NO. 13

FIELD ENGINEERS BULLETIN

U. S. COAST & GEODETIC SURVEY

DECEMBER 1939

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CONTENTS

	Page
The New EXPLORER	Frontispiece
Precise Alignment . . . . Carl I. Aslakson	1
Hydrographic Survey Aids . . . . H. C. Warwick	11
Through the Straits of Magellan on the PATTERSON . . . . R. R. Lukens	16
Triangulation--Ship Intersection Method . . . . Charles Pierce	20
Lighted Survey Buoys . . . . G. C. Mattison	24
Comment: Herbert Grove Dorsey	26
Submarine Scarp off Cape Mendocino, California . . . . Harold W. Murray	27
Comment: N. H. Heck	32
New Shoals for Old . . . . Earle A. Deily	34
Relation of the Tide to Property Boundaries . . . . R. S. Patton	44
Strange Property Descriptions - Eastern Long Island . . . . . . James E. Connaughton	58
Some Reflections on Echo Sounding . . . . Paul A. Smith	59
Plane Table Traverse by Wire . . . . Ross A. Gilmore	71
Where the Decimal Point Goes . . . . (From Engineering News-Record)	72
The Bering Sea Survey . . . . E. W. Eickelberg	73
A Lamentable Ditty	80
Pacific Coast Wire Drag Survey - 1939 . . . . I. E. Rittenburg	81
Least Depth on Shoals Effectively Determined . . . . George F. Jordan	83

Page

Theodolite Micrometer Tests 84
Carl I. Aslakson

Heeling Error in Radio Direction Finder Bearings 93
Crawford F. Faily

Survey Pests 95
(From The Canadian Surveyor)

Basic Bench Marks in New Orleans 98
Karl B. Jeffers

Portable Depth Recorder 100
Herbert Grove Dorsey

Tracking Down Survey Buoys 106
R. P. Eyman

Serial Temperatures by Bathythermograph 108
John C. Mathisson

Control Survey Criteria 114
(Are our Survey Specifications too Exacting?)
Hugh C. Mitchell

Comment: 118
C. L. Garner

Trucks and Triangulation 121
P. L, Bernstein

Proposal to Honor Isaac Ingalls Stevens 125

Charts on Board Ship 127
(From The Nautical Magazine)

Sono-Radio Buoy Improvements 128
Millard F. Timm

Comment:
Herbert Grove Dorsey 130
R. P. Eyman 133

Simplicity in Maps 134
Charles H. Deetz

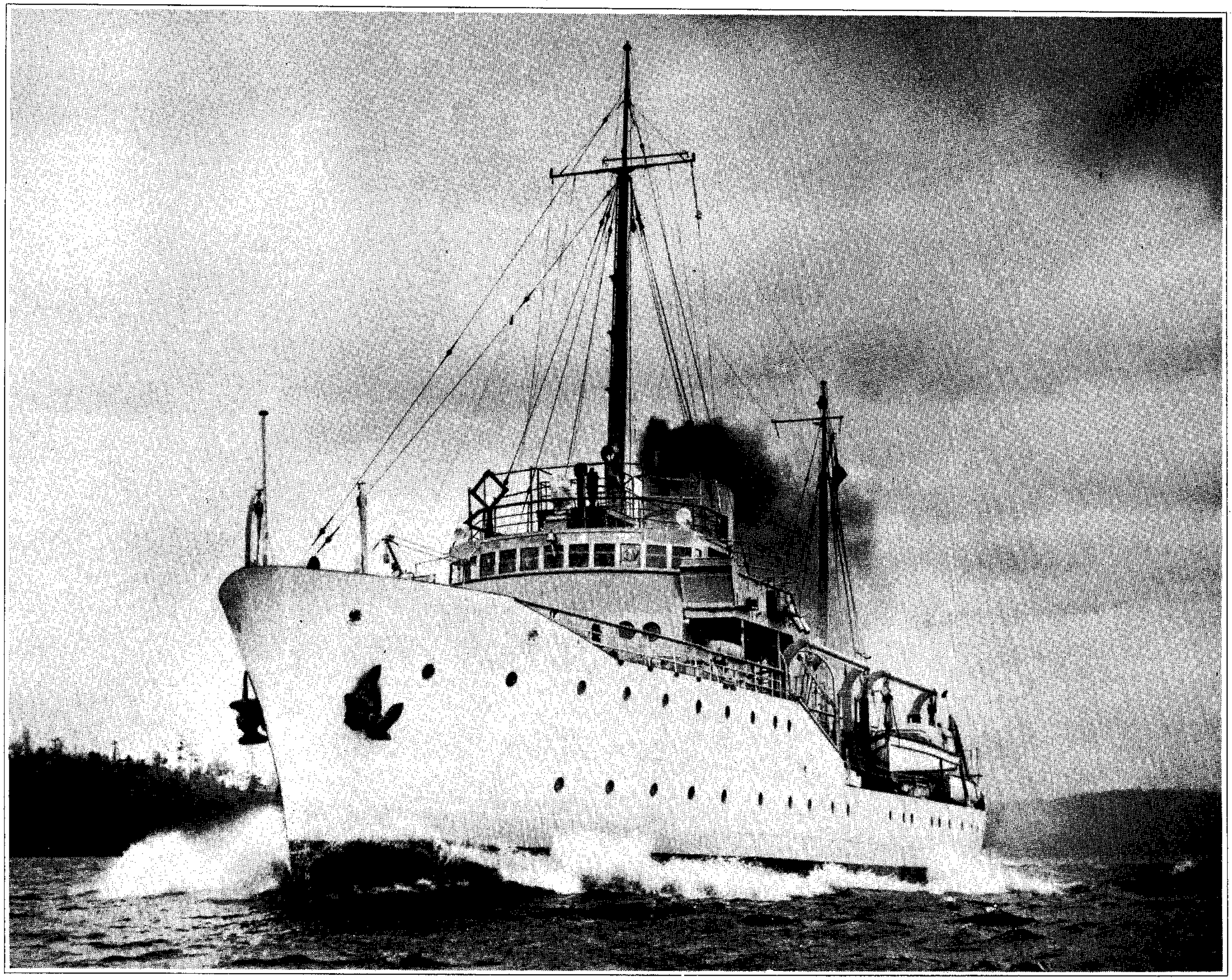
Hydrographic Control - 1939
Ships OCEANOGRAPHER and LYDONIA (Sketch) 135
Ship HYDROGRAPHER (Sketch) 136

Toward a More Perfect Chart 137
George F. Jordan

The Care of Surveying Instruments 140
(From Civil Engineering)

Comment:
Robert H. Griffin (From Civil Engineering) 144
H. W. Hemple 145

	Page
Sono-Radio Buoy "Gulf" in 400 Fathoms . . . . L. P. Raynor	148
It's a Small World After All	150
Special Survey, Sitka, Alaska . . . . L. C. Wilder	151
Plotting Three Point Fixes Without the Use of a Protractor . Charles Pierce	155
It Happened in a Field Station . . . . Marie H. Smithson	160
Honors to Dr. Bowie	161
Motor Vessel E. LESTER JONES . . . . L. C. Wilder	162
Geographic Names of Interest	164
Sea Manners	174
What <u>Not</u> to Paint . . . . (Extracts from Bulletins of Bureau of Marine Inspection and Navigation)	174
Magnetic Observations in Alaska . . . . (Extract from 1939 Season's Report of E. H. Bramhall) .	175
Outsiders' Impressions . . . . From Maritime Commission Cadets	186
The Launching of the New Ship EXPLORER	187
Proposed Assignment of Officers for Field Season, 1940 . . .	189
Statistics and Distribution of Field Parties	191
Field Memoranda, 1939	196
Circular Letters, 1939	198



The New *EXPLORER*

PRECISE ALIGNMENT

Carl I. Aslakson, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Within recent years numerous scientific studies of minute movements of large structures have been made. In general, these studies require accurate determination of both the horizontal and vertical changes of various points on the structures relative to certain points outside the structures, which latter, owing to their mass and location, are assumed to remain fixed. In particular, these studies are important in connection with large concrete dams. The largest dams place a tremendous additional load on the earth's crust, due, not only to the mass of material in the dam itself, but to the water load accumulated behind the dam. Frequently temperature extremes add to the static stresses caused by the load. Movements of various orders must take place in the structures and as a consequence precise alignment, a little explored field of surveying, is becoming a necessity.

At the outset it may be well to define what is meant by precise alignment. Since limited lengths are usually involved in structures requiring studies, we may first limit the length of line over which we desire precise alignment. This paper will be restricted to a discussion of the alignment of intermediate points between two fixed points which are 1300 feet apart. Applicability of the methods described herein to alignment problems over greater distances will be considered later. By precise alignment of the intermediate points is meant that the probable error of alignment shall be of an order many times smaller than that ordinarily attained by the engineer using ordinary transit or wire methods.

The writer recently had the privilege of assisting in a problem in precision alignment at the David W. Taylor Model Basin of the U. S. Navy at Carderock, Md. This project was to establish intermediate points at approximately 40-foot intervals between two points 1300 feet distant from each other. The line lay along a wall inside the towing basin structure and was to be used to control the alignment of the steel rail on which the driving wheel of the towing carriage was to run. Since elimination of all sources of friction was of paramount importance, the ultimate in accuracy of alignment of the towing carriage rail was desired.

Two methods of alignment were employed. One of them, designated as the "Taut-Wire Method," was used by the physicists of the U. S, Navy. The other, which will be called the "Optical Method," was employed by the writer. A discussion of the two methods with their agreement and their relative merits and applications follows.

Taut-Wire Method

At first thought, it might seem that the establishment of a straight line from a taut wire should prove to be an easy problem. Unfortunately, a number of practical difficulties arise. In the first place, there is a large catenary in a wire 1300 feet in length. At the Model Basin a piano wire with an area of .000806 square inch was employed, and although this was stretched until it was under a tension of 186,000 pounds per square inch, there was a 4-1/2-foot

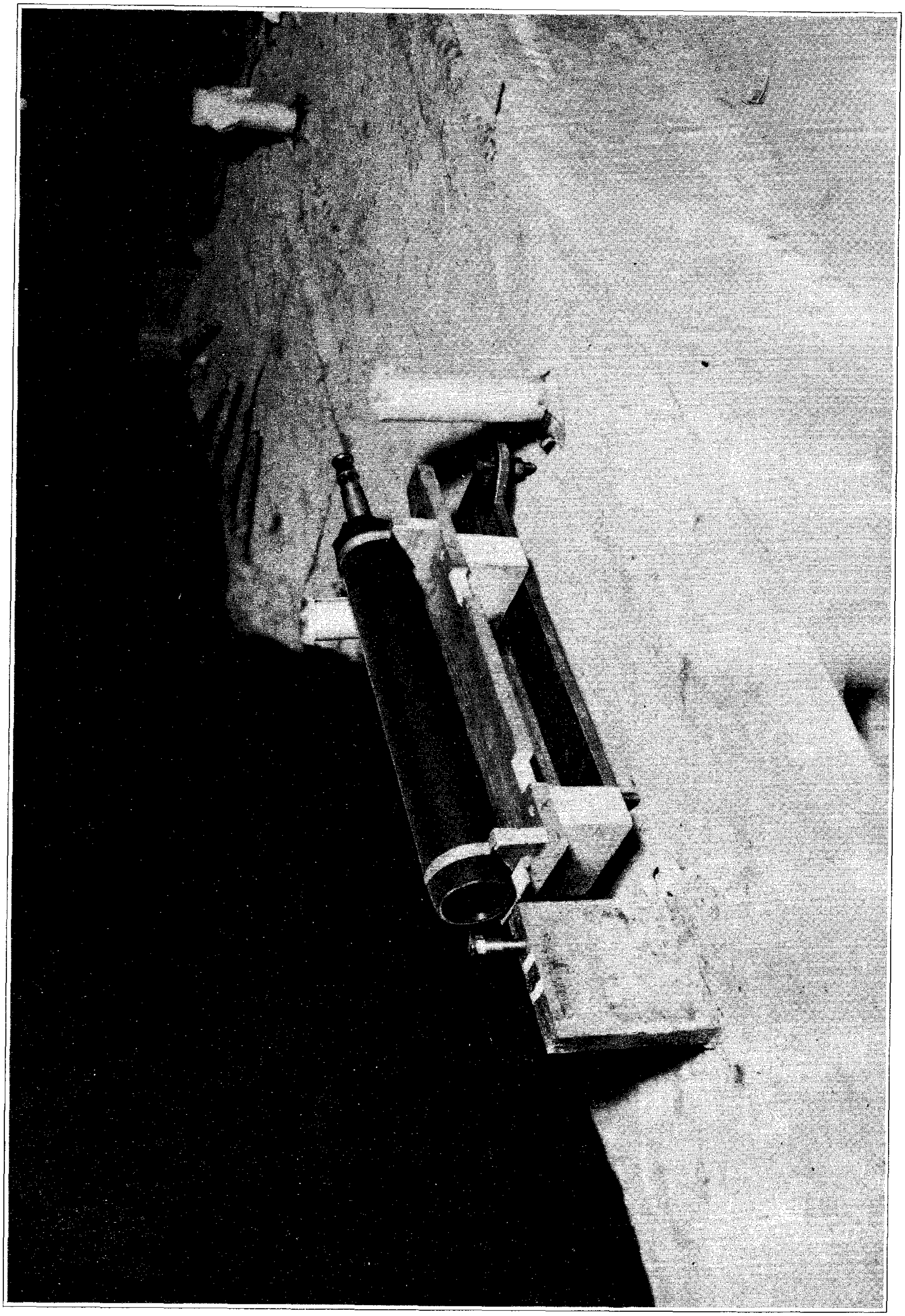


Plate I. Telescope used in reading plumb thread in Taut-Wire Method catenary sag in this wire. Obviously there was also the problem of accurate plumbing from this wire. Certain other practical difficulties were encountered. In a line of that length, absolute freedom from air currents was necessary. The question also arose as to whether or not a magnetic bow might not exist in a steel wire catenary of that length. It was because of this latter uncertainty that a check on the alignment by the optical method was desired.

Briefly, the "Taut-Wire Method", as employed, is described in the following paragraphs:

The piano wire was fastened to the wall near one end of the line. At the other end it passed over a pulley and to it was hung a 150-pound lead weight. Since the area of the cross section of the wire was .000806 square inch, this gave a tension of 186,000 pounds per square inch in the wire. Near the end points of the line the wire was about seven feet above the wall, while at the mid-point it was about 2-1/2 feet above the wall.

Steel posts 1-1/2 inches by 6 inches in cross section, protruding from the concrete wall about 6 inches, were spaced along the wall at approximately 8-foot intervals. One of these posts may be seen in Plate I. Every fifth post contained a 1/2-inch brass bolt with a polished head set into it flush with the top of the post. (This bolt is not visible in Plate I; the one which appears near the objective end of the telescope was used in the vertical control work). These bolts were set on line by transit so that it was known that the precise line would fall somewhere on each bolt.

The method of plumbing used was the unusual feature of the Taut-Wire Method. This was accomplished as follows. A small brass plumb bob was suspended by a fine silk thread from the wire. The silk thread was looped over the wire to prevent eccentricity. The plumb bob hung down past one end of the steel post and was immersed in water to damp its movements. A 12-power telescope (See Plate I) was placed on line on an adjoining post eight feet away. The line upon which the telescope was placed was also established by careful plumbing from the piano wire. The telescope contained a glass diaphragm

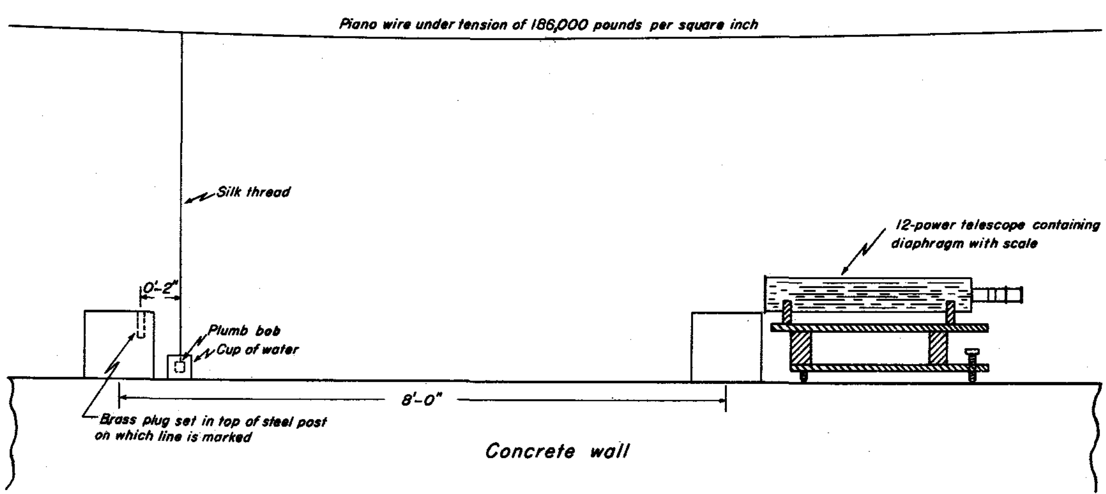


FIG. I

with an etched scale upon which the position of the plumb bob thread could be read to .01 millimeter. A long series of readings of the thread was made and then a sharp stylus was lined in on the brass bolt at the mean reading of the thread on the telescope scale. This process was repeated on each post upon which it was desired to set an alignment point.

The manner in which the piano wire, posts and telescope were arranged while readings were being made is illustrated in Figure 1. It is obvious that the approximate method of establishing the telescope on line introduces no serious error into the results. Since the ratio of the distances of the plumb thread and the telescope to the brass bolt is 0'-2" to 8'-0" or 1 in 48, it is apparent that only 1/48th of the error of alignment of the telescope will enter into the results of line as established on the brass bolt. Roughly, an error of one millimeter in aligning the telescope will affect the established line about 0.02 mm.

The fact that the scale could be read to 0.01 millimeter must not give the impression that a series of readings would give a value of that accuracy or less. The image of the thread itself covered many times that amount on the scale and it was necessary to estimate the location of the center of the thread on the scale. Furthermore, the thread was never absolutely quiet so that it was necessary to take the average of a large number of readings to obtain a representative mean thread position. Results obtained over a period of several months indicated that, under the ideal conditions of freedom from air currents, direct sunlight, and sudden temperature changes, obtainable in the basin room, the Taut-Wire Method as employed there should give a probable error of alignment of approximately ± 0.1 mm. provided at least two sets of observations are made on each point.

Optical Method

The Optical Method of alignment as employed by the writer required the use of two specially designed lights, a steel stand and a Parkhurst first-order theodolite with a 50-power telescope. The theodolite and stand are illustrated in Plate II. One of the specially designed, micrometer-read, lights is illustrated in Plate III.

The lights were originally designed by Lieutenant Commander M. D. Sylvester, (C.C.) U.S.N., and the design was modified by the writer. The essential features of the light may be described as follows:

A sheet metal face covered the box of the ordinary flashlight type of light used by the Coast and Geodetic Survey. This face contained a slit about 0.5 millimeter in width through which the light issued. The inside back of the light-box was painted white and the light source consisted of two 6-volt bulbs placed near the front of the box. Thus the light viewed by the observer did not come directly from the bulbs but was reflected from the white background. A fiducial edge, arranged in a slide so it could be raised, lowered and clamped in position, was arranged at the base of the light slit. Thus a mark could be made along this fiducial edge which was in a vertical line with the center of the light slit. The mark was made with a sharp marking awl in the polished head of a brass bolt which was set flush with the surface of each post.

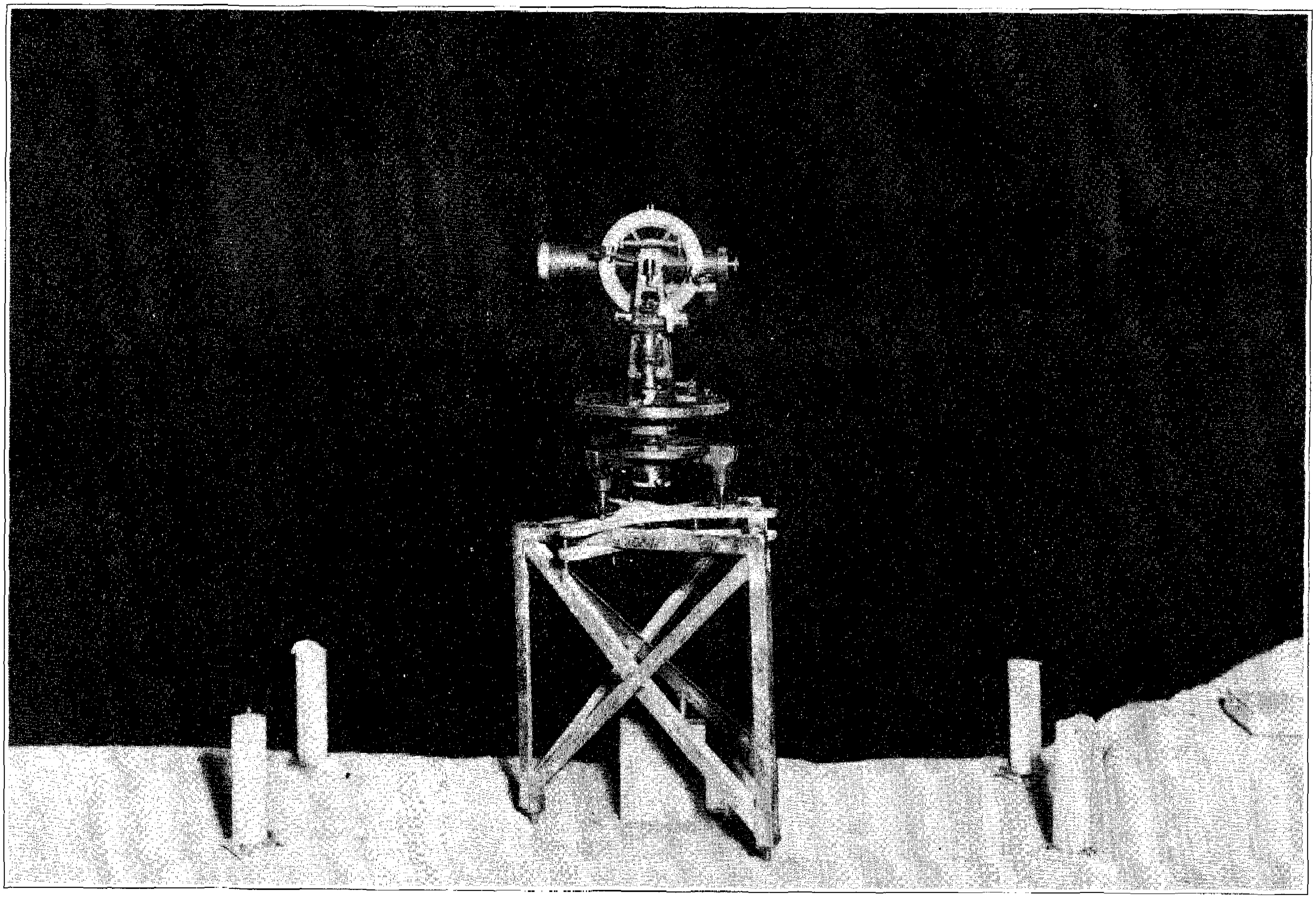


Plate II. Parkhurst theodolite on special steel stand used in Optical Method

The light was mounted on a lathe carriage so that it could be moved back and forth across the line by turning the tangent screw. A micrometer was then arranged so that the relative position of the light slit could be read to .01 mm. for any particular setting of the light.

The whole light assembly was arranged to clamp on the iron posts on which the alignment was being made. The screws which were used to clamp the lights on the post also served as leveling screws. A universal level attached to the side of the light indicated when the light-box was level. By this means an error of about two minutes in leveling could be detected. Since the maximum distance of the fiducial edge from the end of the light slit was only about 15 millimeters, the probable-plumbing error was about $\pm$ 0.01 millimeter. While at first it was somewhat awkward to clamp and level the light simultaneously, the lightkeeper soon became very proficient and was able to clamp and plumb the light in about five minutes.

In order to eliminate all possible errors from the final result, the various sources of error were considered. They may be summed up as follows:

1) Error of plumbing theodolite and lights.
2) Error of leveling of the theodolite and lights.
3) Errors caused by horizontal refraction.
4) Errors of pointing which may be subdivided into
   (a) accidental or compensating errors.
   (b) personal or constant errors.
5) Errors of collimation or the failure of the line of collimation of the telescope to intersect the vertical axis of the telescope.
6) Errors due to play in telescope parts when changing focus.

The various sources of error will be considered in turn.

1) No system of observing will eliminate errors caused by faulty plumbing of the theodolite. However, repeat observations on the same point made from stations at opposite ends of the line or made from the same station, but with different set-ups gave some idea of the magnitude of the errors of plumbing. The plumb bob was carefully tested by spinning and the position of point of the bob was always examined with respect to the punch mark over which the instrument was being plumbed, through a reading glass. It was believed that the plumbing error of the instrument over a point was of the order of $\pm$ 0.1 millimeter. The effect of this error is decreased in proportion to the distance from the point being aligned. If the initial light is at the opposite end of the line from the instrument and a point in the middle of the line is being observed upon, the effect of the error of plumbing the instrument is reduced by half.

The errors of plumbing the lights were without doubt of somewhat smaller order than those of plumbing the telescopes. This was proved by repeatedly setting the light to a mark with a reading glass and then reading the micrometer.

