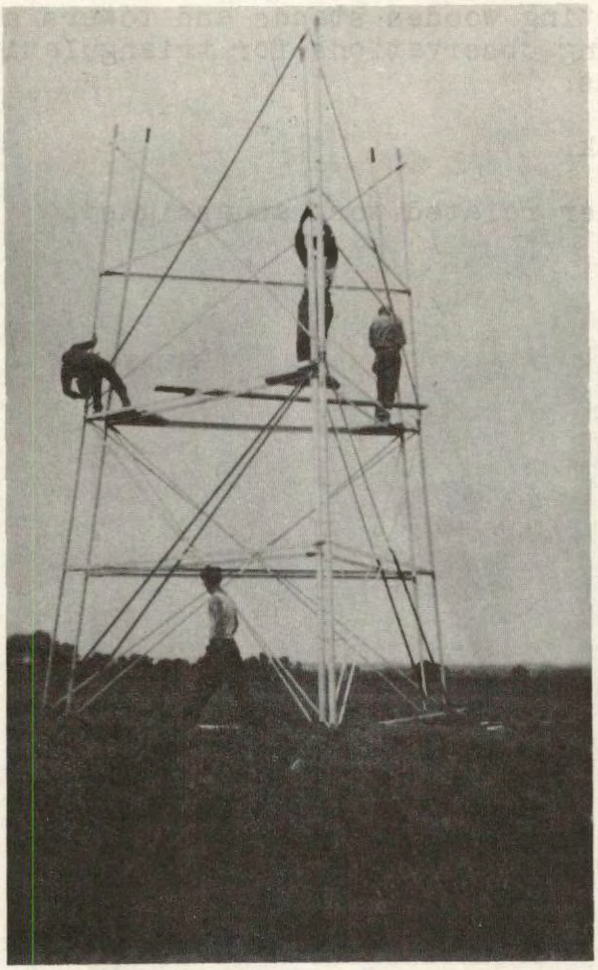
Common school education.

Automobile driver's license.

At least six months' experience as a hand, building steel towers.

Knowledge of all parts of a steel tower.

Carefulness.



Steel builders beginning tower.

Interest in geodetic surveying.

Duties and responsibilities:

Under immediate supervision to be attached to a triangulation party engaged in erecting Bilby steel towers, establishing concrete monuments, building wooden towers and stands and related work.

Examples of work performed:

Under the direction of a foreman to dig trenches for anchoring steel towers. Mix concrete and establish concrete monuments.

To aid in erecting wooden stands and towers and steel towers used in making observations for triangulation and other surveying operations.

Driving a truck.

Performing other related work as assigned.

Steel tower completed.

IMPORTANCE OF GRAVITY IN GEOPHYSICAL EXPLORATIONS

C. H. Swick

The use of geophysical methods in explorations of the earth and in the search for oil and other mineral deposits has attracted a great deal of interest in recent years. Several of the methods employed, such as the seismic, magnetic, electric conductivity and gravitational methods, have proved to be very useful in geophysical prospecting. Many valuable deposits have been found by these means and the proportion of dry oil wells is very much smaller than it was a few years ago before scientific methods were generally used in the search for this product.

A curious result of this success is a tendency on the part of many people to expect impossible things in the use of geophysical methods. They seem to expect these methods to be about as simple to use as the so-called divining rod and to be as effective in finding hidden minerals as a high-powered microscope is in revealing details not otherwise visible. Not long ago a man in Florida wished to know if gold treasure hidden by pirates could be found by using a gravity pendulum. His hopes were blasted when he was informed that it takes a layer of rock 30 feet thick of indefinite horizontal extent to cause an attraction of 1 milligal* at a point above the center of this layer. One milligal is about the limit of accuracy of the gravity pendulum. Although a thickness about one-seventh as great would produce this attraction if the layer were of gold, the pirates could hardly be expected to have deposited their treasure in such large caches. Another difficulty of course, is that it takes at least one day on the average to make a gravity determination and therefore the time and expense required to cover a sizeable area in sufficient detail to find a small mass of heavy material is rather staggering.

There are two different gravitational methods used for geophysical exploration. The more common one employs the torsion balance to measure the horizontal rate of change of gravity and certain other peculiarities of the gravitational field. This instrument is extremely sensitive to variarions in density of the underlying rock and to topographic irregularities. The other method employs the pendulum apparatus or some form of gravimeter to measure the vertical attraction of gravity in

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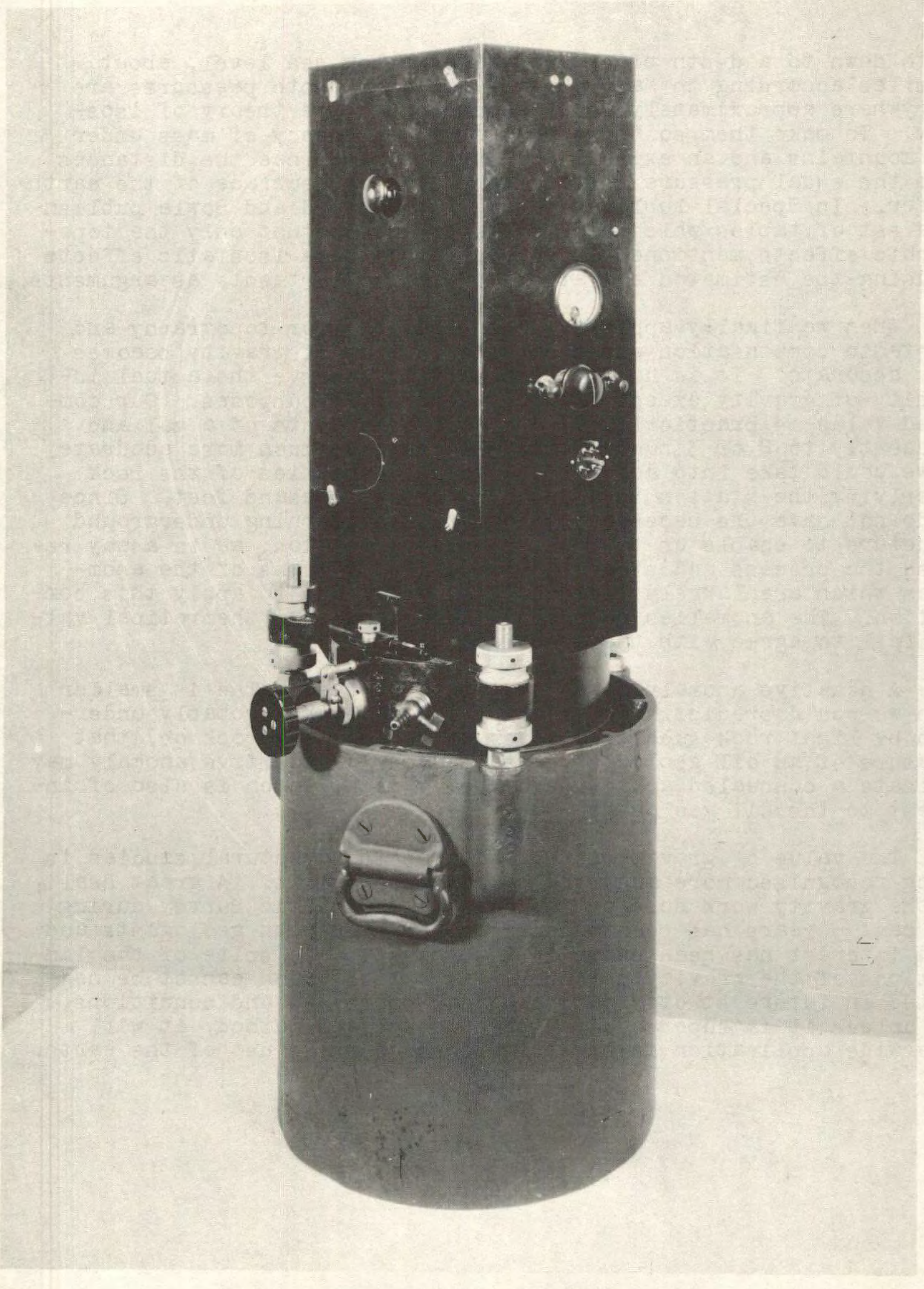
Note: *One milligal = one thousandth of a gal. Gal is a new name for an old gravity unit. It was formerly called "1 cm per sec. per sec." or "dyne."

relation to the attraction at some known base station. The instruments used to determine the vertical pull of gravity are less sensitive to abnormalities of structure and topography in the immediate vicinity of the station and are therefore superior to the torsion balance in detecting broad general features of underground structure. In other words they serve as excellent reconnaissance instruments. Investigations of local structure in sufficient detail to indicate for example the most likely spots for drilling an oil well are usually made with the torsion balance when gravitational methods are employed, although there seems to be a recent tendency on the part of some of the large oil companies to use the gravity pendulums and gravimeters instead of the balance for more and more of this detailed work.

In the remainder of this brief note I shall confine my discussion of geophysical exploration to the use of the gravity pendulum. How does the pendulum help us to determine what is concealed beneath the surface of the earth? Perhaps the simplest way to answer that question is to say that when the pendulum measures a pull of gravity for a certain point, which differs considerably from what we would normally expect, the difference is probably due to the effect of rock of abnormal density somewhere in the vicinity and below the point of observation. Gravity varies from about 978.0 gals at sea level at the Equator to 983.2 gals at sea level at either pole. The law by which gravity varies between these two points has been very carefully worked out and expressed as a formula which enables us to compute the theoretical value of gravity at sea level for any latitude with considerable precision. The law by which gravity varies from sea level to any given elevation has also been worked out very carefully and we know what correction should be applied for elevation of station.

This is all easy going so far but the worst is yet to come. The intensity of gravity is affected by mountains and valleys, lakes and oceans and all other topographic features from the station to the antipodes. Hayford early in the twentieth century devised an ingenious method for computing these topographic effects. He divided the surface of the earth into a regular pattern of zones and compartments with the station as a center, and then computed for each of these compartments what effect certain average elevations of the compartment would have on the station. The pattern is shifted easily from station to station by means of celluloid templates which are made to various scales corresponding with the available maps.

No mention has been made so far of isostasy. We cannot delay much longer. In deriving the best theoretical value for our station we must take account not only of the topography but also of certain variations in the density of the crust of the



BROWN GRAVITY APPARATUS

earth down to a depth of several miles below sea level, about 60 miles according to Major Bowie. At this depth pressures are everywhere approximately equal according to the theory of isostasy. To make them so there must be a deficiency of mass under the mountains and an excess under the oceans since the distances from the equal pressure surface to the actual surface of the earth differ. In Special Publication No. 10, Hayford and Bowie published a set of tables which enables us to compute not only the topographic effects mentioned above, but also these isostatic effects by using the estimated elevations of the compartments as arguments.