2) The errors caused by faulty leveling of the theodolite were negligible since the vertical angle between the lights was always

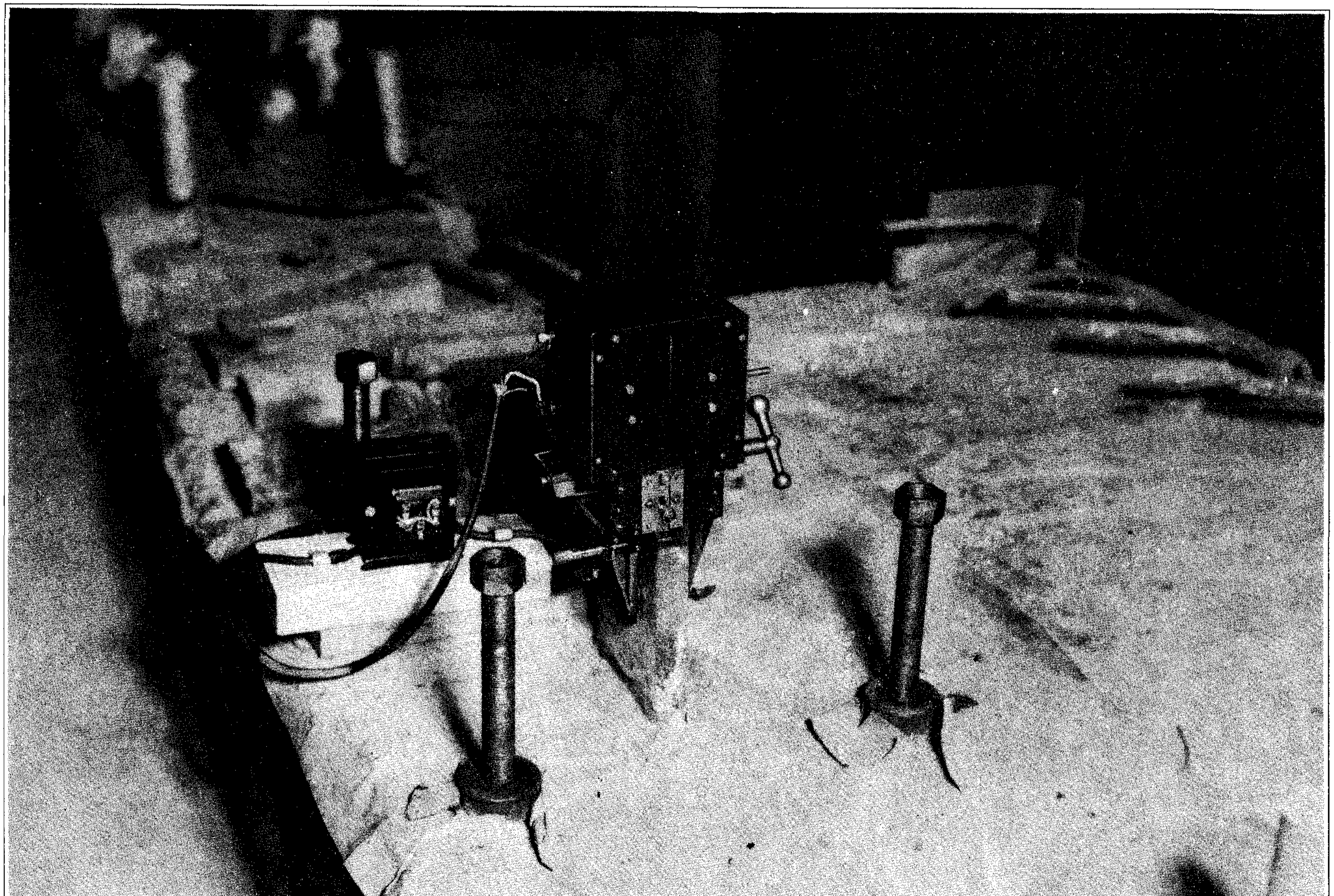


Plate III. Alignment light used in Optical Method less than 1° . A plate level with a value of 10" was used and it was always kept in very careful adjustment. Since the instrument set-up was very rigid, no trouble was encountered maintaining the level of the instrument once it was adjusted. With one of the observed points 400 feet distant, the plate level out of level by as much as one full division (maximum was about 1/4 to 1/2 division) and the maximum vertical angle of 1° between lights, the horizontal error of the point observed upon would amount to only .004 millimeter. Hence it may be seen that this source of error was negligible.

The error caused by faulty leveling of the light has been discussed and shown to be of the order of about $\pm$ 0.01 millimeter.

3) The errors caused by horizontal refraction were not serious owing to the design of the building and the time at which the observations were made. All observing was done between 4:30 p.m. and midnight. No workmen were in the building and all doors were closed. There were practically no cross currents of air. On a large percentage of the observations the nearer light was shielded by holding a piece of pressboard about four feet square above it while the pointing was being made on the initial light to prevent refraction due to the heat given off from the nearer light. Without doubt, a part of the spread of observations is chargeable to refraction rather than to accidental errors of pointing, but it is believed that these refraction errors were of the compensating type since there were never any constant air currents in either direction across the line of sight.

4) The method of observing was such that accidental and personal errors of pointing tend to be eliminated.

5) The method of observing eliminated collimation errors.

Method of Observing

A single set of observations consisted of 40 pointings, 20 being made on the initial light and 20 being made on the alignment light. The manner and order of making these pointings were as follows:

(a) With the telescope direct and the alignment light moved off line several millimeters to the south of the line, the telescope was pointed on the initial light and clamped and the alignment light was moved slowly in a northerly direction by the lightkeeper. The lightkeeper was guided by flashlight signals from the observer. When the observer gave the "OK" signal, the lightkeeper read and recorded the micrometer reading, again moved the light off line to the southward, and read and recorded the micrometer reading. This process was repeated five times.

(b) Next the alignment light was moved several millimeters to the north of the line and with the telescope still direct the above process was repeated, the only change being that for the five readings the alignment light was moved in a southerly instead of a northerly direction.

(c) Now the telescope was plunged, the instrument was reversed, and five pointings were made with the light being moved from the north toward the south, and five with the light being moved from south to north.

Thus it can be seen that personal errors due to the direction of movement of the light tend to be eliminated. Since a total of 40 pointings were made, 20 being on the initial light and 20 on the lining light, accidental errors of pointing tend to compensate. Collimation errors are eliminated by reversing. Since all readings were made and recorded by the lightkeeper, the observer had no knowledge of the micrometer readings until after a set was completed. Hence, the observer was unprejudiced at all times.

Following is a typical set of observations:

Micrometer Readings

5/4/39	Direct	Direct	Reversed	Reversed	Mean	Remarks
Instrument at East End	Light moving N. (mm.)	Light moving S. (mm.)	Light moving S. (mm.)	Light moving N. (mm.)		
Pointing on Post 601-5	9.35	9.53	9.50	9.26		Initial Light on West End
	7.86	9.16	9.14	8.12		
	8.54	8.57	9.30	9.33		
	11.13	7.95	9.27	10.12		
	9.98	9.73	8.11	10.23		
Means	9.37	8.99	9.06	9.41	9.21	

Mean reading scales 0.29 mm. north of taut wire line of March 28-29

6) The errors due to changing focus were eliminated in the following manner.

At first it was planned to eliminate focusing errors simply by not changing the focus between the pointing on the initial light and the light which was being aligned. The Parkhurst theodolite had a sufficient depth of focus so that objects which were distant 1300 feet and others which were distant 650 feet would both appear in clear focus without changing the focusing slide between pointings. After setting the closest point which could be determined without changing focus, it was planned to use that point as an initial, install the initial light upon it and again establish points on the line closer to the instrument set-up until the nearer light became out of focus. This process could be repeated until the points on line were brought as close to the instrument as desired.

The undesirable feature of this method was the necessity of continually changing the initial light, thus running the risk of accumulating errors due to faulty plumbing of the light. It was therefore decided to repeat some of the observations on the lining light using the initial light at the end of the line and allowing the nearer light to be out of focus. The results of these experiments were surprising in that it was found that the light out of focus afforded an excellent target. The center appeared as a narrow, black line with a diffraction pattern of white light on either side of the black line. The observations made when the light was out of focus were very uniform, and were generally better than those which had been made with both lights in focus from the instrument set-up at the opposite end of the line. The mean values of the point as obtained by either method checked well, thus proving that no errors caused by optical illusions resulted from observing on a light out of focus.

An additional advantage of this method of observing lay in the fact that the line of sight to the initial light passed some distance above the light being aligned, thus avoiding the area of heated air which was directly over the light nearer the instrument when the instrument was at one end of the line and both lights were near the other end. In fact, as previously stated, while observations were being made on two lights near the opposite end of the line from the instrument set-up, it was found to be necessary to shield the closer light by a large sheet of pressboard while orienting on the initial light to prevent refraction.

Theodolite set-ups were made only at the two end points of the line. The distance between these points was about 1300 feet. A total of 28 points was observed upon and repeat observations were made upon nine of them.

A complete report on the results obtained by the Optical Method of alignment was included in a special report entitled "Optical Alignment at the David W. Taylor Model Basin." This report was submitted by the writer under the date of September 20, 1939. Lack of space here precludes submission of the data included in that report. However, a summary of the conclusions drawn may be of interest.

Comparison of Optical and Taut-Wire Methods of Alignment

A comparison of the two methods of alignment must include a discussion of two features; namely, the applicability of the method and the accuracy of the method.

Regarding applicability, the Taut-Wire Method is extremely limited. The conditions at the David W. Taylor Model Basin were ideal for the use of this method since a complete freedom of air currents is necessary for its successful employment. Under the ideal conditions obtainable there, the method is an excellent one. Under those conditions the conclusions reached by the writer were that the probable error of alignment of points determined by the Taut-Wire Method was of the order of $\pm$ 0.1 millimeter as against about $\pm$ 0.2 to $\pm$ 0.3 millimeter when the Optical Method was used.

On the other hand, the Optical Method is not limited to use within enclosed structures. Probably a greater number of projects requiring alignment of high accuracy are located in the open, precluding all possibility of using the Taut-Wire Method.

Again the use of the Taut-Wire Method is definitely limited by the length of line involved. It is doubtful whether the method will prove successful if used over a line much longer than 1300 feet. The Optical Method, on the other hand, is capable of being used over lines of indefinite extent and a system can be developed for extension of the lines with little loss in accuracy.

In conclusion, it may be said that further development of methods and instruments for the use of the Optical Method may increase the accuracy of alignment considerably. Consequently, in view of its wide application, it will without doubt be more generally employed in the future.

HYDROGRAPHIC SURVEY AIDS

H. C. Warwick, Hydrographic and Geodetic Engineer
Commanding, U. S. Coast and Geodetic Survey Ship PATHFINDER

The insular shelf off the northwest coast of Palawan Island, P. I., extends some 35 miles offshore but the survey of this area offers sufficient problems to keep it from being an almost unbearably monotonous task. A brief description of the local conditions encountered here seems desirable to explain the necessity of employing the various means used to accomplish the survey.

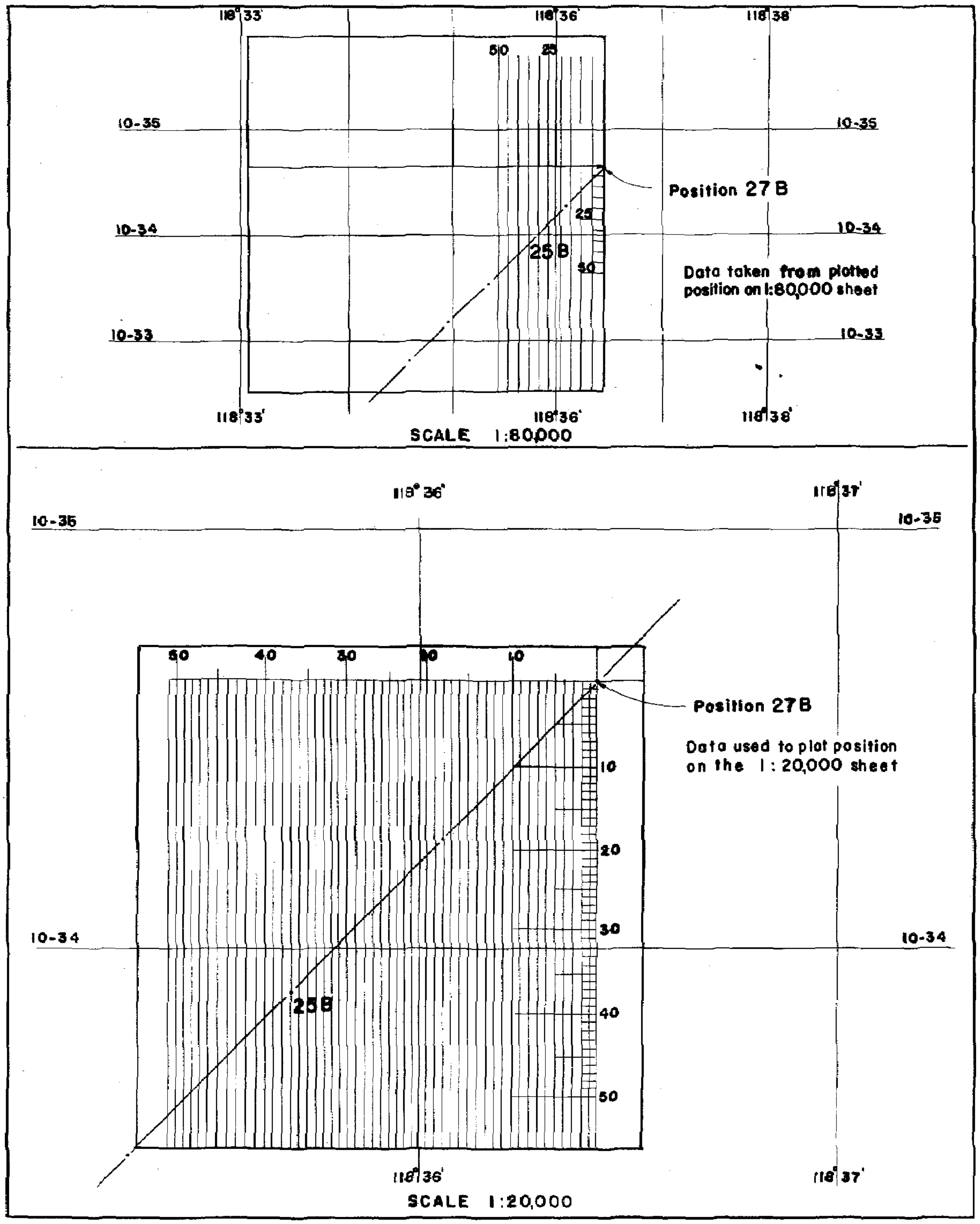
The general depths in this area range from almost nothing to 50 or 60 fathoms and this variation may occur several times on a line from shore to the insular shelf. The vast amount of development required is obvious. Visibility is not always good, regardless of the popular conception that tropical weather is always perfect. Our experience has been that the northeast monsoon (November-March) is accompanied by a thick haze and the southwest monsoon (July-October) by clouds and rain and more rain, not to speak of that southwest wind which tears up along the coast at the slightest barometric disturbance to the north, which occurs only too frequently during typhoon season.

There are some fine, clear, calm days however, and these are most likely to occur between April and August. During such weather it is advisable to concentrate on the extreme offshore work. Empirically it has been found that the major portion of the dangerous shoals are to be found just inside the 100-fathom curve, 50 miles offshore.

In 1937 we made surveys of three different scales, 1:20,000 inshore, 1:40,000 beyond that limit and 1:80,000 to the limit of the reef. The 1:40,000 scale required an extension to the double extension arm of the protractor, and the scale was much too small for the close development required. As the outer limit of the area was for the most part shoaler and more critical than the inshore area, it was decided to abandon the use of the 1:40,000 scale sheet and jump directly from 1:20,000 to 1:80,000. Numerous difficulties were encountered because of the small scale. It was almost impossible to determine whether or not a shoal was satisfactorily developed. This prompted the adoption of the 1:20,000 scale "circle" sheets, or sheets with two or more sets of arcs, constructed for each degree or half degree of angle between two prominent objects.*

When visibility is good or even fair these sheets work beautifully. The scale is proper for adequate development. Frequently, however, one or more of the objects for which arcs of equal angle have been constructed will become obscured for one cause or another. The "circle" sheet is then removed or rolled to one end of the plotting table and replaced by an aluminum plate with a 1:80,000 projection on which all prominent objects are plotted. Positions are then plotted on the aluminum sheet and transferred to the "circle" sheet, the soundings being plotted on the latter only.

* See three separate articles each entitled "Plotting Three Point Fixes Without the Use of a Protractor."
by A. M. Sobieralski, Field Engineers Bulletin, Vol. 3, p. 52;
by L. D. Graham, Vol. 7, p. 91; and
by Charles Pierce, this Volume.

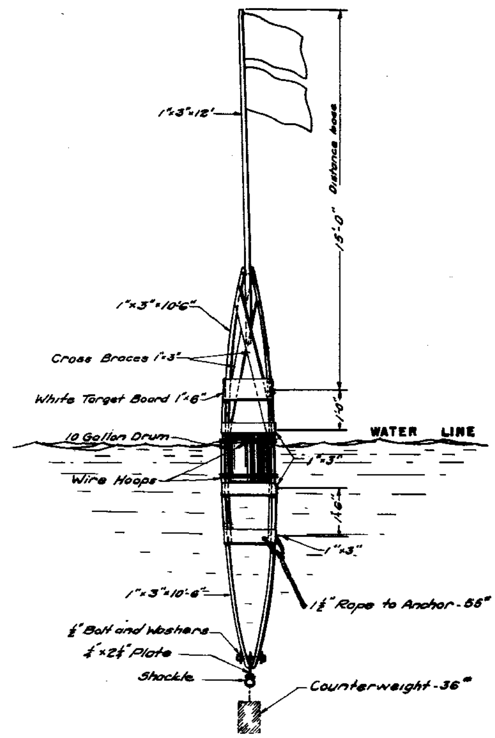


ILLUSTRATING THE TWO CELLULOID TEMPLETS USED IN TRANSFERRING POSITIONS FROM THE 1:80,000 SCALE ALUMINUM SHEET TO THE 1:20,000 SCALE SHEET

FIGURE 1

To facilitate transferring the positions rapidly, a "transfer gadget" was constructed as follows: Pieces of celluloid were cut large enough to cover the area between adjacent projection lines on each sheet. The distance between adjacent parallels and meridians was arbitrarily divided into 50 parts and these divisions were scratched on the celluloid squares and the scratched lines rubbed full of black India ink and numbered from 0 to 50. The meridian lines were drawn full length to facilitate orienting the gadget with the projection. The plotter reads off from the 1:80,000 scale aluminum sheet the minutes of latitude and longitude, if necessary, and then the number of divisions above the parallel and to right of the meridian.* Another officer places his 1:20,000 scale gadget in relative position on the large scale sheet by the readings and pricks the position through a small hole drilled through the initial of latitude and longitude divisions. This has proved a most satisfactory method and speeds up transfers considerably. See Figure I.

While surveying in this area a lookout is kept in the crow's nest at all times, and frequently, if the sun is in favorable position, shoals are detected a mile or more away by the light green color of the water. Bearings are taken to the discolored spot and the approximate position is plotted on the boat sheet. At an appropriate time, when weather and other conditions are suitable, one of the ship's launches is lowered to develop thoroughly the shoal or shoals. Naturally it is impossible for the launch to take and plot fixes from shore objects, so a small buoy, a miniature design of the standard barrel hydrographic buoy (see Figure 2), is anchored as near the center of the shoal to be developed as feasible, and located by the ship or launch from shore objects. This buoy has a target at the top and one just above the water line, exactly fifteen feet apart. To determine a fix, the launch party observes the azimuth to the buoy with an azimuth circle on an extra boat compass and the vertical angle between the two targets on the buoy. The party is furnished with a graph giving distances up to 800 meters for angles from 24° to 0° 20' based on the formula,



DETAILS OF SMALL BUOY USED IN DEVELOPMENT OF SHOALS

FIGURE 2

$$d = 0.3048 \; \frac{15}{\tan \alpha}$$

in which "d" is the desired distance from the buoy in meters, "15" the distance in feet between upper and lower targets on the buoy,

* Since the Philippine Islands are in east longitude.

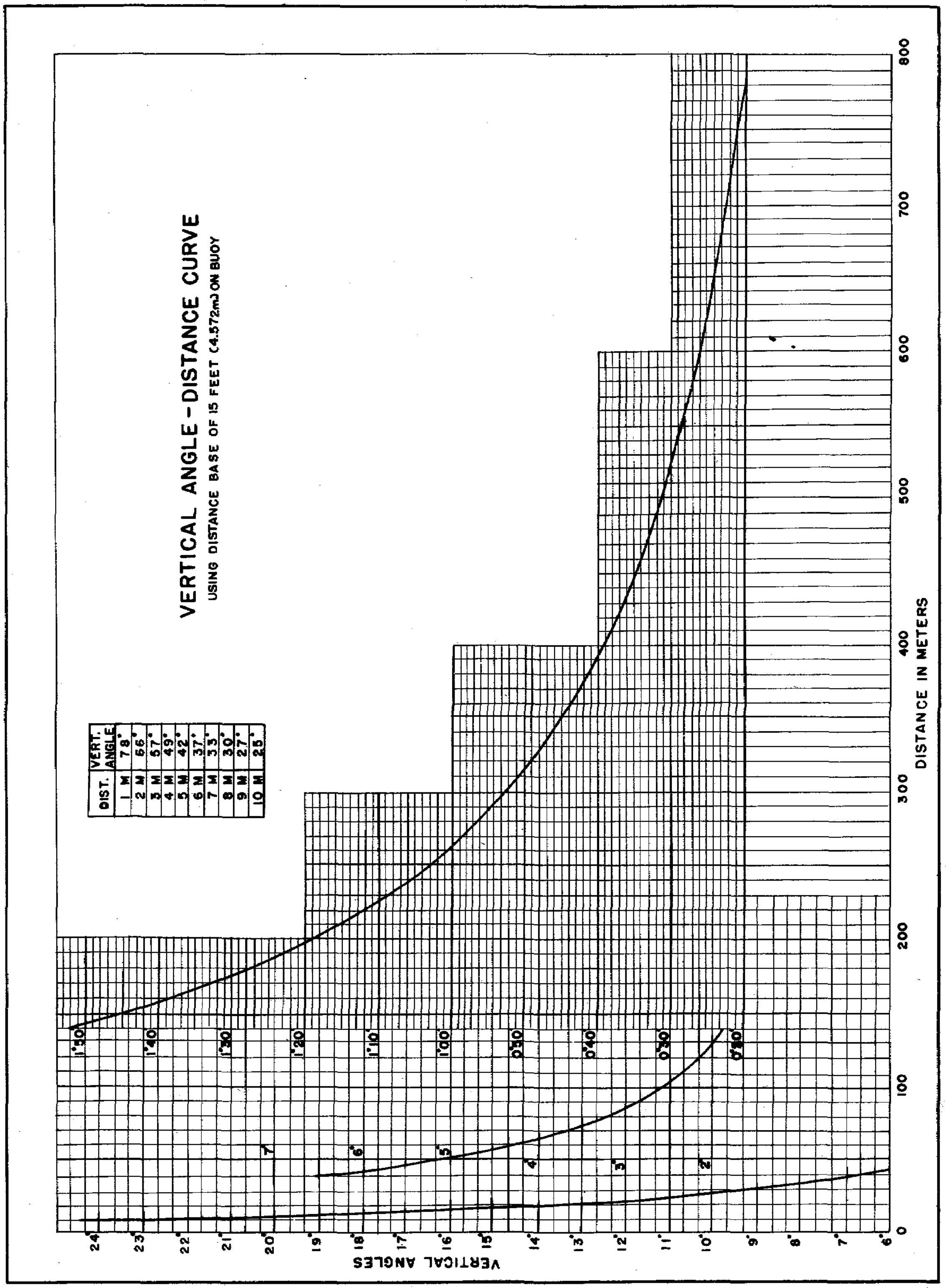

VERTICAL ANGLE - DISTANCE CURVE
USING DISTANCE BASE OF 15 FEET (4.572m) ON BUOY
DIST. | VERT. ANGLE
1 M | 78°
2 M | 66°
3 M | 57°
4 M | 49°
5 M | 42°
6 M | 37°
7 M | 33°
8 M | 30°
9 M | 27°
10 M | 25°
VERTICAL ANGLES
DISTANCE IN METERS

FIGURE 3

"α" the observed angle between targets and 0.3048 the factor to reduce feet to meters. See Figure 5.

The buoy must be kept almost vertical, so more than the usual counterweight is necessary. Furthermore, it can be used successfully only on comparatively calm days.

The positions obtained in vertical angle and bearing are plotted on a small "rose" sheet (Figure 4) which has every ten degrees of azimuth drawn on it and so numbered that the azimuth from launch to buoy may be used on it without conversion; the buoy position is taken as the intersection of the azimuth lines. In practice, the "rose" sheet is about twice the size of the figure shown.

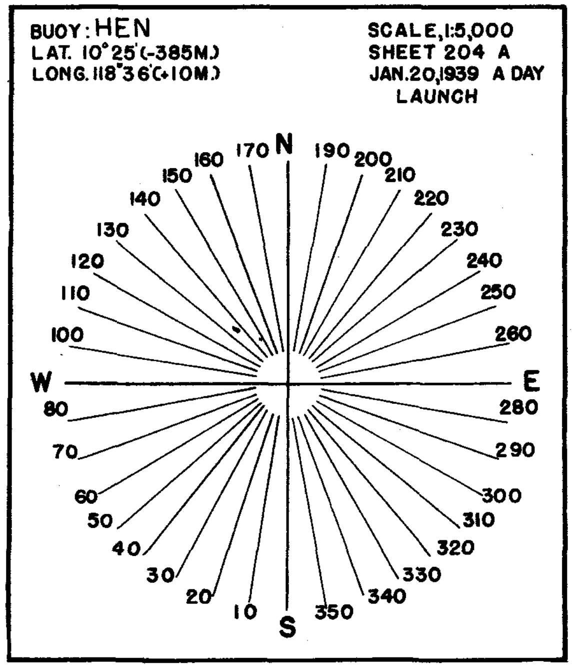


Figure 4.

The name of the buoy, position scaled from boat sheet, scale used, date, letter day and boat used are shown on the "rose" sheet, and this is submitted as a sub-sheet constituting a part of the original records. When the survey is smooth plotted the sounding lines may be plotted directly on the ship sheet, plotting azimuth and distance from the plotted position of the buoy.

Two geodetic survey engineers crossed the bay on a train with us the other morning. They were talking about the ups and downs of the bed of the Pacific Ocean. One unfolded his morning paper and turned to a business index chart on the financial page, the zigzag line of which somewhat resembles an ocean-bed survey--these days. As he talked he penciled in some figures.

"Figure the Philippines here," he said, tapping an indicated mountain peak. "Here she drops to 550 and at this point she goes down 7200 feet." He wrote in the figures. "That's the hole where Earhart went down--somewhere in there. Over here it comes up to 1500 feet again!"

He laid the paper down and forgot it and the two went off talking together. A business man--a paper looter--grabbed up the paper, stared at the chart, looked at the penciled figures, and turned white. His hands began to shake. The way he read it, steel was down to 72 and cotton was off 15 points. "My God," he mumbled. When the train "docked", he started running up Mission Street . . . .

- Earl Ennis, in the San Francisco Chronicle, January 26, 1939.

THROUGH THE STRAITS OF MAGELLAN ON THE PATTERSON
(As told by a former seaman, Thomas Ellingson)

R. R. Lukens, Hydrographic and Geodetic Engineer
Inspector, San Francisco Field Station
U. S. Coast and Geodetic Survey

One day this summer an old gentleman came into the San Francisco Field Station and asked if we had a picture or drawing of the PATTERSON. He had the alert eyes and the unmistakable deep-sea roll of the sailor, and I asked him if he had ever been on the PATTERSON. "Yes," he said, "I came around on her through the Straits of Magellan in 1884 and 1885. That was fifty-five years ago." Mr. Ellingson stated that he was eighty-one years old and spent most of his time panning gold on the Feather River. When asked if he made much money at it, he replied, "No, but it's better than doing nothing."

I was, of course, delighted to hear a first-hand report of that voyage made by the PATTERSON so many years ago and started asking Mr. Ellingson questions. He had been a seaman on the GEDNEY down on the Gulf Coast but got tired of the mud and the mosquitoes, and when the GEDNEY returned to Brooklyn, N. Y., he applied for a transfer to the PATTERSON, which was then fitting out for the long voyage to the West Coast through the Straits of Magellan. The PATTERSON was, of course, especially built for work in southeastern Alaska, and Mr. Ellingson was anxious to see both the West Coast and the Territory of Alaska, which at that time was almost unknown country. His request was granted and he joined the PATTERSON as an A. B. in Washington, D. C. "Before sailing," he said, "the PATTERSON'S masts were shortened seven or eight feet."