When we finally apply these corrections for topography and isostatic compensation our theoretical value of gravity becomes very accurate. It is hardly necessary to observe the actual intensity of gravity except for very scientific purposes. Our computed value is practically always good to a tenth of a gal and frequently to 2 or 3 hundredths. It would be much more accurate if we could take into account the actual densities of the rock underlying the station to a depth of a few thousand feet. Since we do not have the necessary information concerning underground structure to enable us to apply such a correction, we in a way reverse the process and study the structure by means of the anomalies which are largely the result of a failure to apply this correction. The anomalies represent the amounts the theoretical values fail to agree with the observed values.

A negative anomaly means that the observed value is smaller than we would predict. The station is therefore probably underlain by light rock such as a layer of sedimentary rock or, that treasure of an oil geologist, a salt dome. A positive anomaly may indicate a concealed anticline of heavy rock, which is also of interest to the oil geologist.

The value of gravity determinations in structural studies is being recognized more and more by many geologists. A great deal of the gravity work done by the Coast and Geodetic Survey during the past 5 years has been done in cooperation with geologists and much interest has been shown in the results. In spite of the limitations of the gravity method, it is a tool which cannot be neglected in future studies of geological processes and conditions, and unless it is superseded by some more exact method, it will have wide application in investigations of the crust of the earth.

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GEODETIC CONTROL FOR CADASTRAL SURVEYS.

Hugh C. Mitchell

In the April, 1936, number of THE ENGINEERS' BULLETIN, published by the Colorado Society of Engineers, appear two very interesting and timely articles in what are usually thought of as widely separated fields of surveying. One article, written by Carroll H. Coberly, is entitled "Land Surveying as a Specialty", and from it the following excerpts are taken:

> "The question has been asked: What is land surveying? The answer, to be complete, not only must tell what it is, but give some of the elements of which it is composed. Land surveying is made up of two parts. First, the location on the earth of a definite piece of ground. Second, the composition of a description which will enable a future surveyor to follow the 'foot steps' of the original surveyor, or to relocate the identical piece of ground therein cribed.
>
> "In order to locate a piece of ground it is necessary that some definite point be used. This point should be part of a general plan or monument, either artificial or natural, that is both definite and permanent. The surveys of the general land office all are tied to the general point Greenwich and local surveys tied to government land corners are, in reality, only extensions of previous surveys. There are a great many surveys tied to local monuments, such as mineral land monuments, the junction of rivers, the intersection of roads, rocks, trees, buildings, and many other more or less indefinite and temporary points.
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> * * * * * * * * * * * *
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> "Land surveying affects more people than any other branch of engineering. Every house has its plat of ground. Every highway has its right of way. In fact, there is hardly an engineering achievement that does not first require a land survey.
>
> "The average man, who has nothing whatever to do with engineering, thinks it a very simple matter to measure off a piece of land. Therefore, the cheapest man he can get is the most acceptable to make his survey. This attitude is so common and the results so at divergence with one

> another that very little confidence is placed in a survey. This lack of confidence is the result of many mistakes having been made by those who call themselves land surveyors. These mistakes are seldom technical errors, but result from the use of a wrong method. Many of them are very costly to the client. The court records are full of boundary suits that could have been avoided, had the surveys been correct."

The above statements are clear and definite, except that in the second paragraph occurs a statement that should be clarified; "The surveys of the general land office all are tied to the general point Greenwich . . . ." In a way, this statement is misleading. The land office surveys are referred to standard parallels and principal meridians. A standard parallel is defined by its latitude, that is, its distance in degrees, minutes, and seconds, north of the equator. The position of a standard parallel on the ground is determined independently of the position of Greenwich, except in so far as Greenwich has contributed data for the preparation of any astronomical almanacs which are used in the determination. On the other hand, the position of Greenwich, or rather of the meridian of Greenwich, enters directly into the determination of the position on the ground of a principal meridian.

Theoretically, the land office surveys are based on coordinate systems which are accurately defined, and may be located with precision upon the ground, but any attempt to relocate a lost land corner by its described distances from its coordinate axes is apt to meet with little success. It is definitely known that sections and townships are not regular figures of standard size, and that a point located by its description from a standard parallel and principal meridian may be quite distant, even as much as a mile, from the corner as actually monumented on the ground. And of course, it is the monument which determines the position of the corner.

The author of the above paper states that "In order to locate a piece of ground it is necessary that some definite point be used." A monument of stone or other material is a definite point only as long as its physical identity is preserved, and it remains in its original and true position. We know by experience that a position defined by section, township and range, may be far from the position actually established in an original survey. From this one may see that the reestablishment of a lost corner of a public land survey is no simple matter. The truth of this is borne out by the extensive code of laws and practices which have been developed in preserving the integrity of the original surveys and protecting purchasers of the public lands in their rights. That repeated applications of those laws and practices should not be necessary for any one point may be discovered from a careful study of another article in the same number of THE

ENGINEERS' BULLETIN.

In an article "The Geological Survey's Denver Project" is described a topographic survey of that city now being made under the direction of Fred Graff, Jr., of the U. S. Geological Survey. Although apparently totally unrelated to the article named at the beginning of this paper it contains the key to a splendid solution of the problem of insurance of permanency and accuracy for land surveys, and the two articles should be recognized as treating of matters which have a close kinship both in theory and in practice.

The topographic survey of Denver is described as being based on the first-order control survey of the Coast and Geodetic Survey, and on a supplementary transit traverse system of an accuracy of 1 part in 15,000; the scale of the map is 1 inch equals 200 feet, and the contour interval is 2 feet. But the point that at once arrests the attention of the reader is the statement that the map projection used is based on the Colorado System of Plane Coordinates, Central Zone, which means that in this surveying and mapping project there are secured the accuracy and permanency which result from using the national triangulation as a base, while all computations involving supplementary control surveys and detail surveys are made according to the simple formulas of plane surveying. Yet every point determined in the making of this survey is a "definite point", accurately defined in terms of a plane coordinate system that is mathematically based on the national control survey, and can be readily reestablished on the ground from stations of that survey. Such a system is more enduring than are individual monuments of concrete and bronze.

What has been written above naturally gives rise to a pertinent question: If a State system of plane coordinates is used as a base for the topographic survey - that survey which provides maps on which engineering plans are made and carried out - then why not use it also as a base for the cadastral surveys, and thus make easy the coordination of all surveys and maps? Engineering plans not only require the use of land but also a knowledge of the boundaries and ownership of the land and it seems quite certain to this writer that only the national triangulation net will furnish a base for the accurate coordination of engineering plans with both topographic and cadastral surveys. A State system of plane coordinates makes it possible for the surveyor to use the national triangulation survey without having to depart from the simple practices of plane surveying.

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A HUNDRED THOUSAND REFERENCE MARKS FOR A TIDE STATION

Howard S. Rappleye

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Newspaper men have a pet saying to the effect that if a dog bites a man it amounts to nothing, but if a man bites a dog, it is NEWS.

We have been hearing and reading for decades about the value of tide observations in determining datum planes from which to start control leveling of various grades of accuracy but nothing much has been said as to the value of control leveling to the study of the results of tide observations.

One use to which tide observations are put is in the study of the stability of shore lines. If a long series of tide observations shows a progressive change of the plane of mean sea level with relation to the reference bench marks nearby, it may indicate;

1. A change in the elevation of the mean-sea-level surface at the station.
2. A change in the elevation of the nearby land.
3. A combination of the two changes noted above.

This is not a purely hypothetical question but one of great practical importance. We know that relative changes in the elevation of the land masses and the mean-sea-level surface have taken place in the past; we also have every reason to believe that these changes are still going on and they are known to be, in general at least, very slow changes. The problem is one which must be investigated over a long period of time.

To answer the question as to which one of the above three conditions exists, the tide experts are very much handicapped, if not completely checked, unless data from other sources are available.

Geological considerations may aid in the interpretation of tide observations which indicate relative movement between the mean-sea-level surface at the tide station and the nearby reference bench marks.

The most promising line of attack appears to be a combination of long-series tide observations and the control leveling.

With long-series tide stations all connected to the vertical control net, all of the bench marks in the net become reference marks for each tide station. Leveling carried far enough inland will answer the question as to whether relative movement between the observed mean-sea-level surface and the nearby bench marks results from a change of the elevation of the sea level surface, a change of the elevation of the land, or a combination of both.

The only case in which this method of attack might fail to produce results would be when the relative movement is uniform along all the shores under consideration, indicating a uniform change in sea level or a uniform change in the elevation of the whole land mass. However, the possibility of the whole land mass elevating or subsiding without irregularity is so slight that a uniform relative change at all tide stations between the observed plane of mean sea level and adjacent bench marks on shore, could with certainty, be charged to a change in elevation of the mean-sea-level surface and we may safely assume that:

If all long-series tide stations are connected to the vertical control net, subsequent releveling, if carried far enough inland, would settle the question as to whether the land or the water had changed in elevation if relative movement between the two is shown by tide observations.

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TRIANGULATION STATION SERVES TO SETTLE BOUNDARY DISPUTE

Triangulation station Glasgow was established in 1890 by the U. S. Coast and Geodetic Survey. The station was in the southeast corner of a certain section and measurements made at the time of its establishment placed it 178.0 meters north and 28.7 meters west of the stone marking the southeast corner of the section.

In 1906 Mr. J. S. Bilby bought 240 acres of land which included 160 acres in the southeast corner of this section and 80 acres of the section next south. A county road had been built along the south section line dividing Mr. Bilby's property.

A few years later the land south of the road was sold to a neighbor. The new owner had his land surveyed and discovered that it was short two rods on the east side and that Mr. Bilby's land north of the road was two rods longer than it should be. He then claimed that he remembered that the section corner stone was moved when the road was built in 1895 and had his lawyer appear before the County Commissioners to request that the road be moved two rods to the north.

As it appeared that the matter was going to be thrashed out in court, Mr. Bilby decided to do some investigating himself. He got a copy of the original description of station Glasgow from the U. S. Coast and Geodetic Survey in which the 1890 distance from station Glasgow to the corner stone was set down, measured the present actual distance and found that the 1890 and present distances agreed within one inch, thus proving that the corner stone had not been moved.

When this was told to the County Commissioners and the complaining landowner, and the measurement repeated for their benefit, they agreed to call the dispute closed, and costly court proceedings were thus avoided.

This is only one example among many of the worth of triangulation stations in tying-in property boundaries.