Under command of Lieutenant Richardson Clover, U. S. N., but assigned to duty in the Coast and Geodetic Survey at the time, the ship sailed from Hampton Roads, Virginia, on July 30, 1884. Being in the good old days, she went direct to the Madeira Islands* where she remained for a considerable period. Mr. Ellingson said the crew had a grand time there. "Plenty of good wine to drink," was the way he put it. While in port the boys on the PATTERSON raised a contribution of seventy-five dollars for the Stranger's Rest, which was apparently a sort of seaman's institute of that day.

Rio de Janeiro, Brazil, was the next port of call. Here occurred one of the high lights of the trip. The harbor was filled with vessels of all nationalities, and the word spread that the PATTERSON was equipped with the new Sigsbee sounding machine, carrying five miles of wire. It was in the days of the empire, and Emperor Dom Pedro paid a call to the ship. He came out in a great gondola-like barge with twenty oarsmen on each side. "Quite a sight," said Mr. Ellingson. As he came over the side in civilian clothes and a high hat, Captain Clover, no doubt feeling overcome in the presence of royalty, uncovered. The Emperor shook hands and, in good English, said, "Keep your hat on." About a half-hour was spent looking over the ship and examining the new sounding machine,

* Just how the call at Madeira Island was justified is hard to tell. It is certainly a long way off the direct route. Mr. Ellingson seemed to remember it very vividly. (The PATTERSON did call at the Madeira Islands, arriving August 24 and departing August 31, 1884, as verified by the PATTERSON'S log book. Editor.)

which was looked upon as something quite remarkable.*

While in Rio de Janeiro the whaleboat crew of the PATTERSON was entered in a race against crews of English, German, French, and Italian vessels. Needless to say, the PATTERSON'S crew, used to long hours of whaleboat hydrography, won the race. When I inquired if much money had been put up, he replied, "Plenty. I won fifteen dollars on the race." I imagine that the word "plenty" meant all the cash that could be raised on board.

Other South American ports were made without incident. On leaving Montevideo on November 6, 1884, the PATTERSON, with thirty tons of coal on deck, ran into a heavy gale. Though deeply laden, she rode the heavy seas without taking anything but a little spray on deck. Those of us who were on the PATTERSON in later years can testify to her fine seagoing qualities.

At Sandy Point, † which is the southernmost city in the world, they saw the huge seven-foot Patagonians, riding horses without saddles. While here Captain Mendez, of the Argentine Navy and Military Governor of Staten Island, visited the ship. In true Coast Survey style he was questioned, and Captain Clover received much valuable information concerning the straits he was about to navigate.

In the Straits of Magellan terrific winds were encountered and Captain Clover ordered the yards and topmasts struck. On one stretch the ship steamed six hours to make only five miles. At another time the vessel got the wind on the bow, and in order to keep her from running straight into the shore, her commander was compelled to back and wear short around and came near losing both steam launches in doing so.

Beyond Sandy Point they ran into a fleet of one hundred and fifty canoes manned by Tierra del Fuegans all dolled up in war paint. The commander ordered up their six Gatling guns and passed out Springfield rifles and Colt pistols to the crew. In order to avoid running down the frail craft, the engines were slowed down to half speed. All the Tierra del Fuegans were equipped with small hooks on heaving lines, which they threw aboard and caught along the railing. In no time at all the whole fleet of canoes was fast to the ship.

It turned out that they had no bellicose intentions but only wanted to trade, mostly for tobacco, fire water, and lastly grub. Mr. Ellingson said that quite a brisk barter went on for a considerable period. He himself traded a plug of tobacco for a goat and also made a dicker with a squaw for a beaverskin for which he gave her two plugs of chewing tobacco. After the period of trade was over the PATTERSON proceeded on her way, none the worse for the encounter.

They gradually worked their way through the Straits of Magellan and made the last anchorage before the open Pacific on a Saturday night. On Sunday morning all hands were called on deck and ordered to get up topmasts and yards and "den ve had trouble". The whole

* From an entry on October 9, 1884 in the PATTERSON'S log book "At 11:30 sighted the Imperial yacht coming around Rat Island. The men-of-war in the harbor manned the yards and fired salutes of 21 guns. At 11:40 His Imperial Majesty Dom Pedro II of Brazil and personal staff came aboard and inspected the ship and her outfit. At 12:30 His Majesty left the ship and the men-of-war again manned their yards and fired salutes of 21 guns. Expended one Coast and Geodetic Survey work on 'Deep Sea Soundings' presented to the Emperor."

† Punta Arenas (Magallanes), Chile.

crew refused duty. Mr. Ellingson said that Captain Clover was a tough skipper and he lost no time in putting down the uprising. He called all hands to muster and read the Articles of War in which, of course, were written the dire consequences of refusal of duty. He then asked how many men were willing to turn to. Mr. Ellingson said that he and all the rest of the crew, with the exception of one man, immediately went to work. The one stubborn fellow, who continued to refuse duty, was kept in the shaft alley in double irons on bread and water for a week. "As a matter of fact, however," said Mr. Ellingson, "that man had about the best food on the ship, for everybody smuggled titbits down to him during the night watches."*

About this time Ellingson's time was up and he wanted to be paid off and remain in South America, but the captain refused to let him go and he had to ship over. At one of their stops he hired a horse and, with a large tigerskin for a saddle, rode up the mountain to Concepcion. Here he was given some pieces of quartz with gold. This gold apparently imbued him with the mining fever which never left him, for after his days on the PATTERSON he spent many years prospecting and mining in Alaska.

They arrived in Valparaiso, Chili, after the close of the war between Chile and Peru. Here, sailor-like, he again took a horseback ride, during which he was thrown and broke his jaw. "It was about this time", Mr. Ellingson said, "that 'fighting' Bob Evans, in command of the HARTFORD, threatened to bombard the town unless certain of his sailors who had been arrested on shore were released." The townspeople, according to Mr. Ellingson, hated Americans and once when a group of the seaman from the PATTERSON were returning to their ship, the city fireman turned the hose on them.

The next stop was at Callao, Peru. Here he got some leave and took a side trip to Lima to visit his aunt. The next stop was at Panama which was at that time a fever-infested place, but, nevertheless, the crew had two days' liberty. While off Panama they captured sixteen live turtles basking on the surface of the water, and Ellingson said they were fine eating. I well remember when the PATTERSON made another voyage to Panama in 1912, the crew did the same thing. The writer, however, after witnessing a turtle butchered on deck, was unable to eat a single bit of meat.

After stops at Acapulco, Mexico, San Diego and Santa Barbara, the PATTERSON arrived at San Francisco on February 15, 1885, and preparations were immediately started for taking up the first season of work in southeastern Alaska.

"They wanted me to stay on the ship, " Ellingson said, "but I did not like Captain Clover. So in accordance with his promise made at Valparaiso, he paid me off. One day, about a year later, I met Ensign Niblack on Market Street in San Francisco, who told me Captain Clover had been relieved by Lieutenant Commander Snow, who, according to Ensign Niblack, was a fine skipper." At Niblack's insistence Ellingson went down and signed up on the PATTERSON. Finding no vacancy for a seaman, he signed on as a fireman in which rating he got five dollars additional pay per month. He remained on the ship for

* Only two short entries concerning this incident appear in the PATTERSON'S log book. On Sunday November 23, 1884, the entry is "By order of Commanding Officer, Carl Johansen (seaman) and Charles Rehmstrum (seaman) in confinement on bread and water until further orders for refusing to obey an order of the Commanding Officer." Then, on Thursday, November 27, "At 11:40 all hands were called to muster. Commanding Officer read part of articles of war and released prisoners."

Editor.

three cruises to Alaska. During those days the PATTERSON returned to Mare Island for the winter season. At that time he said the marshes around Mare Island were fairly alive with ducks and geese and during the winter the crew lived the life of Reilly. The mess funds accumulated to such an extent that the crew purchased an organ for the ship. The wardroom steward was a very musical individual, Ellingson said, and bought himself a horn to play. The sailors amused themselves by stowing their woolen socks in the horn, much to the annoyance of the steward.

At this time, he stated, the PATTERSON carried two very fine launches, the VIXEN and the PIRATE. I don't know what became of the PIRATE, but the VIXEN was aboard the ship for many years and, I think, was finally lost while being hoisted during rough weather in Puget Sound about 1909.

Returning to the matter of the pictures or drawings of the PATTERSON, Mr. Ellingson wants to make a model of the ship. As I had no suitable photograph in the files of the field station, I procured one from the Washington office and sent it to him. I hope some day to see a fine model of the PATTERSON as the result of his call at the San Francisco Field Station.

The ship GEDNEY, on which Mr. Ellingson served on the Gulf Coast, prior to his enlistment on the PATTERSON, was a steam schooner of 175 registered tons, 122 feet long and about 24 feet beam. Built in 1875 for the Coast and Geodetic Survey by C. H. DeCameter and Company of New York, the vessel was of composite construction and powered by a single cylinder engine of 180 horsepower. After commissioning, the GEDNEY was engaged in survey work on the Atlantic and Gulf coasts until the fall of 1888, when, like the PATTERSON, she was ordered to the West Coast. Unlike the PATTERSON, however, the GEDNEY failed to call at the Madeira Islands. Leaving Hampton Roads on November 16, 1888, the first port of call was St. Thomas, now Charlotte Amalie, Virgin Islands. Thence to Rio de Janeiro, and then through the Straits of Magellan, up the west coast of South and North America, stopping at Valparaiso, Chile, Acapulco, Mexico, and San Diego, finally arriving at San Francisco on April 20, 1889. After outfitting at San Francisco the vessel left for survey duties in the vicinity of Port Orford, Oregon. During the remainder of her service the GEDNEY was engaged in work on the Pacific Coast and in Southeast Alaska, finally being sold in 1915.

The history of the PATTERSON was described in Field Engineers Bulletin No. 12 in connection with the loss of the vessel in December 1938 when it foundered on the coast of Alaska, near Cape Fairweather.

No record remains of the launch PIRATE, one of the two launches mentioned by Commander Lukens. The VIXEN was a 27-foot steam launch built by the Herreshoff Manufacturing Company in 1884. It was lost on December 34, 1908. Several features in Alaska are named after these two launches. "Vixen Inlet" was named in 1886 by Captain Snow under whom Ellingson served, and "Vixen Bay" and "Vixen Islands" by Captain W. I. Moore in 1892 and 1895 respectively. "Pirate Peak" was named in 1887 by Captain Charles M, Thomas who succeeded Captain Snow to the command of the PATTERSON. "Pirate Point", on the southeastern shore of Pearse Island, was named in 1891.

TRIANGULATION—SHIP INTERSECTION METHOD

Charles Pierce, Hydrographic and Geodetic Engineer
Executive Officer, U. S. Coast and Geodetic Survey-
Ship PATHFINDER

Introduction

With the completion of the coastal triangulation to the vicinity of Bluff Point, west coast of Palawan Island, P. I., in September 1938, it was apparent from a cursory reconnaissance of the area south of this point that standard triangulation control would be expensive to execute and strong figures difficult to obtain. The high, densely covered, wooded peaks lie close to the shore line, within 1/4 to 1-1/2 miles, and the topography, in general, consists of heavily timbered ridges running normal or obliquely to the general trend of the coast line. It was also apparent that traverse control would be impracticable as the coast line is rocky and extremely irregular with numerous points jutting into the sea.

A general discussion among the officers of the PATHFINDER brought up the subject of triangulation by intersection of the ship, which to our knowledge has not been attempted in our service, although we understand has been tried by the Hydrographic Survey of Canada on some of their work in the Pacific Northwest.

The following discussion is a report on the results obtained by the PATHFINDER personnel on an experimental trial of triangulation by ship intersection using control in the vicinity of Bluff Point, west coast of Palawan, as a proving ground.

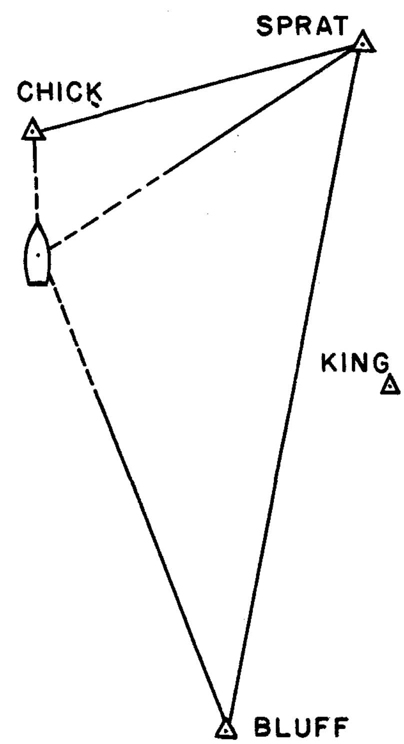
Theory of Triangulation by Ship Intersection

Triangulation stations should be established along the coast line, adjacent stations intervisible, and where practicable, three contiguous stations intervisible. The control starts from two existing stations whose geographic positions are known, as well as the azimuth and distance between them. To locate a third station ahead, the ship is anchored at an offshore position so as to give the strongest distance angles for the two triangles formed by the ship and the three shore stations. The three shore triangulation stations are occupied, using the best theodolites available, and simultaneous horizontal angles are observed on a suitable target on the ship. Triangle computations are made for each horizontal angle measurement made ashore, carrying the starting base line ahead through the two triangles formed by the ship and three shore stations, to the desired line ahead. An equal number of direct and reverse pointings are made to eliminate collimation errors of the theodolites, and the mean lengths determined for the unknown line from each direct and reverse set are averaged. The final mean length of the unknown line is obtained by averaging the means of each set of direct and reverse values.

For computation of the geographic position of the point ahead, standard traverse computation forms may be used. In carrying the azimuth ahead standard second-order observations between the intervisible stations can be made exactly as is done on regular triangulation control.

Field Test

On January 25, 1939, the ship was anchored in the vicinity of the Hen and Chicken Islands approximately two miles offshore. The three stations selected for the test were SPRAT, KING, and BLUFF, 1938, but it was impossible to occupy station KING at that time on account of a rough sea and heavy swell which swept over it occasionally. Consequently station CHICK was used as the third station. Following are the distances of the ship from the shore stations: CHICK, 0.6 miles; SPRAT, 1.9 miles; and BLUFF, 2.6 miles. As mentioned before, a heavy swell was running which caused the ship to roll considerably. A target was made of black and white boards, one foot in length, fastened to a 2" x 2" pole. This target was secured to the awning stanchions on the wings of the bridge, with the top of the target well above the top of the awnings. When the ship swung at its anchorage so as to bring the masts, stack and rigging in line with any of the observers, the target was transferred to the opposite wing. A large black and white signal flag on a long pole was used for signaling the shore stations. The schedule used was as follows. When each observer ashore was ready to observe, a man in a conspicuous position at each station waved a flag signaling ship, "Observer here ready". When all signals were received, the ship then blew one long blast of whistle. This signal was zero hour and so recorded on each of three watches at the observing stations ashore, these watches having all been previously set to within ten seconds of one another. One minute later the ship's long signal pole with flag was placed directly over the target for "stand by". Thirty seconds later it was rapidly hauled down. As soon as the ship's signal flag started down, simultaneous angle observations ashore were made on the ship's target. One minute later the ship's signal flag was again raised over the observing target for "stand by" and 30 seconds later hauled down for time of observation. This procedure was repeated for 14 observations, seven with telescope direct and seven reverse. The time of each observation on the ship's target was recorded at each shore station to permit comparison later in order to verify that the observations were simultaneous.



The target on the ship was very distinct and the beginning of the descent of the signal was detected instantly ashore since it was directly above the target, at which the observers ashore were pointing their telescopes during the 30 seconds "stand by" interval. It should be emphasized here that conditions were quite adverse for this test because of the heavy swell and resultant roll of the ship and target. From station BLUFF, 2.6 miles away, the movement of the target was approximately the width of the astronomical wires. At station CHICK, which was only 0.6 miles away, this movement of the target was correspondingly greater.

Results

The length of the line BLUFF to SPRAT was held fixed as a base line and the length of the line CHICK to SPRAT computed for 14 observations, seven direct and seven reverse pointings. The length as computed in this manner was compared with the length as obtained from the 1938 triangulation. There were three lengths rejected out of 14 observations. Considering the mean length of each direct and reverse set, there were two rejected sets in seven values. The mean length of the line CHICK to SPRAT determined from these five values showed a discrepancy of 13 in the sixth place of logarithms, or 1:31,700.

The theodolites used in this field test were one 6-1/2" Parkhurst second-order direction instrument, reading to one second of arc, and two 7" repeaters, each reading to ten seconds of arc. Observers pointed once on the initial for each observation on the ship's target. Computations included two triangle computations for each observation on the ship or 28 triangle computations, and one abstract of lengths for each set of 14 observations.

The results follow:

No.	Length SPRAT-CHICK		Mean	
	log	meters	log	meters
1 D	3.501 048	3169.92		
1 R	3.501 015	3169.68	3.501 032	3169.80
2 D	R(3.500 962)			
2 R	3.501 043	.89		
3 D	3.501 069	3170.07		
3 R	3.501 093	.24	3.501 081	3170.16
4 D	R(3.501 640)			
4 R	R(3.500 996)			
5 D	3.501 032	3169.80		
5 R	3.501 032	.80	3.501 032	3169.80
6 D	3.501 027	3169.77		
6 R	3.501 059	3170.00	3.501 043	3169.88
7 D	5.501 086	.20		
7 R	3.501 064	.04	3.501 076	3170.12
Mean of 5 sets			3.501 053	3169.95
Value from 1938 triangulation			3.501 040	3169.86
Diff.			13	1:31,700

Conclusions

From this field test under rather adverse conditions it appears that triangulation could be carried forward with this method for a reasonable distance with expectancy of third-order accuracy upon connecting to triangulation control. On the coast line south of Bluff Point, where it appears advisable to use this method, there is a distance of approximately 36 miles, airline, before a connection can be readily made to existing triangulation extended northward.

An interval of two minutes between observations on the ship seems preferable to the 1-1/2 minutes used on this trial. Experience further shows that all the theodolites used should be adjusted for collimation as perfectly as possible and that the remaining error of collimation should be less than ten seconds.

Empirically it appears that 12 acceptable observations for angle measurement should be secured on this class of work, that is, six direct and six reverse pointings of the telescope. It is suggested that 20 observations should be made ashore in order to be certain to have 12 acceptable values. It is further recommended that a rejection limit of 1:10,000 be applied until further information has been secured on this type of work.

Where longer lines are to be observed and to improve simultaneous observations, it might be advisable to install at each station ashore a short wave radio receiver with head phones for the observers, and have the ship transmit by code the instant for observation.

The possibility of depths too great for the ship to anchor would present another problem. In this event it appears feasible for the ship to heave to, but the more rapid movement of the ship's target increases the errors in case the observations were not precisely simultaneous, and this increased movement itself would make truly simultaneous observations more difficult. Anchored buoys could be used and a test of their use might be worth while, but in this case radio communication would be necessary for simultaneous observations.

ROOM DESIGNED FOR CHARTS

Gentlemen:

We have a client who desires us to obtain for him a complete set of charts of the sections of Aeronautical Survey of the whole country.

His intention is to cover the entire walls of a Map Room in his residence with these charts. We are interested to know as quickly as possible the size and number of these charts and how much border they have which could be eliminated.

If you have a diagram or other information regarding the combining of these charts, we would appreciate your sending it as we are designing the room especially to receive them and can, if necessary, change the heights of the ceiling.

Very truly yours,

- - - - - - - - - - Architects.

LIGHTED SURVEY BUOYS

G. C. Mattison, Hydrographic and Geodetic Engineer
Commanding, U. S. Coast and Geodetic Survey-
Ship HYDROGRAPHER

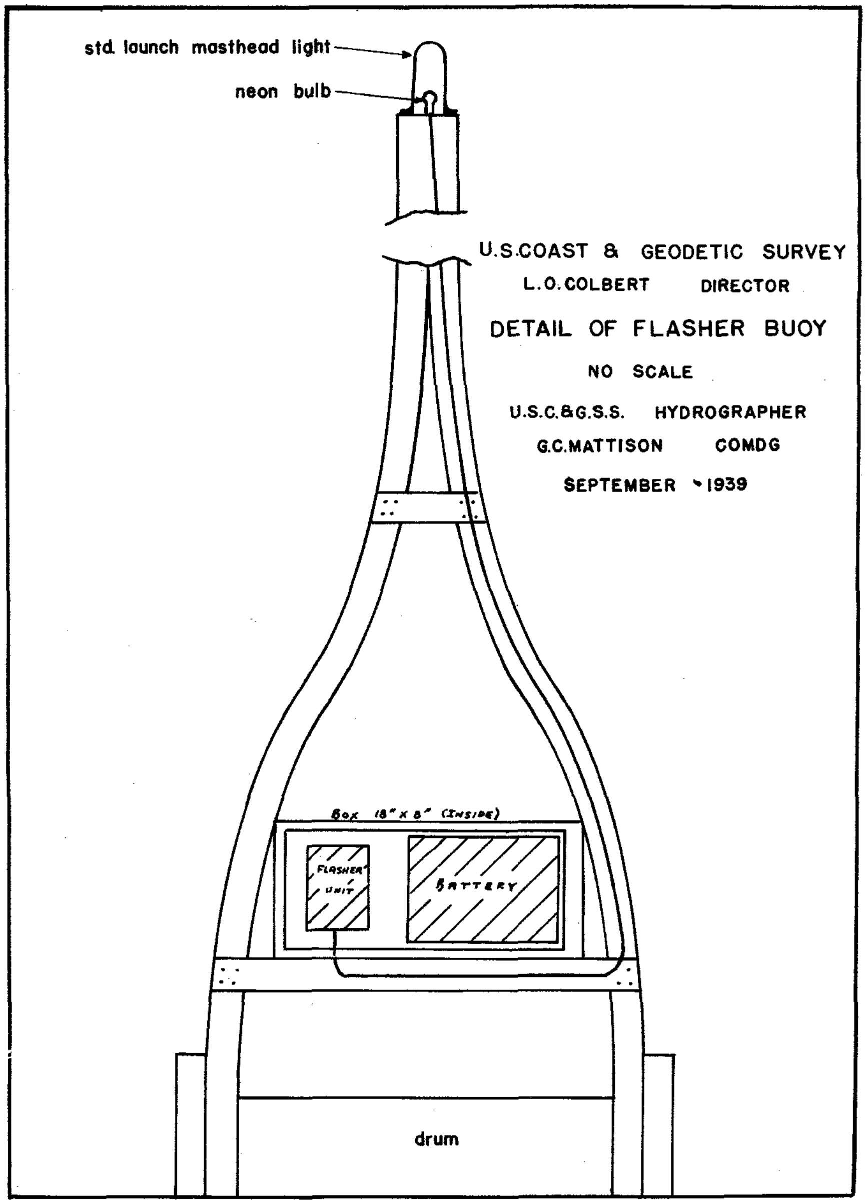
A study of the HYDROGRAPHER's project for the 1939 season indicated that lighted survey buoys would be of great value in expediting the work.

The subject of lighted buoys was not new since lighted sono-radio buoys were used by Commander F. S. Borden on the HYDROGRAPHER in 1936, as described in Dr. Mcllwraith's article on page 146 of Field Engineers Bulletin No. 10. In the case of Commander Borden's buoys, the light was operated by the noise of an approaching ship so that the buoy was dark except when the transmitter was actuated by some sound in the hydrophone. This complicated the sono-radio buoy slightly, and to avoid this and to have the light available for any type of buoy seemed sufficient reason to try another type of light.

Preliminary inquiries addressed to officials of the Lighthouse Service and various supply houses resulted in very unpromising replies. Apparently, the only equipment available would be either too expensive, too cumbersome, or else would not be suitable for marine use. We informed the Washington Office of our needs, with the result that an assembly, which had never been tested at sea, was obtained for trial from the National Carbon Company. This equipment has proved so satisfactory that it is intended to equip several buoys in a similar manner. The three units, consisting of light, flasher equipment and battery, are so compact and light in weight that it hardly seems possible that improvement could be made along these lines. The weight is but a fraction of that of other equipment for such a use. The same relation holds true regarding cost. Although other equipment was not available for test, it is evident from descriptive literature, that the accepted unit has the simplest operating mechanism and apparently requires very little attention to keep it in operation.

Showing Housing for Flasher Unit and Battery and Mounted Light Fixture

The parts used in the assembly are shown in the accompanying photograph and sketch. The light consists of an Amglo Batrilite No. 75-C3R, which fits into a standard 4-prong radio tube socket. This is mounted in a standard masthead light fixture which is held in place by a 1/2-inch brass pipe about 18 inches long



screwed into the base of the fixture. The lower 14 inches of this pipe is flattened out and has two screw holes used for mounting on the buoy upright. Rubber covered Tyrex cable extends from the tube socket into the pipe and out through a 3/8-inch hole drilled one inch below the base of the fixture. This wire extends down the buoy framework to the box containing the operating unit and battery. This box is mounted between buoy braces almost five feet above water. As it is about four inches in thickness, it is almost flush with the edges of the two by four inch pieces on each side. There is ample room in this container for the Eveready Luminous Tube operating unit Model A6-80L, and the 6-volt hot-shot battery of four dry cells. There is no difficulty with the wiring as the terminals are plainly labeled. Rubber gaskets are used on the battery box to make it watertight, and all outlets for connections are made as watertight as possible.

The units can be obtained with a flashing frequency of either 80, 200, or 400 flashes per minute. The battery life with the respective units is 110, 100, or 40 days. The 80-flash unit was selected as it gave the maximum battery life.

The total cost will vary depending on the local cost of the construction material. The Amglo Batrilite cost us $3.00 each and the Luminous Unit $7.95. The total cost for material per buoy amounts to slightly over $20.00. Quantity purchases should make the price within a few cents of that amount.

We have been unable to see the buoy beyond a distance of two miles, and at that distance only under very favorable conditions. One mile seems to be the average limit of visibility. It is believed that a greater range of visibility can be obtained with some other type of globe than the Fresnel. This type is designed for an upright position and will not give its maximum efficiency when rigidly mounted on a survey buoy which is canted over due to wind or current. We may be able to devise a practical counterbalance mounting that will have an effect similar to gimbals. We also intend to experiment with different types of globes. It is possible that a 200-flash tube will give a greater range of visibility than one with only 80 flashes per minute, and with only a ten per cent decrease in battery life.

We intend to use lighted buoys as a protective measure in areas where there is considerable maritime traffic. Although we only have evidence that vessels have dragged two of our buoys during the past two seasons, it is quite possible that vessels colliding with them may account for the loss of some other buoys. It is evident that the majority of vessels do not avoid our buoyed areas, even after receipt of radio broadcasts. Incidentally, it may be of interest to note that one of the known collisions with our survey buoys was with the <u>lighted</u> buoy. No information is available as to whether the collision occurred at night or during the day, but the master of the vessel reported that he had collided with a lighted buoy, the position agreeing with our broadcasted notice.