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INTEREST OF THE STATES IN COMPLETING THE HORIZONTAL AND VERTICAL CONTROL SURVEYS

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A number of states have shown considerable interest in tne completion of the twenty-five mile spacing of the horizontal and vertical control for mapping within their boundaries and in the case of Texas and Iowa, this is evidenced by bills which were introduced in the Federal House of Representatives. A copy of the Texas bill is reproduced here. The Iowa bill was quite similar.

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74th CONGRESS
2nd Session H. R. 12456

IN THE HOUSE OF REPRESENTATIVES

April 24, 1936

Mr. Lanham introduced the following bill; which was referred to the Committee on Merchant Marine and Fisheries and ordered to be printed.

A BILL

To provide for the completion of the twenty-five-mile spacing of horizontal and vertical control surveys in the State of Texas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of $516,000 is hereby authorized to be appropriated, from funds of the Treasury not otherwise obligated, to the United States Coast and Geodetic Survey, Department of Commerce, for the purpose of completing the twenty-five-mile spacing of horizontal and vertical control surveys in the State of Texas, including the necessary connections to similar surveys in adjoining States, the computation, adjustment, and publication of final results.

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THEY HAVE THEIR TROUBLES TOO

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In the March, 1936, number of The South African Survey Journal, a publication issued by the Institutes of Land Surveyors of the Union of South Africa and Southern Rhodesia, are printed extracts from the minutes of member organizations and also a number of their annual reports. This journal contains much interesting material showing that the surveyor in those distant lands faces the same problems that are being met and solved in this country. Some excerpts from the above-mentioned journal may be of interest in this connection.

At a meeting of the Central Committee of the Land Surveyors of the Union of South Africa the following motion was carried unanimously:

> "That this Committee considers that, in terms of Chapter 2, Regulations 5 and 6 in the Regulations, that an Inspector of Beacons should be appointed to each province,

> who, in addition to his usual work of inspection and preservation of beacons and examination of surveys when necessary, could undertake the work in connection with the examination of candidates for trial surveys."

The appointmnet of an official charged specifically with the inspection and preservation of beacons (survey marks) should satisfactorily care for a matter of such great importance. In recent years in this country men have been sent out by this Bureau with instructions to search for stations which were established in previous years along arcs of triangulation and lines of traverse, to report on the condition of stations which were found, revising and bringing up to date the descriptions thereof, and wherever necessary, to take such steps as were feasible to insure the preservation of the data pertaining to such marks, either by the establishment of new marks in the original location or by referencing the old marks to new marks in more protected locations. A survey mark is not only something established to serve an immediate need, but it also is an engineering structure having a large future value which depends completely upon maintaining a definite known relationship between the data determined for the station and a recoverable and definite material mark on the ground.

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The President of the Institute of Land Surveyors of Natal stresses the need for extending the control surveys of South Africa and laments the limited use being made of such surveys in the following terms:

> " * * * * There is an immense amount of work to be done in trigonometrical and topographical surveys, precise leveling, magnetic, geological, hydrographical and aerial surveys, all of which are of immense value to the country. * * * * I should like to see the survey system of this country put on a similar footing to that of Canada. The foundation of this system in this country, by the creation of a very excellent net of geodetic and primary triangulation, has been laid, but through lack of foresight on the part of the Government, this foundation has not been built upon to the extent that it should have been."

In this country the need still exists for extending the national control surveys, but the great progress made in recent years has greatly reduced the need; the use for them is slowly becoming recognized, and here, too, progress is being made, for not only are former uses being greatly promoted, but new uses are being recognized and developed. Foremost among these are the control of aerial surveys and maps, and the use of the national triangulation through the medium of State plane coordinate systems to give permanency and accuracy to surveys of private land boundaries.

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From the annual report of the Council of The Institute of Land Surveyors of the Transvaal the following paragraph is taken:

> "Right of Entry of a Surveyor on Private Lands.- The right of a surveyor to enter on private lands when engaged in Trigonometrical Survey work has been brought into question. The surveyor undoubtedly has this right, but due notice of the intention must be given. The Council has suggested to the Director of the Trigonometrical Survey that when a section of Trigonometrical Survey is to be commenced a notice shall be published in the Government Gazette and circulated to and posted up at all Magistrates' Offices, Post Offices and Police Stations in that area, to the effect that the surveyor will be commencing the survey on a specified date, and will require to enter upon such lands as may be necessary, in order to place flags in connection with the survey."

Of especial interest to all surveyors, this paragraph relates to a matter which has long been recognized as of prime importance in this country. A number of States have passed Acts authorizing the entry of Coast and Geodetic Survey parties onto private property for survey purposes. Copies of such Acts are published in the report for 1893 of the Superintendent of the Coast and Geodetic Survey. No doubt some of the present field personnel have experienced a need for such an Act in dealing with owners of private property on which they desired to establish triangulation stations, though in most cases a little diplomacy should prove more satisfactory in attaining the desired end than an Act of Legislature.

While of course, there may be exceptions it may be stated as a general proposition that the passport of the surveyor for entry onto private land is and should be the good will of the owner, and this is rarely withheld when the owner is given a clear and courteous explanation of the reasons for the survey, and of the direct value to him and to his neighbors of having a station of the national triangulation net on his land. An Act prescribing conditions of entry would, however, place the relations of the surveyor and the property owner on a business basis, and such a basis should not only not prove a deterrent to good will, but should actually promote it by mutual understanding. In the May, 1935, number of the GEODETIC LETTER there was given a proposed form for a standard Act to permit entry of surveyors onto private property in the execution of their work, and suggesting conditions under which entry could be made.

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EFFECT OF WIND ON STATION MONUMENT IN SAND DUNE COUNTRY

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The accompanying illustration shows a triangulation station monument out in the West where there have been disastrous dust storms during the past year or two. It is quite evident from the remains of plants near the station monument that the sand dune on which this particular monument was set was not entirely bare. The wind whipped around the monument and removed the earth for a distance of nearly two feet below the top. It is probable that the only way to keep monuments from being actually blown out of the ground or, more property, undermined by wind effect, is to have them set deeper in the ground.

The monument pictured is not the best type. The illustration indicates that the top is actually greater in cross-section than is the lower part of the block of concrete. The monument should be biggest at its lower end and gradually decrease in horizontal dimensions toward the top.

It is suggested that where the material for monuments is poured in place, that chiefs of triangulation and leveling parties inspect some of the monuments to see whether they have adequate dimensions. One can dig the dirt from the side of the monument very quickly to see whether there has been any skimping of material.

If the monuments are destroyed there is nothing to show for the effort and money expended on the surveying. Chiefs of parties and others cannot be too careful in designing their monuments and having them of adequate dimensions and of the right kind of material.

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INTERESTING STATION RECOVERIES

Mr. Robert W. Knox, chief of party, U. S. Coast and Geodetic Survey, reports some interesting recoveries of old triangulation stations in the West Coast region.

Station <u>BRADBURY</u> was established in Columbia County, Oregon, in 1873 and was marked by a bottle for the subsurface mark and the center pole of the signal for the surface mark. In 1936, when Mr. Knox tried to recover it there were no signs of the old station nor its reference or witness marks. Giving it up as lost, he decided to establish a new station in the same vicinity and choosing the most likely spot, began to dig in order to place his marks. You may imagine his surprise when after digging a foot or so the bottle subsurface mark of the old 1873 station appeared almost in the center of the eight or ten inch hole he was digging. Evidently his idea of the best location for a triangulation station coincided exactly with that of the engineer who established the station in 1873.

Quoting Mr. Knox:

"The party had many amusing experiences in recovering stations along the coast of Southern California during our work between Newport Bay and San Pedro. There were generally as many sightseers around the hole as a steam shovel draws while working in an excavation in a city. In one case the sightseers began betting among themselves as to whether or not we would find the bottle. In this particular instance, we were digging in a lot that had been used as a tree nursery for years and had consequently been plowed up a great many times. But the bottle - a hand blown ale one with the label intact - was there.

"On San Nicolas Island we recovered one station, established over 70 years ago, including the 13 redwood stakes around the station mark and reference marks. The copper tacks in the stakes, however, were gone."

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DESCRIPTIONS OF STATIONS

H. C. Mitchell

The main object in permanently marking and accurately describing a triangulation station is to make possible its future recovery at any time when it may be desired to base new surveys on it. A satisfactory recovery involves not only a positive identification of the station marks, but assurance that those marks are in their original positions.

The identification of the marks has become fairly simple since the adoption of bronze disks suitably inscribed and stamped. Before this type of mark was adopted, the marks used were not so distinctive in character and identification often became difficult and sometimes recoveries were assumed which large discrepancies in the computations later proved to be erroneous.

The recovery of the station mark is promoted by the establishment of reference marks, which also aid in determining whether or not the station mark is still in its original position. Where a station mark cannot be found, but the reference marks are recovered, they make possible the use of data determined for the station. These uses of the reference marks - to establish the integrity of the station mark, or, if it be gone, to provide substitute control stations - naturally require that the distances and directions of the reference marks from their primary be measured with a very high degree of accuracy.

As aids in the recovery of a station, the reference marks should be placed in positions where they are not apt to be disturbed, and where they may be easily described and recovered. In short, it should be easy to recover the reference marks, and having found them, to go to the station. A much wider range of locations for reference marks may be considered than for the station itself, the site for the latter often being very restricted in size.

In proving the integrity of the station mark by measuring the distances and directions of the reference marks, the size of the angle at the station between the reference marks may not be important, but if the station mark be gone and it is desired to reestablish it in its original location from the reference marks, then the angle at the station should approximate a right angle.

The use of reference marks to provide substitute control when the station mark is lost may be accomplished in one of several ways. The station may be reestablished in its original location by measuring off the distances to it from the reference marks. Check on such reestablisnment should be provided by the directions to the marks from the original station. A reference mark itself may be used as a substitute control station, its position being determined by its azimuth and distance from its primary. Or an entirely new station may be established in the vicinity, and its position determined from the original station through the medium of the reference marks.

Whether a mark occupies its original position or not should be determined by repeat measures between the various marks at the station. This is an important function of the reference marks and a good reason why all measurements involving station and reference marks should be made with a high degree of accuracy. IT SHOULD BE POSSIBLE TO TEST THE STATION AND REFERENCE MARKS FOR POSSIBLE RELATIVE MOTION BY MAKING NEW MEASURES BETWEEN THEM AND COMPARING THE NEW MEASURES WITH THE ORIGINAL ONES.