COMMENT

Dr. Herbert Grove Dorsey, Principal Electrical Engineer
U. S. Coast and Geodetic Survey

The Amglo Corporation of Chicago manufactures the neon lamps supplied with the flasher which Commander Mattison used. This company also makes a flasher which they call a "Flasherpak".

Apparently the only way of increasing the brilliancy of the light is to raise the input voltage above six, the usual value. This would give more current in the primary of the step-up transformer and higher voltage to the tube. The battery life would be less when using, say 12 volts rather than six volts, and it is probable that the life of the neon bulb, "Batrilite", would be less, and possibly the contacts of the flasher would wear out sooner, although this may not be true since a mercury switch is used. The Amglo Corporation had no information on those problems except to suggest that the battery life could be extended by putting more batteries in multiple. A trial of higher battery voltage for a month would probably answer the questions of intensity of illumination, battery life, and so forth.

SUBMARINE SCARP OFF CAPE MENDOCINO, CALIFORNIA

Harold W. Murray, Associate Cartographic Engineer
U. S. Coast and Geodesic Survey

The significance of Cape Mendocino and the nearby area to navigators using these waters is a classic example of the use of submarine and shore configuration in position determination. The Pacific Coast Pilot describes the cape as a "mountainous headland" and "famous landmark of the old Spanish navigators". The cape is a turning point for nearly all vessels bound north or south and, in view of the dangers in this vicinity, must be approached with great caution in thick weather because the currents and irregular bottom tend to make the ordinary methods of navigation uncertain. It is also in a region of great climatic change, and the meteorological conditions northward of the cape are quite different from those to the southward. Fog, for example, is more prevalent to the southward, whereas rainfall is heavier and the northwesterly winds of summer are more violent to the northward. The combined influence of these factors on navigation is emphasized by the number of wrecks which occurred during the earlier years of the present century when the then existing hydrographic surveys were so woefully inadequate.

A vessel running the courses commonly used in this locality would approach Cape Mendocino from the north on a course of 176° and would expect to pass about six miles off the cape to clear safely the known dangers. When the cape is abeam and bearing about East, the course would be changed to 160°, a 16° change to the East. That is, to exaggerate, one might say that a vessel has to run out and around the cape, keeping six miles off. It is evident that if one did not run far enough or, in other words, changed course too soon, the vessel would run onto the shoals or onto the cape itself. The currents in this locality are strong and variable, some wind effects are little known, and fog is more prevalent than in most places on the coasts of the United States, there usually being approximately 1,300 hours of fog per year. A vessel passing the cape may well have been running for many hours in fog without sight of any fixed object and be entirely dependent on dead reckoning and soundings for an approximate position.

It was during a period of foggy weather in the year 1916 that the master of the Steamer BEAR, "when his reckoning put him about 15 miles northward of Cape Mendocino, began to take soundings to locate his position" and feel his way to the lightship anchored off the cape. The soundings immediately indicated that the vessel was proceeding over deep water of 100 fathoms or more. When the depths began to shoal from 80 fathoms to 34 fathoms and subsequent soundings showed substantially deeper water, it appeared from the published chart then in use that the vessel had safely passed the cape and the course was changed as usual. About an hour later the vessel stranded two miles north of the cape with a loss of six lives. The contributing factor in the disaster was that the misleading soundings had been obtained in a reported but unsurveyed and, consequently, inadequately charted submarine depression (Eel Canyon) several miles northward of Cape Mendocino.*

* See Coast and Geodetic Survey Special Publication No. 48 (1918), "The Neglected Waters of the Pacific Coast", for details of this and other accidents.

Between the years 1899 and 1917, 15 wrecks or strandings occurred in this area and an additional 50 occurred at other points along the California coast. Accidents off the coasts of Oregon and Washington in this period totaled 26 and 15 respectively. In each case the lack of hydrographic surveys, insufficient knowledge of currents, and inadequate charts were the contributing though not necessarily the sole factors involved.

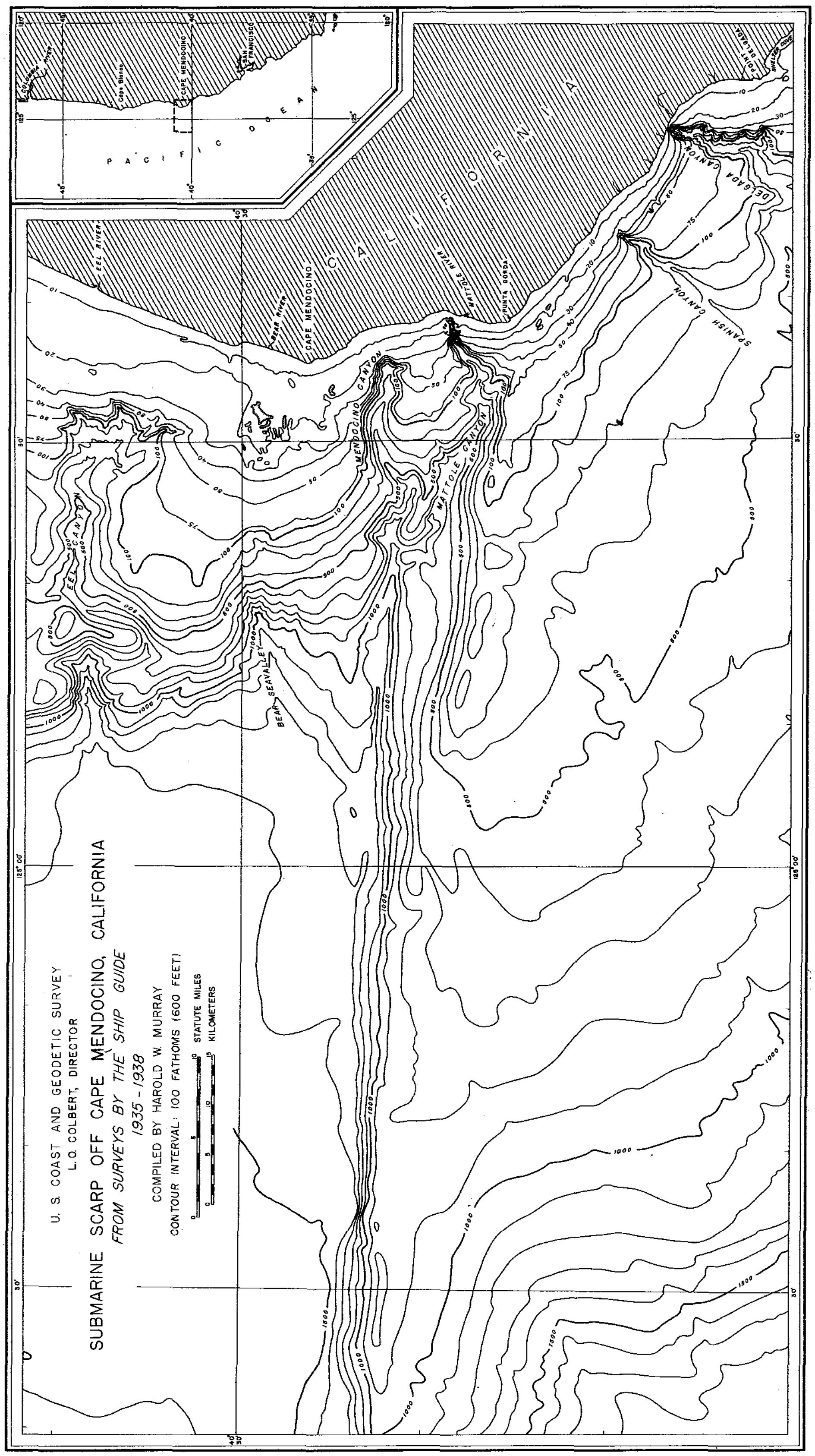
Hydrography previously executed by the Coast and Geodetic Survey in the vicinity of Cape Mendocino, aside from earlier reconnaissance surveys, consisted principally of 1:10,000 and 1:20,000 scale surveys accomplished between the years 1872 and 1886. These surveys, generally speaking, extended from six to eight miles offshore and included the heads of all submarine depressions terminating within the above mentioned limits. All soundings were vertical casts and probably did not exceed 20,000 in number.

It was not until the years 1919 to 1921 that the Roast and Geodetic Survey Ships WENONAH and LYDONIA, R. R. Lukens and E. H. Pagenhart commanding, surveyed the offshore area of Cape Mendocino and exposed the rather complex submarine topography existing offshore for a distance of at least 67 statute miles. The deeper offshore soundings, totaling about 6,500, were obtained by the laborious and time-consuming vertical cast method, horizontally controlled in part by dead reckoning and by three-point fixes on shore objects. The intensity of hydrography was naturally limited by the methods used, by the length of time available, and by the funds allotted to the vessels, but was accepted as adequate for the needs of navigation and the heretofore reported but mysterious Eel Canyon was now definitely surveyed and firmly secured within the confines of a geographic projection.

In 1955 the Coast and Geodetic Survey's plan of making modern and more intensely developed surveys, a project begun in 1932 at the southern limit of the State of California, had progressed northward to the vicinity of Cape Mendocino. The submarine topography revealed in the waters contiguous to the cape is shown by the submarine contours in the accompanying illustration.

The hydrography represented in the illustration was obtained at selected intervals during the period from 1935 to 1938 by the Coast and Geodetic Survey Ship GUIDE, F. H. Hardy, O. W. Swainson, and E. W. Eickelberg commanding. These surveys consisted of three series. One series of nine 1:10,000 and one 1:20,000 scale surveys embracing the area between the shore line and the 20-fathom curve consisted of 48,000 soundings. The second series was composed of one 1:20,000 and three 1:40,000 scale surveys extending from the 20-fathom curve to distances of three to seven statute miles offshore and consisting of about 25,000 soundings. The last series consisted of one 1:120,000 scale survey with about 7,000 soundings extending from the last mentioned limits to more than 66 miles offshore. In all, a total of more than 80,000 soundings have been taken within the area of the illustration. The soundings obtained are principally echo soundings supplemented by vertical cast and hand lead soundings in the waters adjacent to the shore line. Horizontal control consisted of three-point fix angles on shore objects in the inshore area and radio acoustic ranging in the offshore area.

The contour interval shown on the illustration is 100 fathoms (600 feet) for depths of 100 to 1,800 fathoms. In depths less than 100 fathoms the 10-, 20-, 30-, 40-, 50-, and 75-fathom contours are


U. S. COAST AND GEODETIC SURVEY
L. O. COLBERT, DIRECTOR
SUBMARINE SCARP OFF CAPE MENDOCINO, CALIFORNIA
FROM SURVEYS BY THE SHIP GUIDE
1935 - 1938
COMPILED BY HAROLD W. MURRAY
CONTOUR INTERVAL: 100 FATHOMS (600 FEET)
STATUTE MILES
KILOMETERS
CALIFORNIA
PACIFIC OCEAN
EEL RIVER
BEAR RIVER
CAPE MENDOCINO
MATTOLE RIVER
PUNTA GORDA
EEL CANYON
MENDOCINO CANYON
MATTOLE CANYON
SPANISH CANYON
DELGADA CANYON
BEAR SEAVALLEY

shown. The contour interval used in the 1:120,000 scale survey previously mentioned was 25 fathoms, or four times greater. This insured a more accurate contour delineation in areas where echo soundings were practically continuous on rather widely-spaced sounding lines.

The diversity of submarine topography expressed in the illustration is self-evident. Heading the list is the long submarine scarp one-half to one mile in height extending more than 66 statute miles from shore. The western extremity of this feature has not as yet been ascertained. Portions of the face of the scarp plunge downward to the north with a steepness of from 24 to as much as 100 per cent. The downward slope of the top of this scarp, measured from the closed 200-fathom contour to the closed 800-fathom contour, is 1.7 per cent. However, from the western extremity of the 800-fathom contour to the western limit of the 1,000-fathom contour (outside the limit of the illustration), the rate of descent has increased to 3.9 per cent. The ocean bottom to the north and northeast of the scarp is quite flat and about one and three-fourths miles below the surface of the ocean, whereas the bottom to the south of the scarp slopes gently southwestward at a rate of 3.8 to 7.6 per cent accompanied by a depth change of from one-fifth to two miles. This scarp with the three types of contrasting topography constitutes a submarine feature too unusual to possess a known rival on the entire West Coast.

The 100-fathom contour closely approximates the limit of the continental shelf which is broader on the north than on the south. The continental slope beginning at the 100-fathom contour slopes away in the broader areas at a rate of about 4.3 per cent just above Spanish Canyon and is as great as 11 to 19 per cent on either side of Bear Seavalley where it is considerably shorter in length. Here again contrasting topography is presented in that the rate of slope on the north is about three to four times greater than that to the southward.

Submarine canyons are well entrenched on either side of the scarp and protrude several miles into the continental shelf. Mattole and Delgada canyons to the southward of the cape are remarkable in that they extend so close to shore. Eel Canyon on the north has a broad head about five miles wide with five pronounced tributaries. It traverses a distance of 52 statute miles between the 30- and 1,400-fathom contours. The bottom gradient between the 75- and 900-fathom contours, a distance of about 25 miles, is from 5.0 to 3.0 per cent. At the 900-fathom contour the bottom slopes steeply to a depth of 1,300 fathoms with gradients as great as 30.3 per cent after which it lessens to about 2.4 per cent. The submarine knoll existing near the mouth of the canyon, around which the stream channel has had to travel 11 miles, is a phenomenon in deflection of submarine canyon courses. This knoll will evoke an interesting discussion as to whether it is younger or older than the canyon, or contemporary with a portion of the canyon's history. The fact that the mouth of the canyon including that portion of the canyon just eastward of the knoll approaches a straight line would imply, for example, that the canyon was fault-controlled and that the knoll was a subsequent intrusion occurring at some time after the canyon was well established.

Bear Seavalley is about. 18 miles long between the 75- and 1,400-fathom contours. Its gradient is about 14 per cent down to the 500-fathom contour, thence 30 per cent to a depth of 1,000 fathoms after which it levels out from 11 to as low as 2.9 per cent. The name of this feature was supplied by the writer, all other names shown on the illustration being in use on the later editions of the Coast and Geodetic Survey charts of this area. The term "seavalley", however, is a recent decision of the United States Board on Geographical Names and is applied to submarine depressions that are of valley form but unaccompanied by steep adjacent parallel walls such as are found in canyons.

Although outside the scope of this article, it is nevertheless of practical interest to note that another recent decision is "seamount". This new term is being applied more frequently off the West Coast and is used to denote a submarine elevation of mountain form. As a specific example, the first feature to receive this designation was a submarine mountain discovered by the Coast and Geodetic Survey Ship GUIDE in 1933 about 75 miles west of Point Piedras Blancas, California. This feature rises from a depth of 1,900 fathoms to 729 fathoms and has a net elevation above the ocean floor of 1,171 fathoms or 7,026 feet. It was named "Davidson Seamount" in honor of George Davidson (1825-1911) of the U. S. Coast and Geodetic Survey.

Mendocino and Mattole canyons join at a depth of around 900 fathoms. Their lengths inshoreward from this point are 14 miles to the 40-fathom contour and 18 miles to the 10-fathom contour respectively. Two alternate outlets into the broad region of the 1,400-fathom contour are possible: one where Bear Seavalley enters, and the other about nine miles farther westward. The total lengths, in the case of the longer Mattole Canyon, to the two outlets are about 39 and 48 miles. Mendocino Canyon is more direct and has a gradient of about 6.4 per cent from a depth of 200 to 1,100 fathoms after which it levels out to about 2.2 per cent. The gradient along the major portion of Mattole Canyon is about 5.4 per cent or slightly less. Portions of the side walls of these two canyons are similar and yet contrasting. Near the apex of the 400-fathom contour, Mendocino Canyon has a steep wall slope of about 49 per cent on the north side, whereas Mattole Canyon has its steeper side slope of about 52 per cent of the south side where the face of the scarp serves as a side wall. In the same vicinities the opposing walls of each canyon are also similar in that they have lesser slopes of 21 and 16 per cent respectively.

Spanish and Delgada canyons are only partially shown on the illustration. Spanish Canyon is fairly straight and has a gradient of about 7.2 per cent from the 30- to the 300-fathom contour after which it lessens to about 2.4 per cent. Delgada's gradient is about 15 per cent from the 10- to the 100-fathom contour, thence 11 per cent to the 200-fathom contour after which it changes to about 2.7 per cent.

The contouring of several features represented in the illustration has revealed the desirability of additional development for further geological and seismological researches. Such additional development will necessarily be more comprehensive than that needed for purposes of navigation and will be accomplished by the Coast and Geodetic Survey Ship GUIDE, E. W. Eickelberg commanding.

The new development will consist briefly of:

1. A zigzag echo sounding line extending along the fault scarp to ascertain its present unknown western extremity.

2. A system of short, closely-spaced, vertical cast sounding lines crossing the submarine scarp approximately normal to the depth curves between the junction of Mattole and Mendocino canyons and the western limit of the illustration. These lines will be spaced about five nautical miles apart. The sounding interval will be as close as 100 meters on the steepest portion of the scarp. Bottom specimens will also be obtained at each vertical cast sounding. This development will permit a more exact determination of the face of the scarp and will, of course, be intensified if any unusual features, such as cliffs or terraces, are discovered.

3. Spanish Canyon will be further developed by a system of lines running approximately at an angle of 45 with the depth curves. Other areas to the northeastward, including the longest tributary of Eel Canyon will also receive further development.

While the careful development of these features and the intimate knowledge obtained from them are of considerable scientific value, probably the greatest present value is to the navigator. Previously in this article a short description was given of the stranding of the Steamer BEAR near Cape Mendocino. If the master of that vessel had been provided with a modern chart of this locality, he would not have made the assumption that the cape had been safely passed and the disaster probably would have been averted.

At that period, of course, soundings were obtained by vertical casts or pressure tubes. Nowadays, sounding is much simplified by the use of an echo sounding device with which more and more commercial vessels are being equipped. With such a device and a modern chart, a ship rounding Cape Mendocino in fog can determine its position almost as accurately as though the weather were clear, simply by adjusting the profile of this unique bottom as given by a continuous line of soundings, to the chart.

It is pleasant to think that Nature, while making Cape Mendocino one of the most dangerous points on our coasts, with its reefs, fogs, and generally unfavorable weather, has so patterned the submarine topography that the very peculiarities of its features increase the safety of navigation in this locality.

Following are some remarks by Captain N. H. Heck concerning the seismological aspects of the submarine scarp.

COMMENT

N. H. Heck, Hydrographic and Geodetic Engineer
Chief, Division of Terrestrial Magnetism and Seismology
U. S. Coast and Geodetic Survey

Recent confirmation of early surveys which indicated a vertical scarp running west from Cape Mendocino in about latitude 40°18' raises the interesting question as to whether or not this is an extension of the San Andreas Fault. Since this means a sharp change in direction of the fault as it leaves the coast, it is important to introduce the seismic evidence. It is to be understood that the San Andreas Fault is a major earth feature extending from the vicinity of Cape Mendocino through California into Mexico and possibly even farther. The only similar formation on land, comparable in extent, is the great fault which begins in northern Syria, extends through Palestine and across the Red Sea into Africa. It is possible, however, that the great submarine troughs are similar phenomena.

It is necessary first to appraise the accuracy of the locations of the known earthquakes of the region. Several elements are essential. The instrument should be suited for recording the earthquakes that occur, there should be a proper distribution of stations, the time scale on the records should be open so that the time of arrival of an earthquake phase is accurately known, and the velocities of the earth waves of the region should be known. If we were discussing the problem in the vicinity of San Frantisco or southern California, these conditions would be met, but they are far from being met in the Cape Mendocino region.

During recent years there have been seismographs at Ferndale and Ukiah, and it is probable that the earthquake epicenters are reasonably well recorded off Cape Mendocino, but these are not enough stations for best results; and, since we are dealing with a geological phenomena, the history should be as long as possible. Prior to the installation of the two stations mentioned, only approximations of the epicenter could be made. A number of vessels reported feeling shocks in the vicinity, but the difficulty is that no matter what the relation of the vessel to the epicenter may be, if it feels the shock, it appears to come directly from beneath the vessel. It is probable that the recent determinations of epicenters are 10 or 15 miles in error and the earlier ones in still greater error, so that the direct association of earthquakes with the well-defined scarp cannot be made. However, the definition of the scarp is very important in connection with future more precise determinations. While the evidence is incomplete there is reason to think that there is not the same degree of earthquake activity to the northward of Cape Mendocino, either on land or sea, as there is just south of that vicinity.

Professor Perry Byerly of the University of California, in a paper presented at the Richmond meeting in 1938 of the American Association for the Advancement of Science, made the interesting suggestion that the fault continues only until it meets the region where there is a transfer from continental to oceanic crustal conditions (i.e., from 40 km. thickness to practically zero). This is a very interesting speculation, and it is in part supported by the westerly trend of the scarp.

In any case this is an excellent example of the need for accurate depiction of submarine features in connection with geological and seismological problems.

NEW SHOALS FOR OLD

Earle A. Deily, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

The early navigators, lumbering along in their high-sterned galleons, were often accused of having reported strange things seen in the haze of the tropic sun; sea serpents and such, perhaps from the stimulation of too much arrack before the noonday siesta. But sometimes we wonder if their so-called "guess-work" maps were not more closely founded on fact and accurate observation than we have supposed. Chance viewing of an old chart often brings interesting speculation.

To the northwestward of the island of Luzon, the main island of the Philippine group, lies a narrow bank, which is briefly described in the following manner in the newly compiled edition of the United States Coast Pilot, Philippine Islands, Part I.*

> "Stewart Bank, first surveyed in 1924 by the U. S. S. STEWART, extends about 35 miles in a northeast-southwest direction inside the 1,000-fathom (1,828 m.) curve, and has a least charted depth of 278 fathoms (447 m.) on it in latitude 17° 11' N., longitude 118° 42' E. It varies in width from three to ten miles. This submerged ridge lying about 80 miles northwestward of Cape Bolinao and rising steeply from surrounding depths of over 2,000 fathoms (3,658 m.) should prove of great advantage to vessels, equipped with echo-sounding apparatus, passing over it in approaching a landfall."

The soundings of the U. S. S. STEWART in 1924 gave a least depth of 146 fathoms. Subsequent surveys in 1928 by H. M. S. HERALD, sounding with wire, gave a more accurate determination of the shape of the shoal and a least depth of 278 fathoms. This is the now accepted value of least depth, and it is from this survey of H. M. S. HERALD that the present charting of Stewart Bank is made (see section of United States Coast and Geodetic Survey Chart 4200, Philippine Islands, Figure 1), a new feature in a previously incompletely surveyed area.

The following notes of H. M. S. HERALD on the survey of Stewart Bank are quoted because of their particularly interesting descriptive matter:

> "Stewart Bank consists of an extensive submarine mountain, the base of which rises from the sea bed from an average depth of 2,300 fathoms below sea level. For convenience, the level above which heights are referred to in these Notes is the general 'mean level of the sea bed'.
>
> "The recent survey by HERALD shows that the height of the mountain is somewhat of the order of 12,150 feet, though a more detailed survey of the summit might give shoaler water or a greater

* In press. To be issued in spring of 1940.

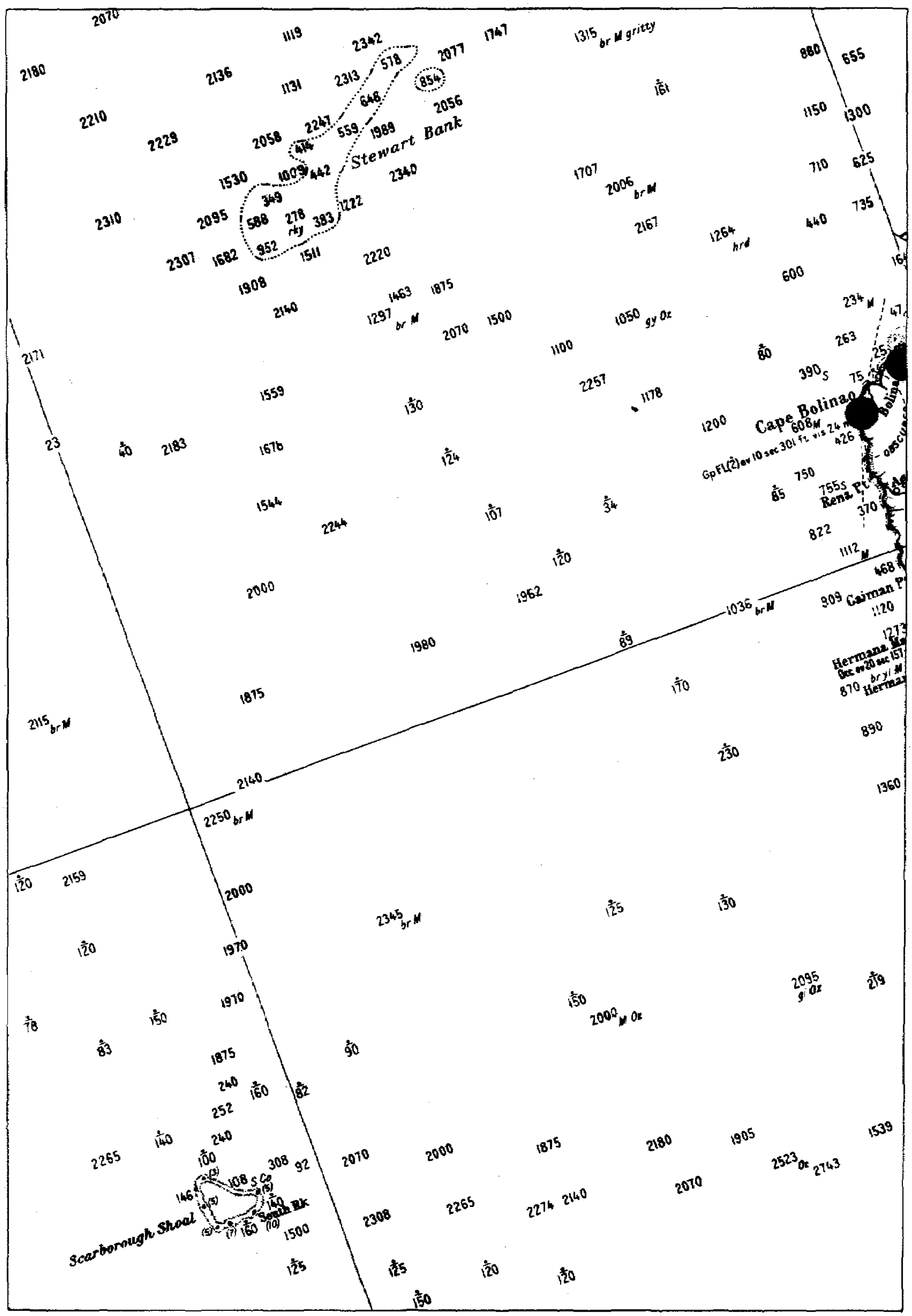


Figure 1

Section of U. S. C. & G. S. Chart No. 4200.

height; it is unlikely, however, that any danger exists in this area.