A collateral function of descriptions of stations and one which may be of considerable future importance is the fixing of local topographic marks in position, and through them giving position to local surveys and maps. If such marks have cadastral value (as a fence corner), ties to them will assume additional value. The distance and direction from a triangulation station to a fence corner, to a line fence, to a local survey station, to a county-line or state-line monument are of great value and should be determined with considerable accuracy. ANY DEFINITE INFORMATION WHICH MAY BE INCORPORATED IN THE DESCRIPTION OF A TRIANGULATION STATION IS INTENDED TO BE A STATEMENT OF FACT, AND EVERY CARE SHOULD BE TAKEN TO SEE THAT IT IS AS ACCURATE AS CONDITIONS PERMIT.

In fact, all material incorporated in the description of a triangulation station is supposed to be accurate - not just reasonably so - but as nearly true as can be made without special research.

Among the various items which might be mentioned as offering special opportunity for error, as borne out in the light of experience, are the following:

Proper names: In this class are local geographic names;

names of streets, roads, and highways; names of corporations and of companies; and names of persons. Important geographic names can usually be checked in the office by reference to maps, atlases, Geographic Board decisions, etc. But even these can be made correct (with few exceptions) in the original records in the field, and this should be done. Unimportant and purely local geographic names often cannot be checked in the office and have to be carried into our publications in the form in which they are received from the field. Street names can sometimes be checked in the office by reference to city maps, but securing such maps often involves more time and effort than is required in the field to see that the names are correct in the records.

Road and highway names are often quite difficult to check in the office. Sometimes a road has two designations - a formal or official name and a popular name. Both should be given, and the record should show which is which. One thing which offers considerable difficulty in office editing of road and highway names is the unconsidered use of capitals, as Road or Highway. Thus a road may be called in the description "Johnstown Road", when what is meant is the road to Johnstown, which may have an official designation of "Highway No. 35","Ridgetop Drive", or something else. The same road may later be mentioned in the same or another description as "the road to Johnstown" or "Ridgetop Boulevard" or something which is almost but not quite in perfect agreement with the official name. While it may be admitted that any of these names will put the engineer on the right road, the office editor does try to have the name for a road or any other feature the same where it occurs a number of times in a publication, and of course, the easiest name to use in securing consistency is the one which is correct. Where a name occurs only once, the question of correct designation is usually not raised but the occurence of different forms of the same name, or different names for the same feature in descriptions of stations immediately challenges the editor to find out the correct name and use it. Often the office decision is a purely arbitrary one, with nothing but a desire for consistency for a guide. Many such cases require attention in the office and it is believed that an understanding of this particular type of error and a reasonable effort on the part of those who write the original descriptions will eliminate most of them.

Names of corporations and of companies, if they be important ones, can be checked in the office by reference to commercial directories. But this takes time which could be saved by a little extra care in the field. Recourse to a telephone directory may often give the correct names for utility companies, manufacturing plants, business houses, and of individuals which, for one reason or another, may occur in descriptions of stations. Such names are not checked in the office unless there is something about them suggesting error. As stated above, a most important indication of error is the spelling of the same name in two or more different ways. This is especially true of names of persons. Sometimes the name of a person will occur in a recovery description, and will differ very slightly from what is apparently the same name in an earlier description. No comment is made on the difference. It would be very helpful for the editor to know that the difference had been noted, and that the name in the later description should be adopted.

Where a station is placed on a man's land and given his name, great care should be taken to see that the name used is correct, particularly that the correct name is stamped on the station disk. If there be the slightest doubt as to whose land the station is on, it is wise to give the station some geographic or descriptive name - a name that in no way ties it up with the land ownership. This is also true where it is necessary to place the reference or azimuth marks on another man's land. Placing a reference mark with the name "Jones" stamped on it on land belonging to Smith, may tend to increase already unfriendly relations between Jones and Smith, and certainly will not strengthen the protection which Smith might otherwise be inclined to give the mark.

Another difficulty encountered in editing descriptions of stations in the office arises when part of a description sent in by the triangulation party has obviously been quoted directly from an earlier description without noting that it is a direct quotation, and some slight error is made in the copying. For instance, several sentences of the description sent in by the triangulation party may agree word for word with the description made by the reconnaissance engineer, except the figures in some distances are transposed, or a proper name is slightly different. Nothing indicates that it is merely a mistake in copying, but the evident conclusion is that such is the case, and that the changes were not noted. The reconnaissance description may be (probably is) correct. If the later description is correct, the one preparing it should call attention to the discrepancies, and state that the older description has been corrected in such and such details. Incorrect copies of earlier descriptions without any indication that they are meant to be verbatim copies may cause considerable loss of time in efforts to reconcile differences. Where the copy is explicitly stated to be a copy, the original will, of course, prevail.

Reconnaissance descriptions as a rule, contain much material which should go into the permanent record, but it should be placed there only after it has been examined by the observing party and found correct and pertinent. In other words, it should go into the description of stations as original matter and not as quoted data. It should not be necessary for the editor of descriptions to refer to reconnaissance descriptions, yet this has repeatedly been found advisable because of apparently inaccurate statements in the descriptions sent in by the observing party. Sometimes, too, one finds in the reconnaissance descriptions, material which should go into the final description, but has been omitted from it. For instance, a reconnaissance engineer was being asked about some question that came up in connection with a station he had selected, and upon reading the observing party's description of the station, he at once stated that a most important feature of his description did not appear. He had reference to the road distance to a point opposite the station from a bridge (a permanent feature) only a fraction of a mile away; because of its shortness this distance would place one very closely opposite the station. The shortest road distance given in the final description was very much greater, and of course, the uncertainty in locating the station with it was correspondingly greater.

An important feature of our descriptions of stations is the description of the route to the station. Often a description of the route is the only sure way of telling one where a station is. Description of the route should be checked very carefully. A strong criticism of this feature of our descriptions has been made by a private engineer who believes that too much space is used in telling one how to get to what should be considered the starting point. In descriptions of route, the point of departure should be from some well known point, as a crossroads or street intersection, to which any well-informed resident of the region can direct one. Sometimes the final description will give the route from one town to the next, then to a small settlement, and thence to the station. Possibly, the route from the small settlement to the station is all that would be necessary, but usually all is printed on the safe assumption that if the field man puts such material in a description he must have a reason for so doing.

The usual form for writing a description is quite simple. The station is first described with reference to more distant points, and progressively related to nearer references, till one comes to a description of the particular locality. The description should take one to the State, then to the county, to the neighborhood, to the general locality, and finally to the particular location and the station. The route for reaching the station should then be given, and after that, a description of the statio marks, then of the reference and azimuth marks and of their locations. This simple form may sometimes be varied to secure greater clearness or compactness, but it may usually be followed in a general way.

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In a certain section of Alabama, in the year 1888, Mr. J. S. Bilby found that a great deal of virgin pine in a four mile stretch would have to be cut down in order to clear the line. This, of course, would require many woodchoppers if the work were to be finished in one day as planned.

He went to one of the servants of Mr. Perry, his landlord and told him he would give him a dollar if he would get thirty strong woodchoppers with sharp axes to report early the following day.

At daylight next morning, Mr. Bilby looked out the window and noted that the whole place seemed to be surrounded by a flock of blackbirds. All ages, sizes and shapes of negroes, ranging from ten to one hundred years, were standing at the edge of the clearing, silently watching for signs of life from the "big house." They were armed with an assortment of axes from fairly sharp to exceedingly blunt; some evidently dating from pioneer days.

Eventually the men were lined up and thirty of the strongest were chosen. With four men chopping together, there was almost a continuous sound of falling trees. How many would be killed, he did not know, but there seemed to be plenty and to spare, - besides the line must go through that day.

In the evening after work was over, Mr. Perry told him of a conversation he had with one of the woodchoppers.

"Nevuh saw trees fall so fas' all day."

"What?" said Mr. Perry. "I didn't know a northern man could get any work out of you niggers. Did he yell at you all the time to keep you going?"

"No, *suh*. He nevuh sed a word, - but effen one of us jist stopped to spit on his hand, -- dar he wuz -- lookin' right at us."

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TABLES TURNED

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On the same line of work at station LOVERS LEAP, Mr. Bilby found that a large live oak tree obscured the line about one mile distant, close to a man's house. He went to see the man and asked his permission to cut some of the limbs, assuring him that there would be no more cutting than was absolutely necessary.

The man gave his consent readily and asked that they cut two additional limbs which overhung his roof. This was done in a very few minutes and the line was cleared.

The owner of the property insisted that Mr. Bilby and his men stay for dinner, which, was an excellent one. After dinner was over, the man pushed back his chair and said,

"And now, Mr. Bilby, how much do I owe you?"

"Owe *me*?" said Mr. Bilby. "Well, this is the first time I was ever asked that question after cutting down part of a man's tree and eating his dinner."

"It's this way, Mr. Bilby. I've been trying for two years to get someone to come cut off those two branches that endangered my roof and could find no one who would undertake the job. So you see, you are rather the answer to a prayer and I'll be glad to pay whatever you ask."

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A LAMENTABLE DITTY, printed on the following page, was found among some old papers by Dr. Brooks of the U. S. Geological Survey and was written by G. D. Wise on September 25, 1852, aboard the U. S. Surveying Schooner FRANKLIN.

A LAMENTABLE DITTY

Oh, what a life is the Coast Survey!
Through mud and mire to tread your way,
While on your head the sun shines bright,
And on your nose the "skeeters" light.
The jiggers and ticks they scar each shin;
They are not good looking, but they will get in
In spite of boots and trousers tight.
The way my legs are, is a sight.

Good people, is there nought beneath the sun
For me to be at except this one?
From the wife of my bosom I'm far away,
Condemned to tramp on the Coast Survey.
Whether the road is dusty or the sands are hot,
No rest for me; I must trot, trot, trot.
My children at home will forget their dad.
Dear me, is there no other trade to be had?
My living to earn is there no other way
Except to tramp on the Coast Survey?

A home I've got in a pleasant spot,
But (isn't mine an unfortunate lot?)
I never see it in summer time,
When lilies and roses are in their prime,
But only when winter's icy breath
Has put them all to a cruel death.
'Tis good, on the land, for one to talk
Of the pleasant sea and its pebbly walk,
Of its crested waves and pearly deep
And on its bosom to be rocked to sleep.
I wouldn't give one foot of turf
For acres and acres of briny surf,
And I'd rather sleep in the town of York
Than bob up and down like a floating cork.
'Tis romantic, I know, but as for me
I like the land much more than the sea.
Who fancies may take such a place of rest,
But a quiet bed will suit me best,
And if on a bosom I have to sleep
I'd rather take one not so deep.

Good people, good people, oh tell me, I pray,
Is there no other trade but the Coast Survey?
'Tis a deuced life for a married man;
I intend to leave it whenever I can.
And glad will I be when the time comes around
To spread our sails and be homeward bound.
In the meantime, good people, do try, I pray
And help me to leave the Coast Survey.

-G. D. Wise.

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