* * *

"As the object of the survey was to obtain the limits and general contour of the Bank, no attempt was made to determine the least water or greatest height. Moreover, the state of wind and sea during the operations was extremely unfavorable for beacon work, which would have been necessary for this purpose.

* * *

"While the length of the main range is considerable, its direction appears to be regular but curving gradually to the eastward towards that limit.

"The slope of the mountain in the vicinity of the highest plateau appears to be regular in all directions, with a slight tendency to steeper gradient on the NW and SE sides; further to the NE the declivity of the NW and SE slopes becomes greatly intensified until, at a distance of some 10 miles from the summit, a long narrow ridge, with steeply falling sides, extends for a distance of over 20 miles. This ridge is probably less than half a mile in width, with heights of from 10,000 to 10,500 feet above the mean level of the sea bed.

"A cursory examination of a few bottom specimens shows that in depths over 2,000 fathoms in the vicinity of the mountain the bottom is covered with globigerina ooze; between 2,000 and 1,600 fathoms specimens of pelagic foraminifera, siliceous organisms, and pelagic mollusca were found, and ferric oxide in minute particles abounded.

"Above 1,600 fathoms the main contours of the mountain became more defined. Here sandy bottom, with numerous small shells, was obtained universally except at those positions situated near the summit plateau and ridge, where exceedingly hard and bare rock was found.

"Briefly, the main level of the sea bed is covered with the recognized Pelagic Oozes, gray in the deeper water and brown in depths of less than 2,000 fathoms. At depths of 1,000 fathoms and over calcareous deposits of Pteropod Ooze were found. No analysis of the various sands obtained has been made at the time of writing these Notes."

Is "Stewart Bank" a newly found hydrographic feature, or did the surveys of the STEWART and the HERALD only reveal the present shape of an anciently recorded shoal? Let us compare a few of the

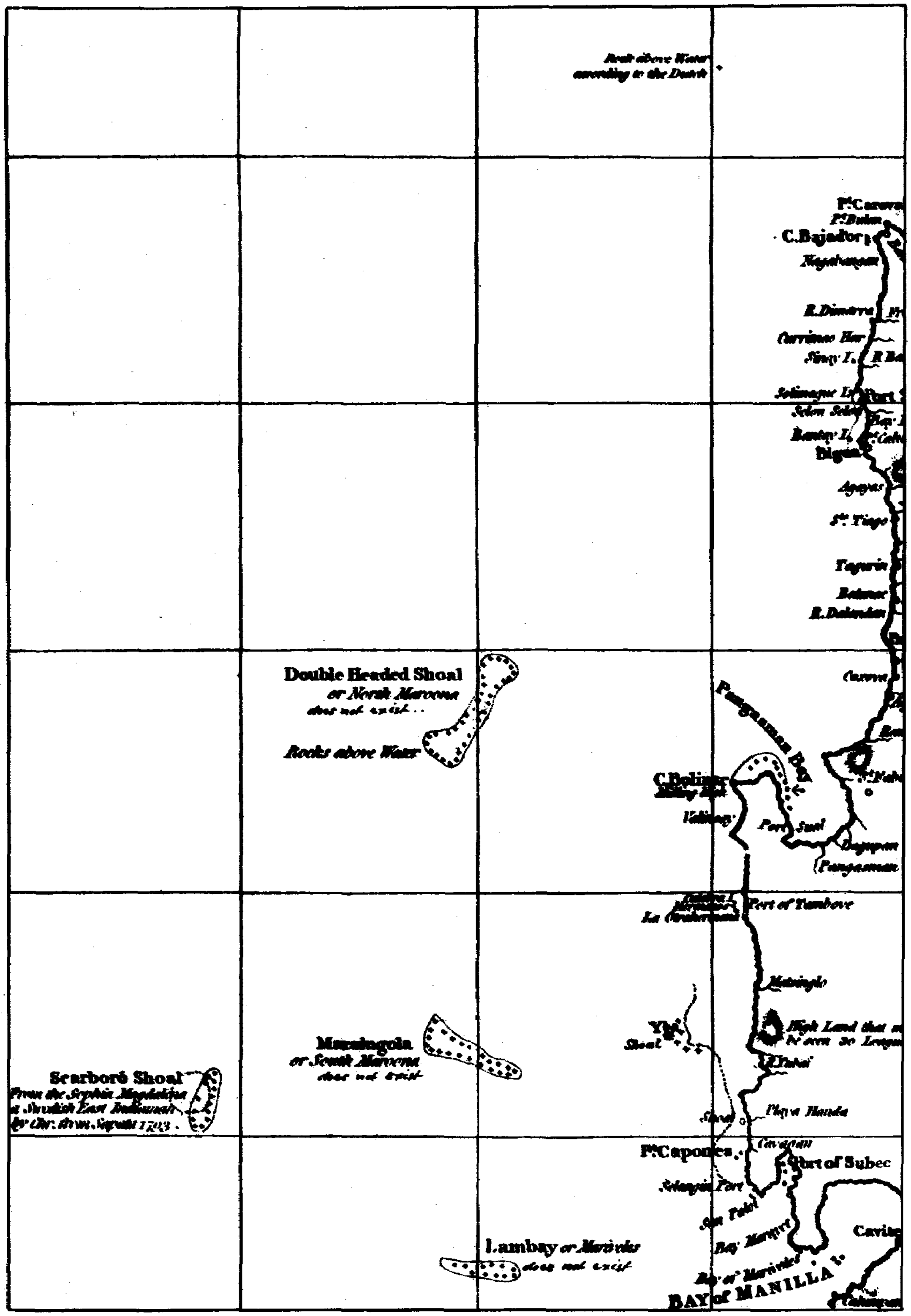


Figure 2

Section of Arrowsmith's Map, published in 1800.

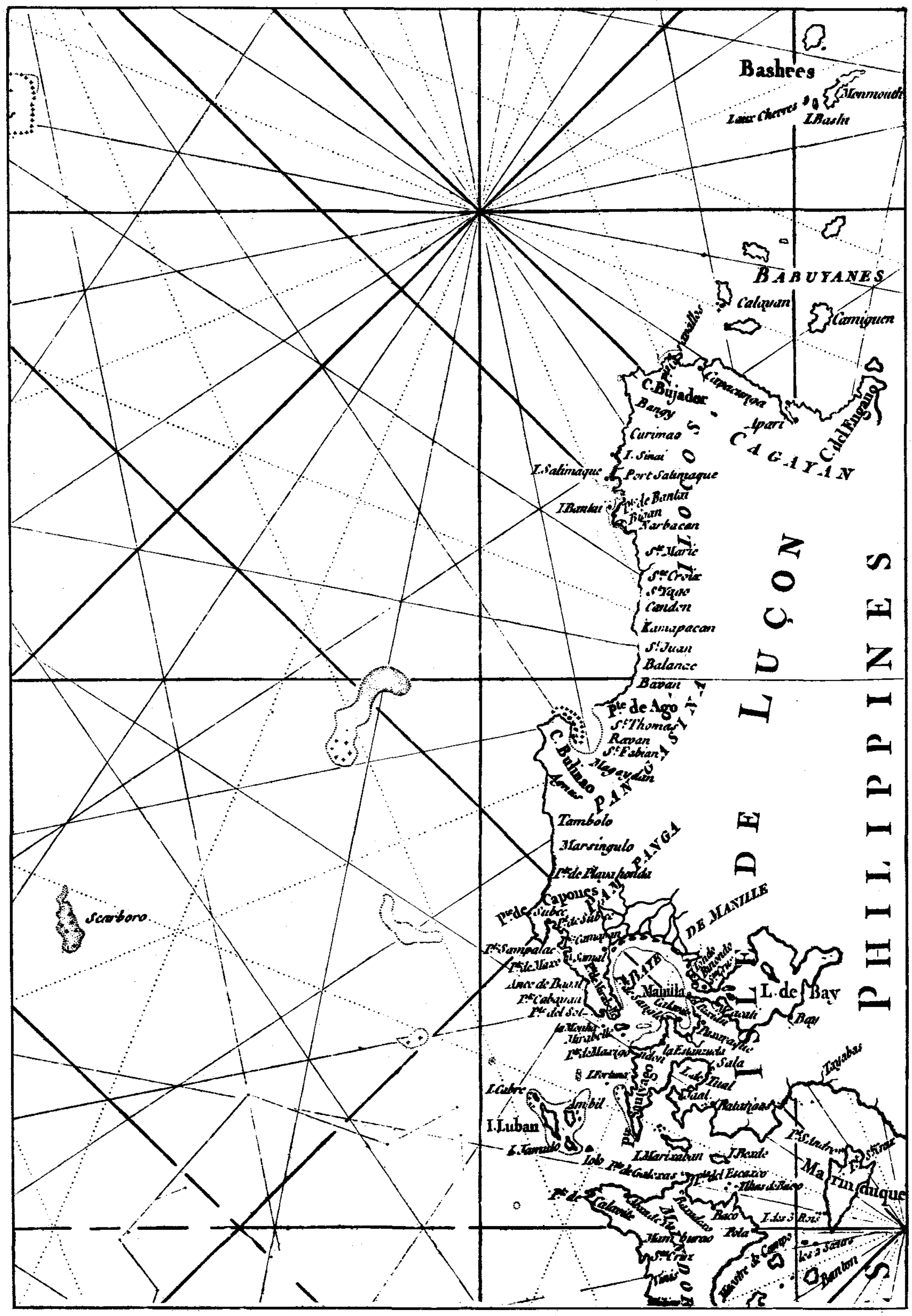


Figure 3

From Map No. 52 of the Neptune Oriental - c.1790.

old maps of this portion of the China Sea with our present day chart.

On a copy of a chart published in London, February 2, 1800, by A. Arrowsmith, No. 24 Rathbone Place, (Figure 2), a shoal of similar shape and size to Stewart Bank is noted in approximately the same position with respect to Cape Bolinao and Scarborough Shoal, the comparative distances being as follows:

	Arrowsmith Chart	C. & G. S. Chart No. 4200
From Cape Bolinao - - - - -	70 miles	80 miles
From Scarborough Shoal - -	110 miles	110 miles

The length of the bank on both charts scales approximately the same, and the resemblance in shape is startling.

The copy of this Arrowsmith chart in the Library of Congress, Washington, D. C., bears on it the tracks of the U. S. S. BRANDYWINE with notes of its daily positions while en route between Macao and Manila, and return. One course apparently passed over the plotted position of the shoal in question. The shoal is titled "Double Headed Shoal or North Maroona" with the note, "Rocks above water", at its southern end. (See Figure 2). An additional note, apparently in handwriting, says, "does not exist".

"Double Headed Shoal", similar in shape, unnamed, however, is shown on Map 52 of the "Neptune Oriental" (see Figure 3), published sometime previously (probably around 1790). The shoal is located on this map 70 miles from Cape Bolinao and 120 miles from Scarborough Reef. This map bears the following interesting title:

A

CHART of the CHINA SEA

Inscribed to
Monsr. D'APRES de MANNEVILLETTE
the ingenious Author of the
NEPTUNE ORIENTAL
As a
TRIBUTE due to his LABOURS
for the benefit of
NAVIGATION
and
in acknowledgment of his many signal Favours
to
Dalrymple

On the "Carta Hydrographica y Chorographica de las Yslas Filipinas", the first map of Padre Pedro Murillo Velarde of the Company of Jesus, published in Manila in 1734, this bank is called "Galit".

On the "Mapa de las Yslas Filipinas", also compiled by Velarde and published in 1744, the shoal bears again the name "Galit".

"A correct Chart of the China Seas containing the Coasts of Tsiompa Cochin China the Gulf of Tonquin Part of the coast of China and the Philippine Islands" (Figure 4), published about 1750, shows "Bolinao Bank or the Double Headed Shot" located 44 nautical miles

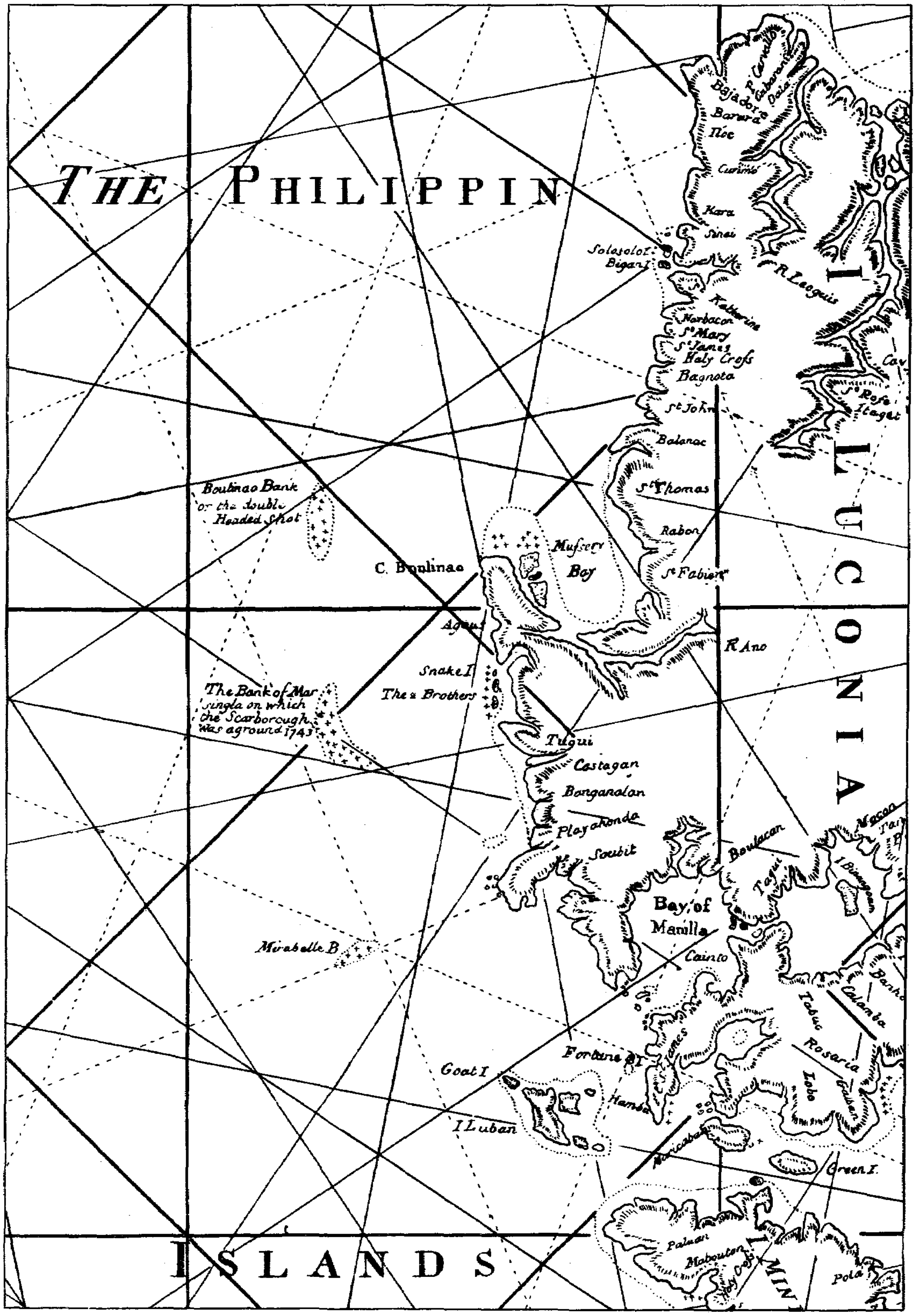


Figure 4

Section of a Chart of the China Seas - c.1750.

(minutes of latitude on this map) from Cape Bolinao and 60 nautical miles from "The Bank of Mar" (Scarborough Shoal). The "Bank of Mar" agrees, however, with the position of "South Maroona" as shown on Figure 2.

On the "Chart of China Sea and the Philippines 1794" in the "Complete East India Pilot printed for Laurie and Whittle (London 18001" the shoal in the approximate position of Stewart Bank is titled:

Galit or Bolina Bank
Called also Double Headed
Shoal and North Maroona.

The "Carta General del Archipelago de Filipinas" (Figure 5), published in 1808, bears on it the tracks of the Corbetas DESCUBIERTA y ATREVIDA, which passed through this area while engaged on a surveying cruise in 1792. This cruise confirmed the location of Scarborough Reef, and apparently proved the non-existence of the large shoals shown for many years previously lying to the westward of Cape Bolinao. From that time on these shoals disappeared from the chart. But were traces of these shoals non-existent? The modern hydrographer would demand more conclusive evidence before removing them from the chart.

We now find the approximate position and shape of Double Head Shoal replaced on the modern chart by Stewart Bank. Recognizing the difficulty experienced by early navigators in taking soundings in great depths, might not this shoal, so extremely narrow in its shoaler portions, have been missed by the Spanish survey party? The old Spanish sounding lines, still retained on our modern charts as indicative of depths in areas where no modern surveys have been made, show such recordings in the deep sea near Stewart Bank as "no bottom in 40 fathoms", and "no bottom in 55 fathoms".

The thought may occur to some readers that "Scarborough" and "Double Headed" shoals were placed on the maps from the reports of entirely different navigators and that these navigators may have viewed the same feature and described it as a different shoal; thus "Double Headed Shoal" may never have existed in the form described. It is true that these charted shoals show great similarity on the early maps in that they were both noted as having rocks awash at their southern ends, but it seems highly improbable that such an error could have been made since they are separated by so great a difference of latitude. Latitude, it must be remembered, was the one factor of position which was comparatively easy to determine, even in those times.

The fact that the longitude was often in doubt is well known. Wide divergences in the position of "Scarborough Shoal" itself have been noted. The "Chart of the China Seas" in the "Neptune Oriental" gives three different reported positions of "Scarborough Shoal". They are explained in a note as follows:

Note

A. Situation of SCARBORO's SHOAL by account from P. SAPATA
B. Do - - - - - - - - - - - - - - do - - - - - to GR. LADRON

This shoal is placed according to the Spanish Account, having been seen in 1755 by a Ship bound to Manila from Macao.

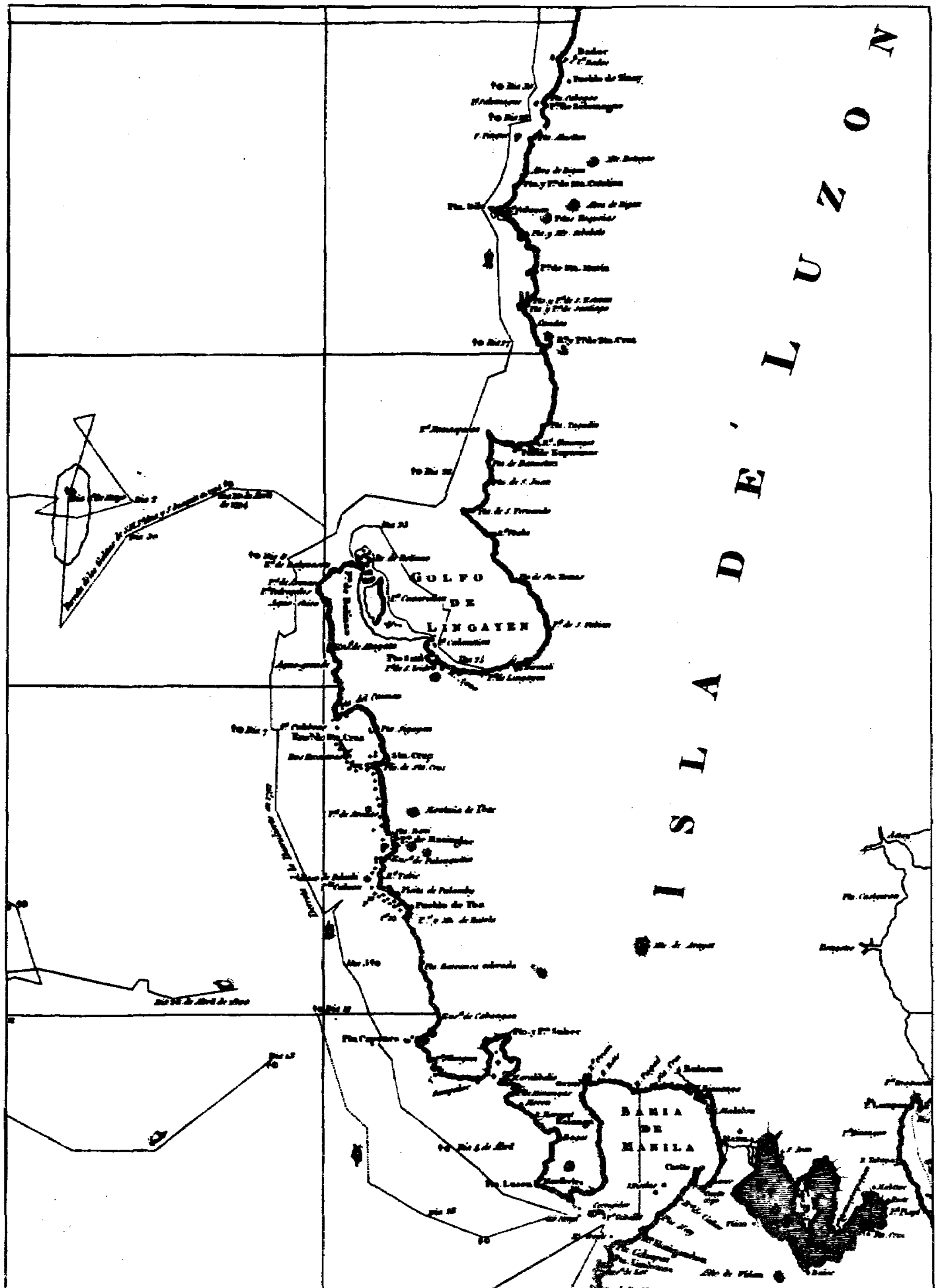


Figure 5

Section of Carta General del Archipelago de Filipinas - 1808.

Position A lies 155 miles west of the Spanish position, B lies 80 miles west of the Spanish position, but the latitude is in every case the same.

Let us now consider the possibilities of changes in depths on the bank in question.

The "Bathymetric Map of the Philippines" included as part of the publication titled "Tectonic Lines of the Philippine Islands" by Rev. W. C. Repetti, S. J., Manila Observatory, shows a tectonic or seismotectonic line, numbered I, as lying in the China Sea northwestward of Luzon and passing between Luzon and Formosa with a northeast-southwest trend. Extended southwestward to the vicinity of Stewart Bank it places that submarine peak well within the tectonic zone.

On February 14, 1934, a strong earthquake epicenter was located in latitude 17° 21' N., longitude 119° 20' E., or just 15 nautical miles eastward of the northern tip of Stewart Bank. This earthquake is most adequately described by Father Repetti in the "Seismological Bulletin of 1934 - January - June" of the Philippine Weather Bureau.

The shaken area was approximately 723,400 square miles in size. Although there was considerable alarm, the damage done on land was negligible. A sea disturbance was observed at San Esteban on the west coast of Luzon where the first movement of the sea was reported to have been a recession of such extent that people rushing out onto the exposed shore to gather fish which had been left stranded narrowly escaped drowning when the water returned.

The fact of greatest importance and interest, however, was the rupture of the Manila-Shanghai cable, and a report from the cable company after this occurrence stated that there were indications of a change in depth of approximately 100 fathoms. Extracts from the report are contained in the afore-mentioned "Seismological Bulletin of 1934". While it cannot be certain that this increase in depth occurred suddenly, the changes in sea bottom conditions given in the various reports of the cable ship and the shocks felt while repairing the cable during the period between February 23rd and 25th suggest that the second break, which occurred on March 2nd, was due to subsequent slumping, an after effect of the earthquake of February 14th. The second break was actually located between the first breaks, and during the repairs the cable was found to be buried at the place where the break occurred.

In an area of such great seismic activity, considering the submarine topography of Stewart Bank as delineated by the survey of H. M. S. HERALD and considering that there have been indications of increases in depths in the nearby area, is it not possible that this shoal may have originally existed as first reported and subsequently drawn on the early maps? Perhaps North Maroona may, in truth, have once greeted the venturesome sailor with wave-spurtingrocks beating a thunderous applause for bravery in daring uncharted seas.

RELATION OF THE TIDE TO PROPERTY BOUNDARIES

Rear Admiral R. S. Patton*
U. S. Coast and Geodetic Survey

The grants, charters and conveyances which constitute the first links in the chains of title on which are based the present ownerships of lands along our seacoasts contain frequent reference to such boundaries as the high water line, the high tide line, the line of ordinary high water, etc., and similar reference to the opposite, or low stage of the tide. As a rule these references are indefinite to the point of ambiguity, primarily because of the inherently complex and variable character of the tidal phenomena, and secondarily because, at the time the early descriptions were written, either the significance of the first factor was not appreciated, or it was not considered of sufficient importance to require precise definitions of the phrases used.

The result is that our courts are called upon from time to time for precise and workable interpretations of these vague and ambiguous phrases. The frequency with which such interpretations are necessary is strikingly evident to the Coast and Geodetic Survey, which, as the agency of the Federal government officially charged with the study and prediction of the tides, and the generally recognized authority in this country on that subject, is called upon many times each year for tabulations of tidal data applicable to this or that matter in litigation.

Statistical data, however, serve the ends of justice only to the extent that they are properly interpreted, and proper interpretation of tidal data is usually possible only when the tabulation is appraised against a background of pertinent scientific principles and physical facts pertaining to the situation under consideration.

Decisions which have come to the writer's attention sometimes contain imperfections which suggest that this background is not always made available to the court. For example, a decision which on more than one occasion has been submitted to the Coast and Geodetic Survey with a request for an opinion as to its meaning reads in part as follows:

> "The limit of the monthly spring tide is, in one sense, the usual high water mark, for, as often as those tides occur, to that limit the flow extends. But it is not the limit to which we refer when we speak of 'usual' or 'ordinary' high water mark. By that designation we mean the limit reached by the neap tides. That is, those tides which happen between the full and change of the moon twice in every twenty-four hours."

It is impossible from the language quoted, to be certain as to what the court had in mind. Strictly speaking, the neap tides are those which are caused by the moon and sun in quadrature. This happens once each fortnight, and the range of tide at that time, other factors being equal, differs by a considerable percentage of the total range from the average range for the entire period between the

* This article was prepared by the late Rear Admiral R. S. Patton prior to his death in 1937. Rear Admiral Patton was Director of the U. S. Coast and Geodetic Survey from April 29, 1929, to November 25, 1937.

full and change of the moon.

The custom of regarding each decision rendered as a precedent to be taken into account by the courts when dealing with similar cases would seem to have a two-fold bearing upon the situation:

> (1) It probably has some tendency to extend the application of imperfect decisions to subsequent cases in which the pertinent body of fact is closely similar, and
>
> (2) We could expect a similar tendency toward an a priori application of decisions, which were correct with respect to the underlying body of fact on which based, to matters which superficially seem identical, yet which a searching study of both cases would reveal as having important points of difference if only those concerned knew where to look for them.

The importance of our shore lands is rapidly "increasing. Values in most of our coastal states have reached levels which demand accurate knowledge of the area involved in any conveyance. The riparian rights which accrue to the owner of the adjacent upland constitute an important factor in such values. There is a rapidly growing public interest in the proprietorship in the ripa which is inherent in the sovereignty of the people. On the Atlantic and Gulf coasts at least ten states have formally created agencies to administer some or all aspects of this sovereignty. Six of these ten agencies have been created or charged with this function within the past four or five years. As to the Pacific coast, the extent to which California is interesting herself in the subject is nationally known.

Everywhere there seems to be uncertainty and obscurity as to the specific applications of the principles embodied in the law and the court decisions to the sites to which those principles must be applied. The need for a clarification of the whole subject is plainly indicated. That clarification can come only from a meeting of the legal and the engineering minds.

Therefore to the writer, as an engineer familiar with the true tide and the related phenomena which combine to produce those periodic fluctuations in the water's surface popularly known as the tide, it seems worth while to discuss, as briefly and with as little technical detail as possible, the physical factors which must serve as a background to any adequate consideration of this subject. The discussion will make no pretense of being a complete one. Rather, the thought is, by a hasty reconnaissance, to blaze a trail which may indicate the route to be followed by those who in due time may endeavor to go into the matter thoroughly. The writer would also emphasize that he has no knowledge of the law: if that fact becomes too strikingly apparent later he can only beg his readers' indulgence on the ground that he is merely trying to contribute his mite toward the needed achievement.

Four factors unite to produce the daily fluctuations in the elevation of the water surface which we call the tide. Each factor is complex, and three of the four are variable within themselves, and the great complexity and variability of the tide is due to the almost unlimited number of combinations into which these four factors can unite to produce both differences at the same time at different points and differences at the same point at different times. These four factors are:

(1) The astronomic tide-producing forces.

(2) The unchanging configuration of the major ocean basins.

(3) The variable configuration of the minor tributary basins.

(4) Related terrestrial phenomena.

The Astronomic Tide Producing Forces

The astronomic or true tide results from the force which we call gravitation. Newton's law is that the attractive force which one body will exert upon another varies directly as the mass of the attracting body and inversely as the square of the distance separating the two. The only two heavenly bodies which are close enough to the earth to have any tide-producing effect are the sun and moon. The sun is many times larger than the moon, but the latter is so much closer to the earth that its tide-producing effect is a little more than double that of the sun.

Earth, moon and sun are in constant motion and in consequence their relationships to each other are constantly changing in both direction and distance. These changes are cyclical in character and in consequence of them the tides manifest certain directly-related cycles of change.

It would take too long, and is not pertinent, to describe how the sun and moon operate to produce the tides. It will be sufficient for our purpose to list the principal characteristics of the tide, and in connection therewith to state such facts as need to be taken into account.

1. During each period of slightly more than 24 hours we have in general two high and two low waters. This rule, however, is not an invariable one either as to time or place. We may have only one high and one low water during that period, and sometimes one each and at others two each. We will revert to this subject when we consider our second major factor.

2. The high and low waters of each day occur about 50 minutes later than the corresponding ones of the preceding day. This lag corresponds and is related to the daily retardation in the time of the moon's meridian passage.

3. The range of tide at any point changes from day to day, passing through fortnightly cycles. When the moon is in its first and third quarters the tide producing forces of sun and moon are opposed to each other, and, other factors being equal, the tidal range attains the minimum of its cycle. This minimum tide is called the neap tide. Thereafter there is a gradual increase in range until the time of new or full moon. At that time moon and sun are pulling together and, again other factors being equal, the tidal range attains its maximum for the cycle and is known as the spring range. The neap range is usually about 20 per cent less than the mean range, and the spring range about 20 per cent greater than the mean range.

Spring and neap tides seldom occur at the exact times when the moon is in its equivalent phases. There is usually a lag of from one to two days which is known as the phase age of the tide.

4. The moon travels around the earth during a lunar month of 27-1/2 days, moving in an elliptical orbit which has the earth at one focus, Therefore the distance between moon and earth is constantly changing, and the tidal range changes in consonance. When the moon is nearest the earth, or in perigee, the tidal range, known as the perigean range, is about 20 per cent greater than the average, and when the moon is in apogee, or most distant from the earth, the range is about 20 per cent less than the average and is known as the apogean range.

There is a lag in the occurrence of the perigean and apogean tides similar to that which we noted with respect to the spring and neap tides.

5. The moon's orbit lies in a plane which is inclined to that of the earth's equator. Twice each lunar month, therefore, the moon will be momentarily in the plane of the equator; at all other times during the month the moon will be varying distances north or south of that plane.

As the earth rotates on its axis points everywhere on the earth's surface describe circles which are in or parallel to the plane of the equator. They are, in other words, circles of latitude.

Now consider the moon's relation to two points at the opposite ends of any diameter of any circle of latitude. At the two moments each month when the moon is in the plane of the equator its relation to these two points is identical and if all other factors were equal the tides there would be the same. At all other times during the month the moon's relation to the two points is not the same, and consequently the tides will differ from each other to an extent which will depend on the distance of the moon north or south of the equator.

Because of the earth's rotation these two points may be said to change places every 12 hours. Point A rotates to the spot occupied 12 hours earlier by point B and vice versa. Consequently the two tides, 12 hours apart, at either point A or point B will differ from each other in the same way as, under the preceding assumption the tide at A differed from that at B. In other words, when the moon is on the equator the two tides of each day at any point tend to be the same, and when the moon is north or south of the equator the two tides will be unequal.

This difference is called the diurnal inequality. It changes continuously with the moon's declination. When the moon is on the equator the diurnal inequality is least, and the tides are called equatorial tides, and when the moon is at its greatest north or south declination the tides are called tropic tides. The effect of the diurnal inequality can be described in a general way by stating that it is equivalent to increasing the range of one tide at the expense of the other.

6. Changes in the relative positions of earth and sun result in cyclical changes in the component of the tide resulting from the sun's attraction. These changes are similar in kind to those already described, but (1) their magnitude is less, and (2) their periods are longer, being semi-annual instead of fortnightly.

7. The foregoing variables may combine in numerous different ways to produce variations in the tide. Thus a spring tide and a perigean tide occurring simultaneously will produce an actual tide of exceptionally great range, while a neap and an apogean tide would give a correspondingly reduced range, and a spring and an apogean tide, or a neap and a perigean would combine to give a range not far

from the average.

8. Besides the daily and semi-daily tide producing forces, we find groups having periods of half a month to a year. In addition there is a variation in the range of tide resulting from the westward motion of the moon's node of about 19 a year, or a periodicity of 18.6 years.

The Major Ocean Basins

As pointed out previously, the astronomic tide results from the tide-producing forces of the sun and moon and the relative positions of these two bodies with that of the earth. These forces are distributed in a regular manner over the surface of the earth, varying with the latitude. It will be observed at once, however, that although the tidal ranges vary, the variations bear no relation to latitude, being largely local or regional. What is it, therefore, which from the same causes produces such different effects?

For many years scientists held that the "progressive wave" theory furnished the answer. This theory considers the tides of the world as due principally to the action of the tidal forces on the broad and deep waters of the Southern Ocean where it was assumed these forces raised two tidal waves, 180 apart in longitude, which traversed this belt of water from east to west, forced by the moon to keep step with its own motion. These waves sweeping around the southern latitudes were supposed to generate secondary waves in the Atlantic and Pacific oceans, which traveled northward across the equator and into the northern hemisphere impressing minor waves into all the water areas in their paths. The various tidal ranges observed then were explained by the amount the energy in the waves was concentrated due to the shape of the regions through which they traveled.

As tidal observations increased in number throughout the world, however, they did not give data to accord with this progressive wave theory, and at the beginning of this century there was evolved the "stationary wave" theory. This newer theory does away with the conception of a single world phenomenon and substitutes regional oscillating areas as the origin of the principal tides of the various oceans.

We are all familiar with a stationary wave oscillating in a small tank when one end is raised and immediately lowered. The whole mass of water moves rhythmically first to one end of the tank and then to the other, so that it is low water over one half the tank at the same instant that it is high water over the other half, with a line across the middle about which the water oscillates, with no change in elevation.

This surge is repeated again and again with a gradually decreasing magnitude until finally the waters resume their normal state of rest. In such a tank the extent of the rise and fall of the water at the two ends will depend on the magnitude of the generating force, but the period of each oscillation across the tank is independent of the generating force. It depends solely on the length of the tank and the depth of the water in it.

If, however, the tank end be raised and lowered repeatedly at regular intervals, the period in which the water oscillates becomes equal to that of the disturbing force, but in all other respects the character of the oscillation will depend on the relation which the natural period of the tank bears to the period of the disturbing force. Thus, if the end of the tank be lifted each time at the exact instant when the water at that end has reached its greatest elevation, the oscillations will rise higher and higher until the water spills out. Conversely, if the end of the tank be raised at the instant when the water there is at its lowest point, the tendency will be to reduce and even destroy the oscillation.

This simple example very crudely suggests the basis for the stationary wave theory of the tides. The actual characteristics of the tides, as observed on all coasts of the world, can best be explained on the assumption that the waters of the oceans naturally divide themselves into basins, within each of which the waters oscillate somewhat in the manner above suggested. Each basin has its own natural period of oscillation. Each basin is acted upon in regular periods by the forces imposed by the sun and moon. The resulting tide in the basin will depend on the relation between the natural and the imposed periods.

We have noted that except when the moon is on the equator we usually have two unequal tides during the day. In other words, the actual tide may be said to be composed of a semi-daily and a daily component. Some of these basins will respond better to one of the periodic forces of the sun and moon than to another. We will then have regions where the semi-diurnal tide is predominating, other localities the diurnal tide, or in other words, in each of the various locations the stationary waves best developed are those whose forced periods most nearly approximate the natural period of oscillation of the particular oceanic area in question.

For example, we find not only areas in the Pacific Ocean and Indian Ocean of the proper dimensions to sustain stationary waves with a period of twelve hours, but also those which give rise to a well developed daily tide and thus we find considerable "diurnal inequality" in this area. As it is explained that this condition arises from the combination of a daily tide with a semi-daily tide, the greater the daily constituent the greater the inequality. In the Atlantic ocean the daily tide is not well developed because the period of oscillation of this basin is near that of the semi-daily tide. Therefore, there is little diurnal inequality along its shores. Finally, there are a few localities where the semi-diurnal factor disappears and we have but one high and one low water a day.

From the above brief discussion of the modern concept of the tides, it will be seen that tidal ranges taken over long periods of time to average out meteorological effects will be as unchanging as the great open seas in which they are generated.

There are basins, although small, compared with the oceanic areas, which may be regarded as similar to large vibrating areas, and partly by this view the large tides in the Bay of Fundy and Cook Inlet are explained. Taking the Bay of Fundy, we find that its natural period of oscillation is about twelve hours, which coincides very nicely with the period of the ocean tide. This brings about a stationary wave movement within the bay that is sustained by the tide of the ocean, and, as shown previously, in this kind of a wave the rise and fall of the tide increases with the distance from the axis about which it oscillates. The tidal range is further increased near the head of the bay by the converging shore line and gradually decreasing depth, which confines the energy of the moving mass of water into a gradually decreasing volume. The increase in range between Cape Sable and Minas Basin approximates 365 per cent.

South San Francisco Bay presents a somewhat similar case, although with less increase of range at the head. The mean range of tide at Golden Gate is 5.9 feet, with a mean value of 7.6 feet at Alviso, or a percentage increase of 90 per cent. The size and depth of the basin are such that the type of tide is partly stationary and partly progressive and this helps to explain the increase in the mean range of tide in the upper reaches of the bay.

The Variable Configuration of the Minor Tributary Basins

The two factors heretofore discussed determine the characteristics of the true ocean tide. Those characteristics, save for the fluctuations of the definitely known cycles, are fixed and unchanging. The effect which the astronomical forces will exert at any future moment can be computed with mathematical accuracy. Only an unconceivable cataclysm could alter the great ocean basins sufficiently to have any perceptible effect upon their tides. Therefore we can safely say that a hundred, or a thousand years hence the tides at any point of the ocean remote from the disturbing effect of local influence will be the same as they are at present, except for major geologic changes.

But when the basins become so localized as to be susceptible of modification by either natural or artificial agencies, important changes in their tidal regimes may be expected to accompany physical changes which occur from time to time.

Such changes are constantly in progress in many small basins indenting the coasts of the United States. Along a shore composed of sand or other readily erodable material, the inlets by which the tidal waters of the ocean enter and leave these basins, are in a state of great instability. The waves and currents of the ocean, and particularly certain powerful components which operate in the immediate vicinity of the shore in times of storm, carry large quantities of sand to the inlets and there deposit it with a consequent tendency to reduce the cross section of the inlet, retard the flow of tidal currents into and out of the basin, and cause the inlet to close.

On the other hand the regular tidal currents through the inlet exert an unceasing effort to scour away these deposits and maintain channels adequate to accommodate their flow.

Thus at each such inlet we have a continuous conflict between two opposing sets of forces; the one group striving to close it, and the other to maintain or increase its channel. The condition of the inlet at any time reflects the vicissitudes of this struggle. If the inlet currents dominate the situation the inlet will have a deep, well defined and unobstructed channel leading from the ocean to the basin. If the alongshore forces are the stronger the inlet gorge proper may be deep and free from obstruction, but at one or both ends of the gorge delta-like shoals will be formed containing one or more narrow, tortuous channels along the lines of maximum current flow.

For a given range of ocean tide and size of basin the condition of the inlet at any time will be an important, and usually the principal factor in determining the range of tide in the basin. The shoals already described act like dams to cut off the flow in the lower levels. The retarding effect of friction is everywhere increased. Bends, and irregularities in the widths and depths of the channels disturb the smooth, regular, streamline flow of the waters, deflect one portion of the current against another, and tend toward a condition of turbulence. The accumulative effect of all these factors is that each basin at any moment has its own characteristic tidal range, and that this range is usually less, and occasionally very much less than the range in the adjacent ocean.

Similar retarding influences exist elsewhere within the basin, with the result that the tidal range frequently decreases gradually with increasing distance from the inlet.

The variations in tidal range resulting from the foregoing factors are well illustrated by tidal observations made some years ago in Barnegat Bay, New Jersey. At this spot the range of ocean tide is 4.0 feet. At a point near the inner end of the inlet and distant 5/4 mile from the ocean the range was 2.0 feet. At a point on the west shore of the bay, directly opposite the inlet and 4-1/2 miles distant therefrom, the range was 0.8 feet. At Bay Head, the northern extremity of the bay, 21 miles from the inlet, the range was 0.7 feet.

Such examples could be multiplied indefinitely. If, in addition to the conditions we are now considering, we will keep in mind the opposite conditions as exemplified in San Francisco Bay, where the tidal range increases with increasing distance from the entrance, a brief examination of the column of mean tidal ranges in the official tide tables published by the Coast and Geodetic Survey will afford convincing evidence of the high degree of individuality and variability of the ranges in the basins along our coasts,

The foregoing illustrates varying mean ranges at different points in a basin at the same period of time. We likewise have variations in the range at a single point at different periods.

Basin ranges are reduced by the growth of shoals at the inlets, by the closing of one or more of the inlets through which the tidal waters enter and leave the basin, by the building up of mud flats and the growth of marsh within the basin, etc.

Basin ranges are increased by storms which erode the shoals at the seaward end of the inlet, by freshets which augment the scouring effect of the tidal flow and produce a better channel through the inlet shoals, by the opening of a new inlet through the barrier beach which separate ocean and basin, etc.

Such changes have been accomplished artificially. Men have filled up inlets and converted tidal basins into tideless lagoons. Conversely, engineers working in aid to navigation have improved inlet channels and thereby materially increased basin ranges. A case in point occurs at the Coquille River, Oregon. Here the range of ocean tide is 5.2 feet. In 1880 the bar at the entrance had a low tide depth of 3 feet and the range of tide inside was 3.3 feet, By 1928 artificial improvement had increased the bar depth to 13.5 feet and the range inside to 5.1 feet.

Related Terrestrial Phenomena

By reason of certain influences of non-tidal origin, additional to the minor effects of the long-period forces already mentioned, the imaginary plane of sea level, above and below which the tides oscillate daily by approximately equal amounts, is itself subject to variations in elevation. Some of these affect the range of tide and others do not, but all affect the position of the contours along the margin of the land marked out by the high or low waters at different times.

Typical of these terrestrial factors are wind and barometric pressure. A storm wind of some days duration blowing from off the land toward the ocean has been known to reduce the water level adjacent to the shore as much as three feet below normal. Conversely, a wind blowing in the opposite direction will temporarily elevate the water surface an equal amount above normal.

Variations in barometric pressure likewise bring about fluctuations in sea level. Indeed, as a first approximation, any arm of the sea may be regarded as a huge inverted water barometer. When the barometric pressure over this arm rises the level of the water will be lowered, while with a decrease in the barometric pressure the level of the water will rise.

Thus at any point on the coast sea level varies from day to day, from month to month, and from year to year. From one day to the next sea level may vary by a foot or more, and within the same year two values of daily sea level may differ by five feet or more. Monthly sea level is subject to variations of both periodic and nonperiodic character, so that within a year sea level for two different months may differ by as much as a foot. Yearly values of sea level may show differences of a quarter of a foot or even more.

Mean Values of Tidal Planes

By reason of all the foregoing complex variations the most convenient method of dealing with the relationships between the various phases of the tide is in terms of average or mean values. Thus we have mean lower low water, mean low water, mean sea level, mean tide level, mean high water, mean higher high water, etc. Each of these expressions designates a more or less accurately determined average value, of the phase designated, usually expressed in terms of its vertical relationship to one or more of the others, or to permanently marked points on shore.

Obviously, the accuracy of determination of these mean values will depend on the length of the series of observations from which they are derived. If we start with no known relationships, a series several years in length is the minimum which gives an accuracy sufficient for present engineering purposes, and a series of 19 years will be even better, as it takes full account of the longest-period forces.

Series of such length, however, are necessary at only a few widely separated points so selected as to be indicative both of the various basin tides and of regional meteorological conditions. These furnish primary stations from which the relationships at secondary stations in their vicinity can be derived by comparisons based on much shorter periods of observations. A considerable number of these primary stations* is already available in this country, so that it is today a relatively simple matter to obtain accurate knowledge of the tidal planes at most of the points where it may be needed.

Tidal Contours as Property Boundaries

All the foregoing indicates the background of fact which must be taken into account in any adequate solution of this problem. We are now ready to deal with the problem itself.

It is no part of the writer's purpose to advocate any particular tidal contour, as, in theory, the proper one to separate the proprietorship of the state from that of the individual. While that question is very much in evidence at present, it is in principle one for determination by the jurist rather than the engineer. Therefore, solely for the purpose of definiteness and simplicity of discussion, mean high water will be assumed to have been adopted. The factors to be considered would be equally applicable to any other contour selected.

The problem then becomes one of so formulating the law or the court decision that it shall be so definite and specific that the engineer using standard engineering methods in applying it on the ground, can arrive at only one result.

Our boundary is the line or contour along which the substantially horizontal plane of mean high water intersects the sloping surface of the land.

We must recall that we are dealing here with two different relationships; vertical and horizontal.

Each mean plane is ascertained and perpetuated in terms of its vertical distance above or below permanently marked points called bench marks. The Federal Government has established this relationship at thousands of points along our coasts. Each determination makes possible the location on adjacent parts of the shore, of the position of the contour of intersection. If for any reason the elevation of the plane be changed, the contour of intersection will be shifted along the sloping surface of the land.

Even though the elevation of the tidal plane remain unchanged, usually from time to time there will be appreciable horizontal changes in the position of the line along which the plane intersects the surface of the land. These changes result from the action of waves and currents in producing erosions from and accretions to the land. They are in progress all the time, and physiographically speaking, at a very rapid rate. In fact, this zone where land and water meet is, generally speaking, the scene of the most rapid and radical natural changes which occur anywhere on the earth's surface.

It is the writer's understanding that this variability in position of this line of intersection is generally recognized in the law; that erosions and accretions are regarded as acts of God, and that as the proprietor has no recourse from the loss suffered from the first, so he is entitled to the gain from the second - at least in those cases where the changes are so imperceptible that they cannot be

* See Primary Tide Stations; Field Engineers Bulletin, Vol. 12, page 190.

noted from day to day. The following discussion assumes the correctness of that understanding.

On the outer coast the following considerations make the problem a simple one from the engineer's viewpoint.

For all practical purposes the elevations of the various mean tidal planes are fixed and unchanging, and their relation to adjacent bench marks is a constant one. A possible exception to this rule occurs in the very infrequent case where an elevation or subsidence of the coast may be in progress. This exception, however, is not a serious one. In the first place, these geologic changes are usually so slow that generations are required for them to attain to appreciable amounts. In the second place, the coastal bench marks either are now or soon will be connected to the Federal precise level net of the United States, so that any change in the relation between tidal plane and bench mark can be detected by leveling carried beyond the zone of earth movement.

The range of tide, and hence the elevation of the mean high water line, varies from point to point along the coasts. The rate of change, however, is a very gradual one. Therefore, assuming a reasonable spacing of bench marks, it usually will be sufficiently accurate for the engineer who must indicate on the ground the momentary position of the mean high water line, to start at the nearest bench mark, carry spirit levels to the pre-determined elevation of the line and then by the same method stake out along the beach the contour having that elevation throughout.

In the rare cases when the high water plane has a more pronounced slope it would be a simple matter for the engineer to interpolate elevations between two adjacent bench marks (whose elevations with respect to each other can be derived from the Federal precise level net) and to run his contour to conform thereto.

We should recall, however, that a line so marked would have no permanent value, as erosions and accretions eventually would make it inapplicable.

Along the outer coast, therefore, it should not be difficult for the legislature or the court to formulate a precise and unambiguous definition of any tidal contour adopted as a boundary, by stating it in terms of its elevation with respect to a series of bench marks along the coast, and possibly, as a further precaution, by stating the elevations of the bench marks in terms of the Federal precise level net.

Application of the method is facilitated by the fact that for many sections of the coast all necessary data already exist in the archives of the Federal government.

In the basins the situation is much more complicated. Possibly it will be found that the method suggested for the outer coast can be applied here also, but certainly its application will be a proper one only if it takes careful account of the actual tidal regime of the basin.

I doubt whether there exists on any part of our coasts a natural basin; that is, one unimproved by man; where a contour derived from the elevation of mean high tide in the adjacent ocean and carried at that elevation around the basin by spirit levels would not depart more or less from the position of the true mean high tide line of the basin. In short, in the basins the plane of mean high water is usally a tilted or warped surface, or a combination of both.

As an extreme case, consider Barnegat Bay, for which tidal data have already been given. That bay is bordered, particularly along parts of its western shore, by extensive areas of low, flat marsh or meadow, and the area which would be included between the true and the instrumental mean high tide line could appropriately be measured in square miles rather than acres.

At the opposite extreme we have San Francisco Bay as an example, where the mean high tide line derived from the ocean would lie far out in the waters in some of the southern parts of the bay.

The writer would not imply that such discrepancies would survive in any litigation. He merely cites them as extreme examples, which differ only in degree and not in principle from cases which have come to his attention.

The situation, while complicated, is not inherently difficult. Exact knowledge of the tidal regime of the basin will afford the solution.

Such knowledge in most cases is not available at the present time. While the tides in all or nearly all the basins on our coasts have been measured the work was done for other purposes and would require supplementing for this one. The additional work could be quickly and cheaply performed. A relatively short period of simultaneous observations at a number of points about the basin would afford data which, by comparison with those at a primary station, could be reduced to accurate mean values. Between the points thus determined interpolations would furnish intermediate values of adequate accuracy, and the method suggested for the outer coast could be applied. The value of the result would depend on the adequacy in number and location of the points at which the observations were made, and this matter should receive careful consideration by an experienced agency.

The foregoing relates to a sound engineering method of defining the present mean high water line for future use. Sometimes it is necessary to ascertain the most probable position of that line as of some date in the remote past. The difficulties attending such an effort afford the most conclusive argument for obviating similar future uncertainties regarding present conditions.

Usually after all obtainable data have been assembled it will be found that any determination which may be made is subject to considerable uncertainties. Surveys and maps must be used whose accuracy is problematical. Interpolations must be made between showings of conditions as of two more or less widely separated dates, which depend not only on the correctness of the showings as of the two dates, but also on an assumption of continuity in rate and character of change during the intervening period which may or may not have existed. Local testimony envelops the situation in a fog of uncertainty and contradiction.

In the last analysis, the difficulties are those of relative values. A century or more ago when the foundations for some of our present difficulties were laid, the methods and processes used, and the precautions taken, were such as were considered appropriate to the then existing values. No thought, or too little thought, was given to the future. Since that period values have increased tremendously; in many cases land is worth more per square foot today than it was per acre then. And so, in some regions, our court calendars are crowded with cases seeking authoritative determinations of questions for which the methods originally used would have afforded no adequate basis for determination even if they had not been further obscured by the lapse of time.

It does not seem to the writer that we are profiting as we should from these experiences. Nothing is more certain than that values will continue to increase, and that if we continue to act only in terms of present day values our actions will be as inadequate for our successors a century in the future as these of our predecessors a century ago are now proving to us.

Especially in matters pertaining to this tidal boundary, on one side of which proprietorship is vested in the State, it would seem that we should hope for constructive, forward-looking vision adequate to meet the situation.

Artificial Changes in Basin Regimes

This is a subject of some importance at present, and which will become increasingly so in future. Important cases within this category, involving property of considerable value, have been decided on bases which, in so far as the writer is informed, took no account of the human instrumentality involved; if so, presumably because that aspect of the matter was not brought to the attention of the court.

It has already been stated that artificial works of improvement at a basin can materially change its tidal regime, and here the question of responsibility, including the possibility of demonstrating that the same exists, becomes an interesting one. The first is a legal question; the latter essentially an engineering one.

To give concreteness to the picture let us again revert to Barnegat Bay. For many years the range of tide toward the northern end of the bay has been only a few inches and the physiography of the region has adjusted itself to that range. Now suppose that during some severe storm an inlet broke through one beach which separates bay from ocean. The range of tide in the bay would immediately be increased, probably to an extent which overflowed the low, flat meadowlands in the vicinity. This would be an act of God, for which no court would entertain a plea for relief from any damaged landowner.

But suppose that, without giving due thought to the consequences, men dug the same inlet, as has been attempted in more than one locality. Then it would seem to the layman that the damaged property owner would have in theory a just cause for seeking damages, and to the engineer that the relation between cause and effect was so direct and obvious that the ground for an award of damages could readily be shown.

In other actual cases, however, this relationship between cause and effect is not so clear. In engineering work it is sometimes economical to resort to indirect means to accomplish a desired purpose, as when engineers, instead of resorting to a large amount of expensive dredging to remove a shoal or improve a channel, build a relatively inexpensive training wall which so deflects the current as to cause it to do the work for them.

In such cases the change may be brought about so gradually, extending over such a period of years, that the relation between cause and effect becomes obscured and difficult of proof.

As this is written there is pending in a certain state a case involving the ownership of an island in the heart of one of our important seaports, in which the city is seeking to wrest title from a corporation now in possession. This case is one of a number of similar ones; the total values involved probably run well into the millions of dollars.

The case hinges on the question whether the island was covered by the tide at ordinary high water as of a certain date almost a century ago. The city can produce presumably reliable evidence to show that it was so covered some two decades ago. On the other hand there is other evidence of a much earlier date, presumably of equal reliability and including official Federal surveys, which indicate that the tract in question was then bare at high tide.

In the writer's opinion no actual contradiction is involved in these two seemingly conflicting groups of evidence. Between the two periods, to which the respective groups apply, extensive artificial improvements of the basin and its entrance were made which could scarcely have failed to result in a material increase in the tidal range, and as a result of this increase the island, which was of the typical marsh formation and therefore low and flat, could well have been bare at high tide at the earlier period and covered at the later one.

This case is typical of those in which the relation between cause and effect is difficult of proof. Tidal data taken in the basin prior to the beginning of the improvement would give a direct and conclusive answer to the problem. But if tidal observations were ever made they can no longer be found, and presumably the case will be decided on a basis of probabilities as indicated by other indirect and less conclusive evidence.

If this case were unique it would not merit the space which has been given it here. But it is not unique; it is a sign-post to point out the way to avoid countless similar controversies in the future. The development of our coastal basins is in its infancy. The next century will see progress of which we scarcely dream today. That progress will be brought about in large part by the States or their political subdivisions or agencies which also have a function of guarding the rights of their citizens. Factors in that guardianship pertinent to our subject are on the one hand to protect the individual from uncompensated damage and on the other hand to protect the citizens as a whole against excessive damage claims by individuals. To that protection an exact knowledge of physical conditions prior to improvement is an essential prerequisite, of which exact knowledge of the tidal boundary constitutes an important part.

STRANGE PROPERTY DESCRIPTIONS
EASTERN LONG ISLAND

James E. Connaughton, City Surveyor
Little Neck, New York

Mr. Connaughton, recently called at the Washington Office to examine certain of our old topographic surveys. During his visit he mentioned several unusual descriptions which are recorded in deeds of Long Island properties. His field experiences in this connection are interesting.

Editor.

The old surveyors preserved their lines by running ditches. These were dug about two feet deep, two feet wide at the bottom and three feet at the top. Many of the lines were more than a mile long. In 1935 I had to survey several properties in Easthampton, and as this section is woody, I employed a number of field assistants who were familiar with it. In running some of my lines, I found that the ditches made years ago coincided with my lines and were straight. But on other properties in the same vicinity, I found that the lines I ran did not follow the ditches. The older men in my party explained why. "You see," said an old timer, "the reason is simple. The straight lines were 'pork' ditches and the poor lines were 'rum' ditches." He said the old-time surveyor would hire two gangs of men, one to start from each end of the line and work toward the center. Different surveyors would offer different prizes to their gangs, sometimes pork, sometimes rum. In one case the gang reaching the center first would receive a pig (pork) as a prize, but in the other, the gang reaching the center first would get a large jug of rum. This latter gang, being a drinking class, would not work as carefully as the sober gang, hence the "rum" and "pork" ditches.

A peculiar description which puzzled me was a "four load" and and "five load" meadow. An old timer explained that his grand-dad knew the meadow very well. He said his forebears could cut four loads of grass from one piece and five loads from the other, so the property was always known as the Four Load and Five Load Meadow.

Then there was the "shift" meadow, and again an old timer had to come to my rescue. It was explained that a certain man had two sons and divided his acreage in two parts. The elder son was, in alternate years, to mow and cart the grass from the section nearest the home, and the younger the other. At the time of the father's death, the one working the home acre was to own it from that time on. And so it was called Shift Meadow,

Another description which I ran across was the "mean" acre and the "fair" acre. This was explained to me as property surveyed by the farmer himself. The farmer would measure the circumference of his cart wheel, then tie a piece of rope to part of the wheel rim. Each revolution of the wheel was counted until the number of feet around the tract was sufficient to make up an acre. In the case of a "fair" acre, consideration was given to the smoothness of the area over which the cart traveled. The "mean" acre was considered not so accurate since the wheel went over large stones, logs, or bogs--hence, the "mean".

SOME REFLECTIONS ON ECHO SOUNDING

Paul A. Smith, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

The greatest single improvement yet made in echo sounding instruments is, without question, the perfection of graphic recorders. They have eliminated many of the most objectionable features of the earlier types. Visual indicators, while they may appear to lend themselves to slightly greater precision of individual soundings, are subject to all the limitations of human observation upon transient phenomena. Critical soundings, such as sudden shoaling or deepening or other indications of abrupt changes in depth, being of a transient nature, may be missed when the observer takes his eyes momentarily away from the dial. Strays, caused by water or ship noises are sometimes troublesome and may, on a visual indicator, be mistaken for the true echo. The continuous graphic record, visible to the navigator or surveyor as it is made, leaves little to be desired. The critical soundings are permanently recorded without the continuous attention of an observer, and the complete profile so obtained enables a recorder to select depths for the numerical records after he has seen enough of the profile to determine which are really the critical soundings; and no reliance upon memory is required.

Apart from these real advantages, the graphic record has an intrinsic or psychological advantage that will play a large part in bringing navigators to realize the valuable aid it offers. The actual trace of a submarine profile automatically recorded on a strip of paper as the vessel crosses prominent and distinctive submarine features, brings forcibly to the navigator a realization of the value of such data that cannot be obtained from the visual indicator.

A number of profiles recorded during the summer of 1939 by the Hughes instrument on the Ship OCEANOGRAPHER, F. S. Borden, Commanding, are reproduced with this article. A glance at such records shows the great advantages they offer over a record of individual soundings. The Submarine Signal Company has also designed and produced for the Coast and Geodetic Survey a portable depth recorder in which provision is made for correcting for index, draft, and tidal

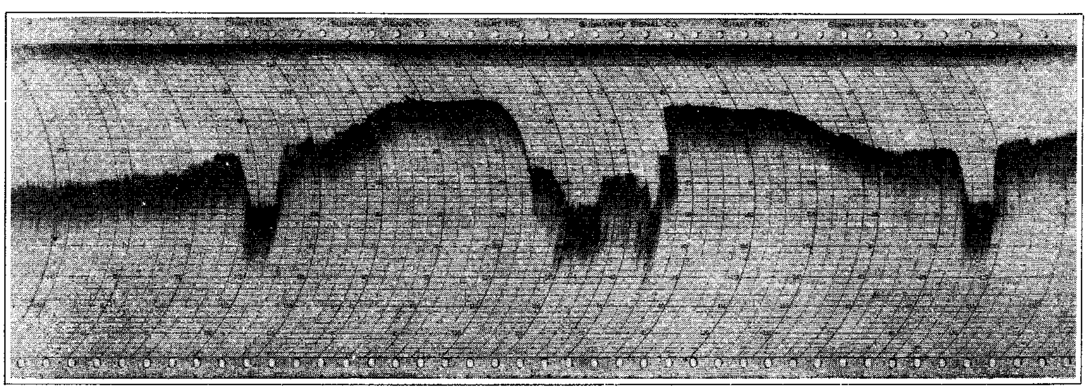


Figure 1. Graphic record made in Boston Harbor, October, 1939, by Submarine Signal Company depth recorder. Vertical scale graduated in feet (or fathoms). Paper travel about two inches per minute. (See also "Portable Depth Recorder" by Dr. Herbert Grove Dorsey, in this volume.)

variations. A sample of the record produced by this instrument is shown in Figure 1. The instrument is described in detail by Dr. Herbert Grove Dorsey in a separate article in this volume.

The full advantage of graphic recording of echo soundings is realized only when the amplifier and recording device are so designed as to record the actual impulses as they are received; that is to say, the intensity of the recorded trace should be proportional (other things being equal) to the intensity of the echo. When this is accomplished, as in the Hughes as well as in the latest form of Submarine Signal Company depth recorders, the trace may be said to be a crude oscillographic record of the echoes. This characteristic greatly assists the hydrographer to interpret the record, in that it is possible to identify silt layers of low density, as well as other characteristics of the bottom. Troublesome reflections from layers of water of different temperature or density may frequently be recognized on the record by their characteristic shading.

A Standardized Procedure Needed in Handling Records

Due to the rapid growth of the instrumental and electrical developments, and the consequent change in design of echo sounding apparatus, it has been difficult, if not impossible, to standardize procedure in field work. This has been especially true in the treatment of certain field corrections that must be made to echo soundings. Prevailing practice might be said to be make-shift, rather hastily adapted and changed from time to time to fit each new development in echo sounding, as is usually the case with new observing equipment. It now appears that a limit of depth measuring accuracy commensurate with the practical difficulties encountered has been reached. It seems appropriate, therefore, to take stock of the situation, with a view to possible improvements in procedure, with particular regard to echo sounding, that will (1) decrease the time required to plot surveys following the field work, and thereby get the results on charts earlier; and (2) increase the accuracy of the reduced and plotted soundings.

For the sake of analysis, echo sounding problems may be separated into two broad groups having to do with (1) shallow water sounding, where the utmost precision in depth measurement is required, either for large scale charts or for engineering construction (dredging and harbor maintenance, for example), and (2) deep water hydrography for smaller scale charts or other needs where relative accuracy may be more desirable than absolute precision in depth measurement.

Common to both these groups we find certain limitations inherent in all echo sounding devices. They depend upon the physical principles of sound transmission from which the practical side cannot be divorced.

In the past the practice has been to build echo sounding instruments with fixed (i.e., not readily adjustable) initial, and a constant disc or stylus speed, and then to make certain corrections to the indicated depths. These corrections are necessary because of:

1. Tidal or surface level changes of the water.
2. Draft, or depth of oscillators and hydrophones below the surface of the water.

3. Initial or index error. (This quantity, usually a constant, depends upon the type of instrument and field methods used to determine it.)

4. Variation in velocity of sound in the water from that for which the instrument is calibrated.

5. Steepness of slope of sea bottom.

6. Settlement of vessel when underway.

7. Distance separating oscillator and receiver.

8. Motor speed variation in the indicator or recorder.

The above tabulation is arranged approximately according to the magnitude of the corrections. Most hydrographers who have had experience with echo sounding have, at one time or another, been so overwhelmed by the mass of arithmetic necessary to make these corrections that the actual hydrography seemed to be a minor part of the work. So it is desirable to seek a practical means of eliminating this system, which requires so much time and labor and in which there are so many opportunities for making arithmetical errors.

Tidal or surface level variations may be allowed for by change of initial or scale index, when these data can be transmitted frequently and immediately to the hydrographic party from the tide gage. This has been done in at least one instance by the U. S. Engineer Corps through radiophone. Its greatest value is, of course, in harbor hydrography where the tidal datum is usually known in advance, but there is no reason why these data could not be transmitted automatically and used more generally. Comparatively simple equipment would be required to transmit to the surveying vessel a continuous record of tidal variations, without the constant attention of an observer at the tide gage.

Variations in the temperature of the water may be observed frequently from a vessel underway at moderate speed in depths up to about 75 fathoms by recent models of the Bathythermograph.* With frequent temperature and salinity determinations, or with frequent bar-check† comparisons, it is not particularly difficult to allow for the necessary velocity of sound corrections if the instrument is equipped with adjustable motor speed.

Probably few hydrographers will, at first thought, favor such an adjustable motor speed, on the grounds that it would probably create more difficulties in the reduction of the records than it might eliminate. It should be pointed out, however, that provision can be made to register such speed variations on a graphic recorder. Furthermore, velocity corrections, as generally made now, must necessarily be based on assumptions between a few widely scattered observations. Such a practice is especially undesirable in river es-

* A. F. Spilhaus, Journal of Marine Research, 1937-8, Volume 1, pages 95 to 100.
A. F. Spilhaus, personal correspondence (1939).
See also, "Serial Temperatures by Bathythermograph", by John C. Matthison, in this issue.

† The bar-check was described by Lieutenant Commander D. H. MacMillan, R.N.R. (retired) in his article "Echo Sounding in Harbour Hydrography" in The Dock and Harbour Authority for August, 1938. This article was reprinted in Volume 12, Field Engineers Bulletin, pages 136 to 141.

tuaries and small bays where the temperature and salinity varies, not only regionally and seasonally but even diurnally, by significant amounts. Some attempt has been made to handle the velocity correction in the above manner by the U. S. Engineer Corps, and there is no doubt that the great advantage gained justifies the effort.

The bar-check is undoubtedly the most practical method for insuring proper instrumental constants when soundings are to be recorded fully reduced for all factors. The time consumed in making frequent bar-checks will be more than made up in time saved and errors avoided in arithmetical corrections as now applied to numerical records in the conventional manner.

Settlement of the vessel, when under way, is a function of the ship speed, hull coefficients, draft, and depth of water. It is due to a regional depression of a considerable body of water in which the vessel moves, and is not an increase of the displacement of vessel with respect to the water surface only.* It cannot therefore, be determined by reference to the surrounding water surface. Model basin tests of various hulls show that settlement may be computed when hull coefficients, speed, and depths of water are known. Launch hulls are, however, subjected to such wide variations in loading conditions, that it is inadvisable to give any formula for what might be called average conditions.

Squat is usually not a serious problem if the oscillator and receiver are mounted amidships, or a little forward of amidships, as they generally are.

If an accuracy in depth measurements of a fraction of a foot is required, actual observations of settlement and possibly squat should be made. They may be determined by direct level readings from an instrument on shore to level rods on board the boat when stopped and when underway, taking proper precautions to correct for tidal changes during the observations. The combined effect may also be obtained by sounding over a flat horizontal area at dead slow speed, and subsequently sounding over the same area at normal sounding speed. Both methods require unusually calm surface conditions, and the latter requires an unusually smooth sea bottom. Settlement at normal sounding speeds, in depths of water greater than seven times the draft of the surveying vessel, will probably be of the order of 1/2 foot. It may in extreme cases be as much as a foot. In shallow water, great care must be taken to run at slow speeds if the work requires ultimate accuracy.

In surveys for charts, as in construction surveys, the expedition with which the final results are obtained and applied to the chart is second in importance only to the quality of the surveys. In estuaries, harbors, and many coastwise areas where natural changes are rapid, and frequent resurveys are required, it is doubly important. One party organization, that has been used in order to have the completed channel survey available at the close of the field operations, is shown in Figure 2 (Launch MASSASOIT, after W. P. Eaton, U. S. Engineer Corps). Such an organization is ideal where horizontal control may be obtained visually from more or less permanent objects, and where the tidal datum is established. When corrections are applied to the instrument during the survey, tedious arithmetical reductions and consequent checking are eliminated. Offshore surveys require more complex control such as the taut-wire,

* See "Speed and Power of Ships", 1933 edition, by D. W. Taylor. Pages 68 to 77.

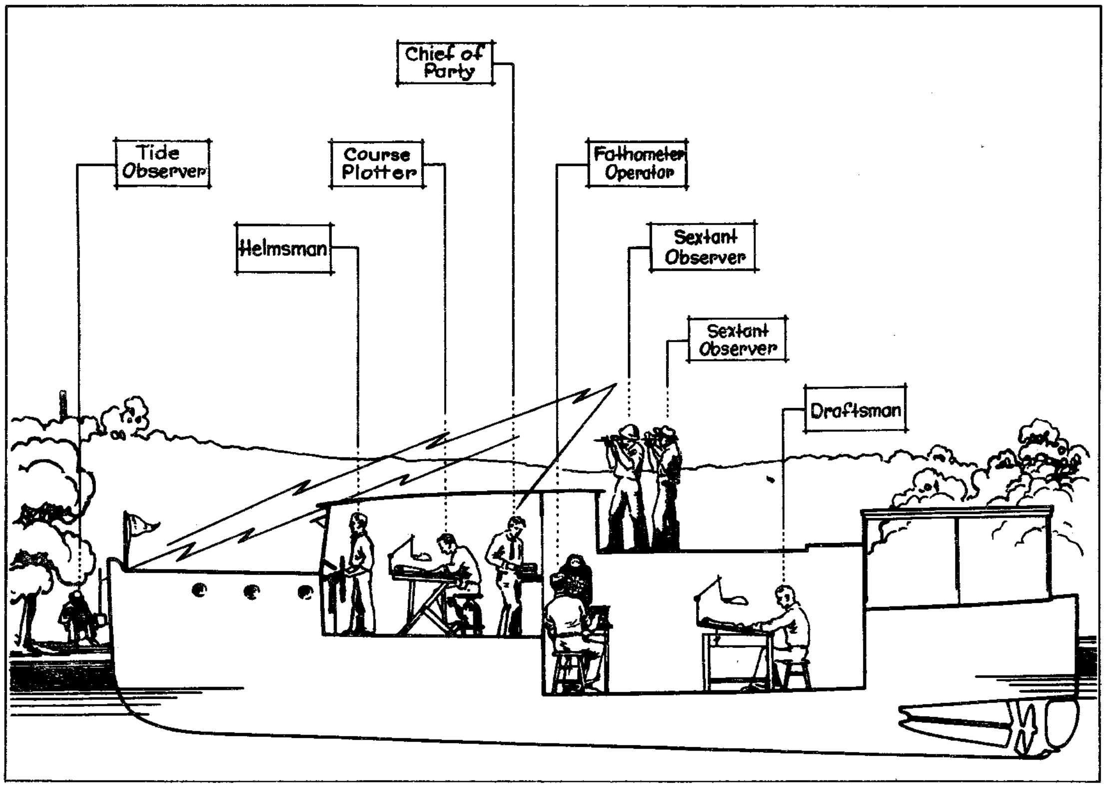


Figure 2. Party organization on U. S. Engineer Corps Launch MASSASOIT (after W. P. Eaton).

sun-azimuth traverse, or radio acoustic ranging and must, necessarily, be subsequently adjusted for horizontal control. The soundings, however, may in general be recorded fully corrected for all factors by settings and adjustment of the instrument. The more conservative hydrographer will doubtless raise his voice to remonstrate, citing, among other difficulties, the continual vigilance now necessary to be sure the index setting and speed indicator on a visual instrument are correct, and that they are properly recorded in the record. In this matter the graphic recorder again offers a great advantage, in that it affords a means for automatically registering such changes on the record. It cannot be too strongly emphasized that these adjustments can be incorporated safely in depth recorders only when they are automatically registered on the record.

Limitations of Echo Sounding

It is sometimes difficult to realize, when one first sees the excellent records produced by modern depth recorders, that the profile standing out so sharply is not a true line profile or section. It is a composite profile, made up of echoes reflected from many points of the bottom over which the area of the oscillator beam passes as vessel moves over the water surface. This is plainly apparent in some of the deep water records (Figures 4, 6, and 7). The diameter of the spot of the oscillator beam on the bottom depends upon the angular spread of the beam and the depth of the water. The width of the area effectively sounded in one passage of the vessel over a horizontal, flat bottom would therefore be

$$w = 2\, d \tan \phi$$

where "w" is the diameter of the oscillator spot on bottom, "d" is the depth of water and "ϕ" is one-half the angle of the oscillator beam. This assumes that echoes are received from all points of the area within the oscillator beam. Such a condition probably is not a frequent occurrence, and only a fraction of the reflected energy probably is received due to scattering upon reflection, and because the same directional properties exist in the receiver as have just been described for the oscillator. In any case, "w" becomes limited by the energy output of the oscillator, the diameter of source and the freauency. In this case

$$\sin \phi = 1.22\, \lambda/\delta$$

when λ = wave length of the emission,
and δ = diameter of source.

The beam is usually restricted to about 50 degrees total angle in the latest supersonic oscillators. Although sharper beams have been used, the 30 cone seems to be a conservative value considering the pitching and rolling likely to be experienced in the open sea. The fact that the beam covers an appreciable area of the bottom makes it an important aid to the hydrographer in shallow water, for it enables him, in a sense, to scan an appreciable width of the course. In deep water, however, it constitutes a serious limitation in so far as it may be desired to obtain true profiles and slopes in rugged topography.

These limitations are well illustrated in several of the accompanying profiles. In Figure 4 note the characteristic "hanging parabola" appearance of the peaks. It can be shown that this characteristic shape of the peaks is due to the spread of the oscillator beam, and the movement of the ship over the reflecting point.

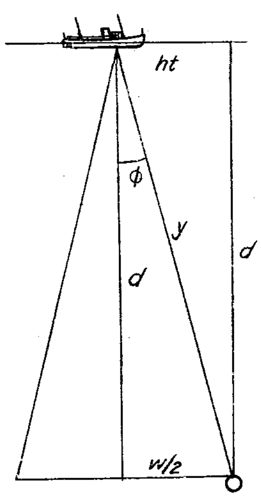


Figure 3.
Horizontal range of focused oscillator as function of depth.

Assume a reflecting sphere of negligible radius at depth "d". In Figure 3 the ship is steaming from left to right, and the paper of the graphic record is moving from right to left. If "p" be the distance the record travels while the ship travels the distance "h", then

$$x = pt$$
$$y^2 = h^2t^2 + d^2$$

If "t" is taken between +1 and -1, the unit is immaterial, and the equation reduces to

$$\frac{y^2}{d^2} - \frac{x^2}{p^2d^2/h^2} = 1$$

a hyperbola with short minor axis.

This curve is plotted (Figure 5a) for the condition of the prominence shown in Figure 4 at a depth of 229 fathoms. It is obvious from this demonstration that the steepest profile appearing on any trace will be the limiting envelope given by the above formula. Figure 5b shows the theoretical change in form of this typical hyperbola with change in depth of the reflecting point. It has been assumed in this derivation that the reflecting point

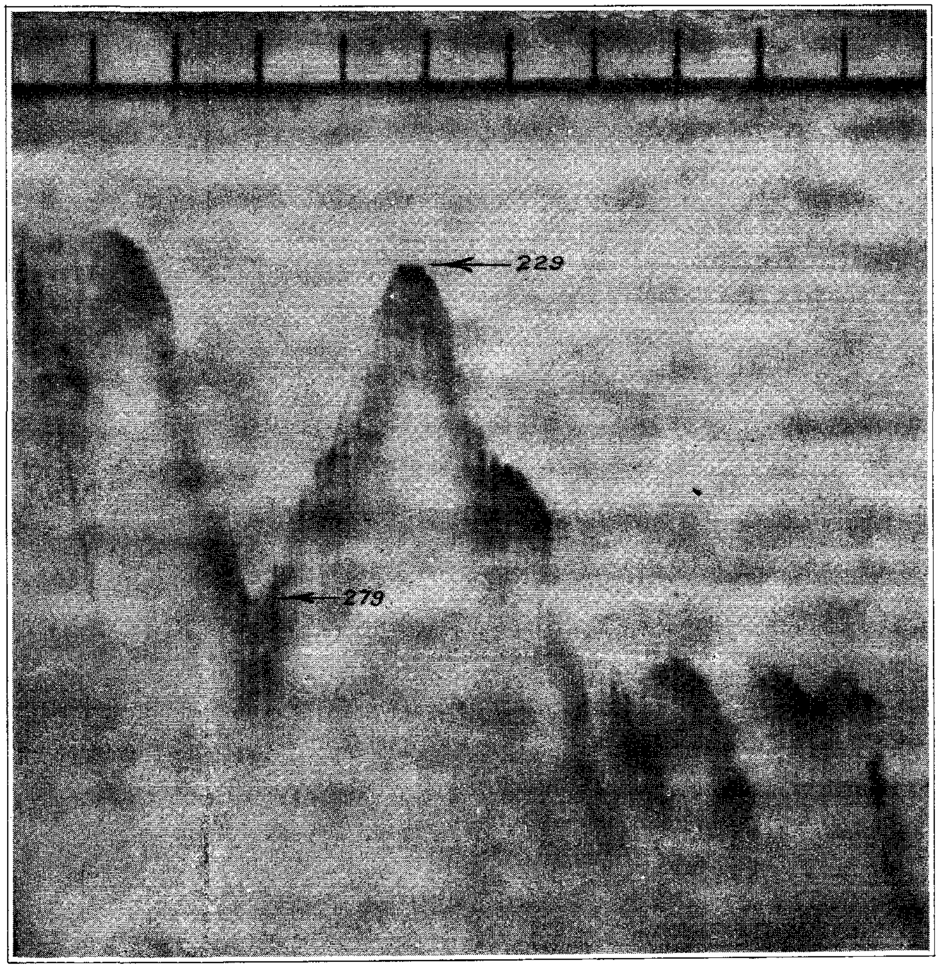


Figure 4. Illustrating some limitations of echo sounding in deep water and in rugged topography. Compare the shape of the 229-fathom peak with the theoretical curve of Figure 5a. Note also simultaneous reflections from different points on sea bottom at right end of the trace.

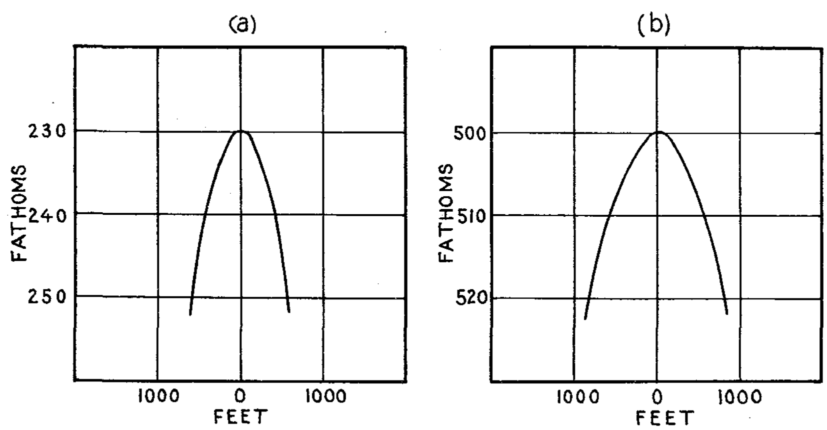


Figure 5. Echo sounding in deep water. Theoretical envelopes for reflecting point at depths of (a) 230 fathoms, and (b) 500 fathoms. Compare (a) with actual record of 229-fathom peak, Figure 4.

lies in the same vertical plane as the course of the vessel. Where the reflecting surface takes the shape of a ridge dipping sharply across the course, another factor enters which will reduce the apparent slope of the limiting envelope.

Dr. E. C. Browne (Cambridge, England) has pointed out (personal conversation, 1939) that the broadening of the recorded trace often noted in comparatively uniform depths when other conditions remain equal (speed of ship, state of sea, and constant sensitivity of amplifier) may be due to a bottom broken up by minor irregularities, similar to cobblestones, rather than a thin sedimentary covering of low density. Interference effects and some scattering due to irregularities of the bottom were probably present, but not generally apparent on the records unless the complete absence of echoes in the steepest parts of some ravines may be attributed partly to these phenomena.

When crossing over narrow ravines or deep, steep-sided canyons located at considerable depth, another important phenomenon is recorded. The small sharp cut in the profile of Figure 6 at the extreme right in about 225 fathoms depth is a particularly good example of reflections from opposite shoulders of a steep ravine. It also indicates that the deepest part of the ravine probably was not recorded. As the vessel was approaching the ravine from left to right and reached a point above "a", the opposite side of the ravine at "d" began to record faintly at "c", taking the characteristic hyperbola form, and the shoulder "a" was likewise carried through on the record to "b". Other similar phenomena will be noted on the deep water records, Figure 7.

From the foregoing it should be apparent that any rational analysis of deep water slope corrections will require first a detailed contoured sheet of the region in question, from which it might be possible to work out the corrections for each point of the actual sounding record. This is a tedious task that, to the knowledge of this writer, has not yet been done for any intensively surveyed area. Commander F. Pinke, Royal Dutch Navy (1938) proposed a method, making certain assumptions based on individual profiles in oceanographic work, but he recognized the limitations where complete topography is not available. It is improbable that the need for such detailed reductions will make itself felt for some years to come. The greatest value afforded by knowledge of deep water submarine topography at this time is in position fixing during navigation by echo sounding. It is therefore desirable to chart the echo sounding topography rather than that obtained after applying slope corrections, in order to avoid the reverse of the correction process when navigating by echo sounding.

In conclusion a word may be said about position finding methods in hydrography. Strong sextant fixes used intelligently by experienced hydrographers should be adequate for almost all hydrographic work. The accuracy obtainable is commensurate with other practical limitations encountered, such as character of bottom, sea conditions, and tolerances in draft of vessels as well as tolerances in dredging.

Since the hydrographer now has a continuous record of depth, he naturally will seek an equivalent convenience in position finding, and improvements are bound to be made. Here again the problem varies between that of large scale harbor work and that of small scale offshore surveys. Whenever it is possible to use visual fix methods, it should be possible, if deemed necessary, to construct a simple

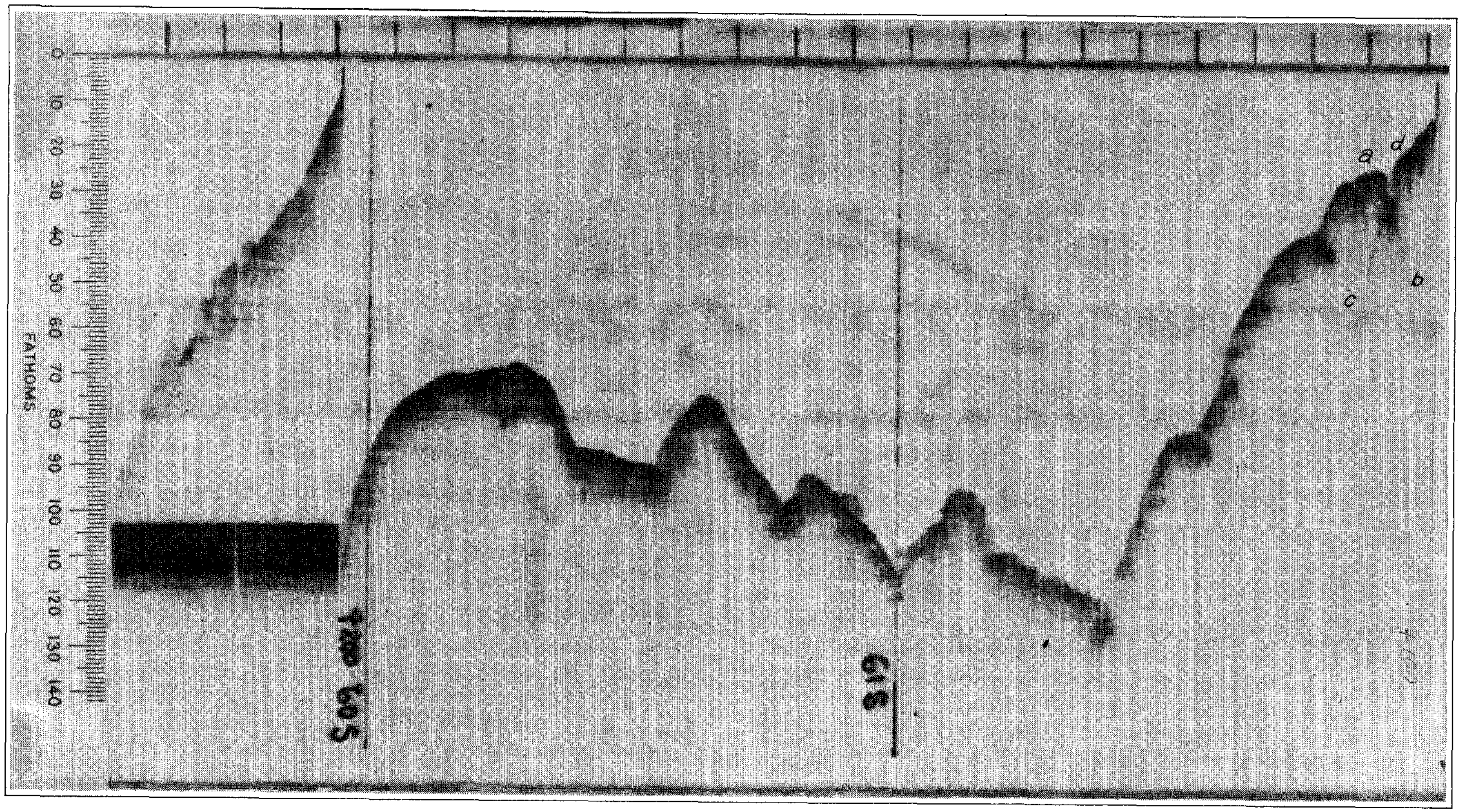


Figure 6. Echo sounding record illustrating type of trace recorded when passing over narrow, steep-sided ravines. (a-d)

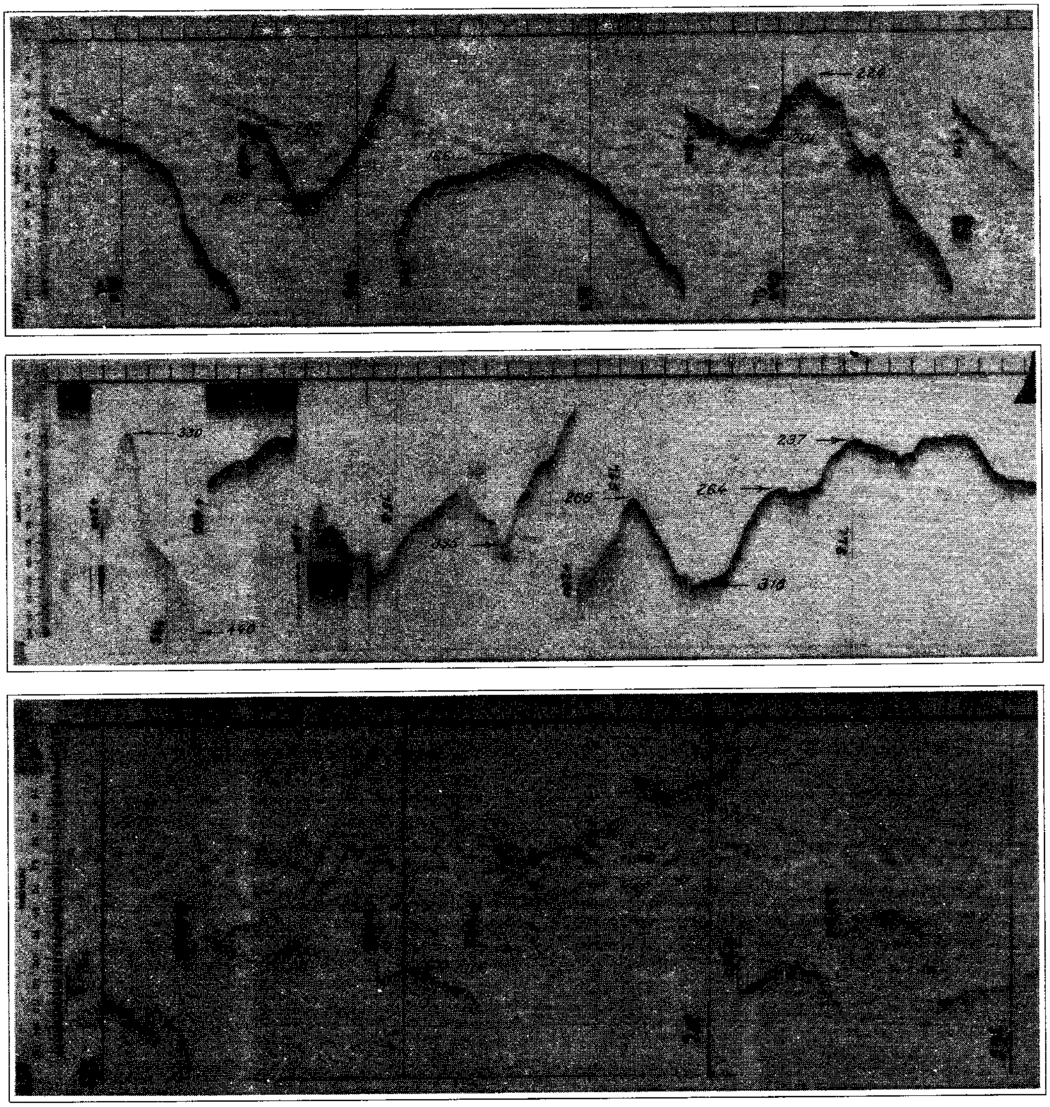


Figure 7. Echo sounding records on continental slope south of Nantucket Island 1959.
(Top) Note the "crossed profile" at the bottom of the 289-fathom valley at left indicating bottom of valley was not recorded.
(Center) Compare the 330-fathom peak or ridge at the left edge with theoretical curves of Figure 5. This is an excellent example of the limiting envelope for a point or ridge too sharp to reflect the details of the side slopes back to the surface.
(Bottom) Traces become faint on steep slopes in deep water. Simultaneous echoes such as the ones in the 1103-fathom valley at the left edge of trace occur frequently in rugged topography since the reflecting area of the beam is larger in deep water.

device that will trace automatically the surveying vessel's position from sextant angles that are maintained continuously on a set of signals. For accuracy, as well as simplicity, the use of optical methods to establish the connection between shore control and boat will certainly not be superseded for some time to come by other indirect methods. At any rate one should not lose sight of the objective, namely, to make an accurate, continuous, and instantaneous trace on the survey sheet of the track of the vessel as it moves along a sounding line. It is not impossible to do this, and for visual fix hydrography it should be susceptible of a simple and efficient solution.

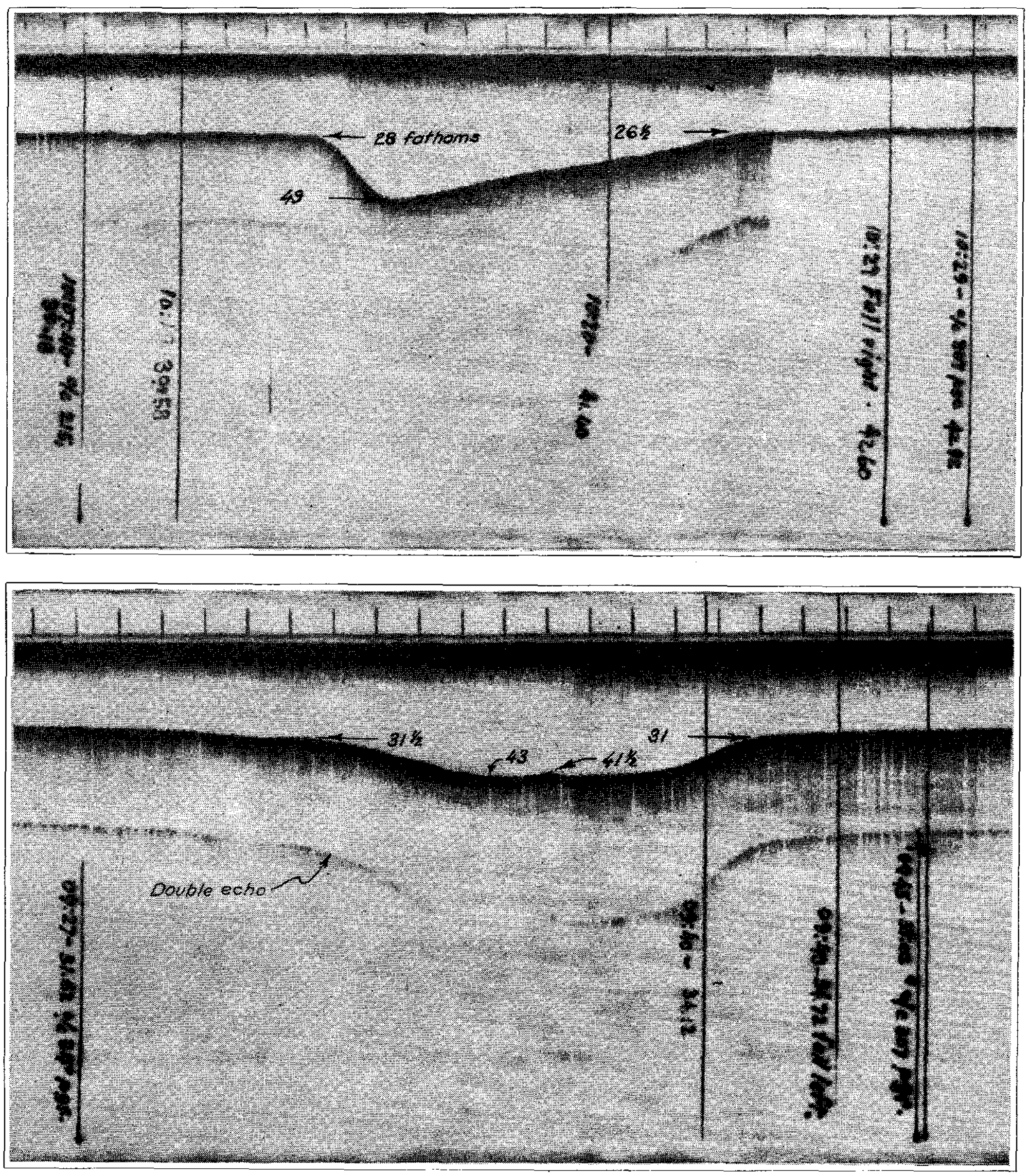


Figure 8. Echo sounding record across shallow Hudson Submarine Channel.

Above all, however, is the importance now of completing a hydrographic survey to the point where adequate depth contours can be drawn. In these days of incipient black-outs when all lights, radio beacons, and controlled aids may be eliminated, we come squarely against the fact that the ship with an adequate chart and a depth recorder can still be navigated safely in coastwise regions without dependence upon shore aids. As to what constitutes adequacy and accuracy in hydrographic surveys, I should like to quote Captain G. T. Rude:

> "The true measure of the adequacy of a survey is the ability to draw all depth contours with no doubt existing as to the accuracy of their trends and also as to the sufficiency of check cross lines; the true measure of the accuracy of a survey is the agreement of the soundings on the check cross lines compared with those at the intersections with the line of the main system" -- (G. T. Rude: "Hydrographic Data", Bul. Geol. Soc. Am., v. 44, p. 517-528, June 30, 1933).

Acknowledgement is made to Dr. O. S. Adams, Senior Mathematician, Coast and Geodetic Survey, for assistance in the derivation of the formula expressing the graphic trace in terms of ship speed, depth of water and recorder paper speed.

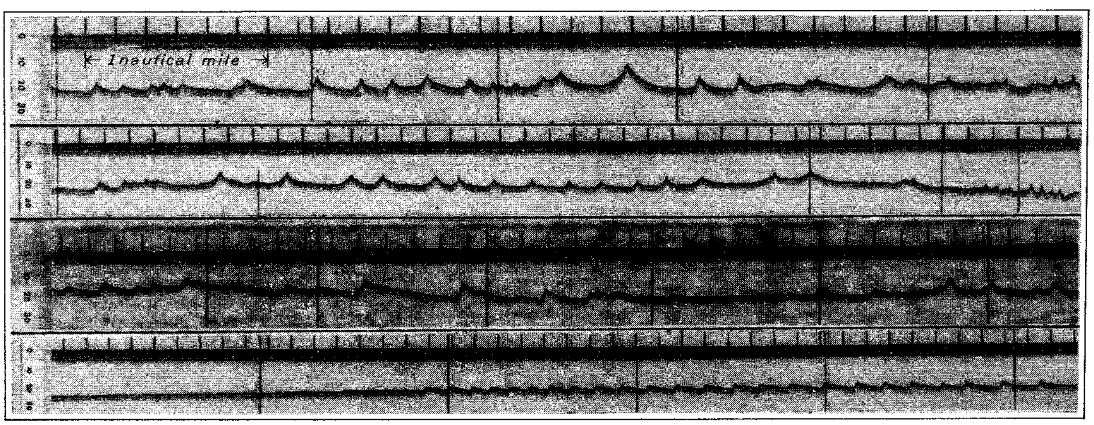


Figure 9. Large Sand Waves South of Nantucket Island. Echo sounding records made on the Ship OCEANOGRAPHER, F. S. Borden, Commanding, 1939. Vertical scale at left shows depths in fathoms. Speed of ship ten knots. Two top records illustrate symmetrical sand waves found where ebb and flood currents are about equal in strength. Bottom section shows progressive waves of current ripple type caused by current flowing in one direction. Largest sand wave (top section) is 60 feet high, from trough to crest. Compare with Van Veen: Sand waves in the North Sea, The Hydrographic Review, May, 1935, p. 21-29, and Onderzoekingen in de Hoofden, 1936.

PLANE TABLE TRAVERSE BY WIRE

Ross A. Gilmore, Jr. Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

The following method of measuring plane table traverses by wire instead of stadia has perhaps been frequently used but since I have not seen any written description of it, it may be of interest to some topographers.

During the 1937 season along the Texas Coast, approximately 60 statute miles of plane table traverse were run primarily to locate hydrographic signals. This coast, like the Louisiana coast, is extremely low, being but a few feet above sea level. Due to this pronounced flatness of the terrain, heat waves are common during the summer and the resulting refraction is a decided obstacle when running stadia traverses. It is almost impossible to read accurate stadia distances of any practical length during the heat of the day through such a turbulent atmosphere as is found close to the ground in such flat country.

An extension to the stadia rod will often alleviate this condition by elevating the line of sight, and the method of "skip stations" as described in the Plane Table Manual, Special Publication No. 144, can be used to advantage. However, since all the traverses of this project were from four to five miles long, the method of measuring with wire was adopted as more expeditious, as there wasn't much detail to be surveyed and very little vegetation to hinder its use.

On this particular project it was possible to place the hydrographic signals quite a distance inland from the beach and they could be spaced farther apart than is usual when the signals are built close to the high water line. This resulted in speeding up the work considerably as the plane table was set up at each signal only and the distance measured with a 100-meter length of wire. Standard stranded sounding wire was found very satisfactory for this purpose. The wire was carefully measured and marked at 25, 50, 75 and 100-meter intervals by weaving a small piece of cloth between the wire strands at the respective intervals. Extra length was allowed on each end of the measured wire for holding toggles.

Pins about 20 inches long were used for marking the 100-meter lengths. These pins were made from the No. 8 gage wire used in signal building. Most of the traverse distances measured were over 1000 meters and quite a few as much as 1600 meters. A convenient way of keeping track of the number of lengths measured was to use six pins, the rear chainman retaining one pin at the initial point and the head chainman starting out with the other five. When the latter had used his five pins he had gone 500 meters and the rear man came forward to him with the four pins he had collected as he proceeded along the line together with the initial pin. The head chainman then resumed his measuring from this point as a new initial. Plus or minus distances at the end of the lines were measured with a steel tape and the total distance was plotted along the azimuth line drawn on the plane table sheet. Due to the simplicity of the method and the exercise of a little care by the chainmen no errors were made in measuring as was proved later in closing the traverse on a control point.

The chainmen were easily kept on line by the use of the alidade for alignment and signaling them with a white flag on a long pole. Where necessary, intermediate points were sometimes established on the traverse from which necessary detail could be located. These points were marked by a small pole with a flag and could be occupied later with the plane table. Generally, however, all detail could be located from the main traverse stations. The topography was rodded-in in the usual manner by stadia just before the rodmen started their wire traverse.

This method is exceptionally efficient in flat country where the main purpose is to locate hydrographic signals. The positions of other objects can readily be obtained by intersection cuts as the traversing progresses.

WHERE THE DECIMAL POINT GOES*

John B. Douglass, Charleston, West Virginia

The number of computers who have trouble in placing the decimal point in slide-rule computations is astonishing. Perhaps the following rules will help: they were taught the writer by Prof. Carl Cathers, West Virginia University and to the writer's knowledge have never been published before:

When multiplying and the slide goes to the right the product will possess the sum of the digits of the multiplicand and the multiplier less one; when the slide goes to the left the product will possess the sum of the digits. If dividing and the slide goes to right the quotient will have a number of digits equal to the dividend digits minus the divisor digits plus one; but if the slide goes to left the quotient will possess a number of digits equal to the dividend digits minus the divisor digits. If numbers less than one are being multiplied the ciphers are handled as minus digits; when dividing the ciphers are handled as plus digits.

Troy Carmichael, President,
Standard Bitulithic Co., New York, N. Y.

Referring to the article by John B. Douglass of Charleston, W. Va., on "Where the Decimal Point Goes": His rule is of course correct, but it has to be memorized. In order that this rule shall ever be before me, I move the slide to the right and near the end on the wood thus exposed, I put the following sign in white ink:

X Sum + 1
÷ Difference + 1

Then, moving the slide until it extends to the left, I put this sign

X Sum
÷ Difference

In this way the proper rule to use is always exposed.

* Reprinted through the courtesy of Engineering News-Record.

THE BERING SEA SURVEY

E. W. Eickelberg, Hydrographic and Geodetic Engineer
Commanding, U. S. Coast and Geodetic Survey Ship GUIDE

Since the past season marks the beginning of a concerted program to expedite the charting of the Bering Sea area, a resume of the experiences encountered should prove of value for future planning.

This first year in this region has revealed the enormous extent of this project. Because of the short working season, the small number of working days during the season and the comparatively shallow water requiring closely spaced sounding lines as far as sixty miles offshore, the survey of the Bristol Bay area from Cape Sarichef to Cape Peirce looms as an undertaking which will require many years for completion.

Not only in this area but in the large unsurveyed area to the northward of Cape Peirce there is considerable steamship traffic by large vessels. From the shipowners operating in this territory increasing complaints may be expected about the inadequacy of present surveys. Many geographical features along the north shore of Bristol Bay are reported to be as much as ten miles out of position, and some of the charted bays are reported not even existent. In many respects this area is of far more importance than that of the Aleutian Islands, since there is no commercial traffic to the west of Dutch Harbor. What little service is required by the cattlemen and trappers is furnished by a small trading schooner, whose captain navigates by local knowledge as far as Attu Island at the western extremity of the Aleutian Islands.

It is estimated that 15 years will be required to complete the Bristol Bay area with one survey ship. To complete it in shorter time will require more ships and more modern equipment because weather conditions prevent an extension of the season either in the spring or autumn. One possible method would be to obtain more working days during the working season by permitting an accumulation of leave (on working grounds only), for overtime and holidays worked.* This year, between May 15th and September 15th, there were 29-1/2 holidays. By such an arrangement one could, in effect, lengthen the season by one month, during the best working weather. The importance of spending as much time as possible on the working ground is realized when one sees the frequency of interruptions by more or less brief storms, and the need to utilize every available working day or fraction thereof.

The Coast Survey Officer must consider weather from the standpoint of visibility necessary for ship and launch hydrography and of sea conditions not too rough for the successful use of the Fathometer and sono-radio buoys, for small boat work and the necessary contacts with camp parties ashore. The following should be considered with that in mind.

While one should not condemn this area because of one season, knowing that "One swallow does not make a summer", still there are some outstanding conditions here which are not encountered in other

* Legislation authorizing such extensive compensating leave would, however, be required. (Editor)

regions and which tend to limit the amount of work which can be accomplished in this locality. It should also be noted that this coast has a bad reputation locally. Arriving at Port Moller on May 25th, we were greeted with the words, "Well, Captain, you have a pretty tough assignment." (This from the "skipper" of the canning tender STARLING, who has been coming up here for many years). And, as if to substantiate his claim, two days after we left Port Moller the 675-ton, four-masted fishing schooner SOPHIE CHRISTIANSEN was blown ashore in that very harbor during a sixty-mile gale. The captain of the FERN, a former lighthouse tender but now a trading vessel making monthly freight and mail trips from Seward to the westward and from Dutch Harbor to the head of Bristol Bay, declares that they can expect their worst weather on the run from Cape Sarichef to the head of Bristol Bay.

In spite of all this, weather conditions were ideal for survey work during the latter half of May and the month of June and practically three quarters of our season's work was accomplished during that period. The additional work that was done after the first of July was done literally a day at a time. From July 1st to the end of the season there was only one occasion where we had two full working days in succession. During September we were on the working grounds from the 1st to 19th inclusive, and had only two questionable days for launch work, (i.e., it was impossible to survey the inshore lines).

During July there were four storms of force six to ten, and five and one-half days of working weather; in August six storms and five and one-half days of working weather; from September 1st to 26th eight storms and four days suitable for working. In early May and September the prevailing winds are from the north, from which there is no shelter, and these cause seas of sufficient severity to prevent the proper functioning of both Fathometers on account of strays and to make the sono-radio buoys become very noisy. In the autumn, coincident with the formation of the Siberian high, the low pressure areas come along with the regularity of eggs out of a hen; frequently two low pressure areas are on the map at the same time, and the only difference is that it blows harder some days than others.

Clear weather affording visibility for distances of 15 miles is unusual. It usually occurs just before a southeaster and then lasts not more than one day. This is the time that must be used for fixed position work, development work on offshore shoals, and for location of offshore sono-radio buoys. There is very little sunshine, so that one can practically eliminate the possibility of buoy location by inclined azimuths. A taut-wire apparatus is needed for this work and one is expected to be available next season; a gyrocompass would also be useful but installation of one in a vessel of this age might not be considered economically advisable. It is entirely possible, however, that this work can be accomplished by RAR methods, except that the close spacing of lines and development necessary are difficult without the accurate steering which only the gyro can furnish.

The approach of a low pressure area is always indicated by exceedingly clear weather, and by the presence of cirrus clouds pointing in the direction of the low pressure area. The cloud indication is usually very reliable and frequently we have anticipated these blows even when the weather summary did not predict them because of lack of ship reports. Forms for plotting weather data are provided our vessels by the Weather Bureau, in return for cooperation in sending daily weather reports to San Francisco. These maps are for the North Pacific, 14" x 24" in size, and forecasts based on data plotted thereon have been of considerable aid in the planning of the work.

Camp Parties

On an open coast such as Unimak Island there is no substitute for a camp as a base from which to work. This is because of the very-few days on which landings can be made. Even in a moderate wind the seas break so sharply on the steep sand beaches that a whaleboat even with only a light load can rarely land. On two occasions the steepness of this beach was the cause of some surprise to two members of the crew who, on a smooth day, decided to step ashore from amidships, and, in doing so, promptly disappeared from view. The water temperature at the surface is about 38 degrees in the spring and 46 in the fall so that most of the landing parties wear hip boots and everyone avoids in so far as possible a dip in the surf.

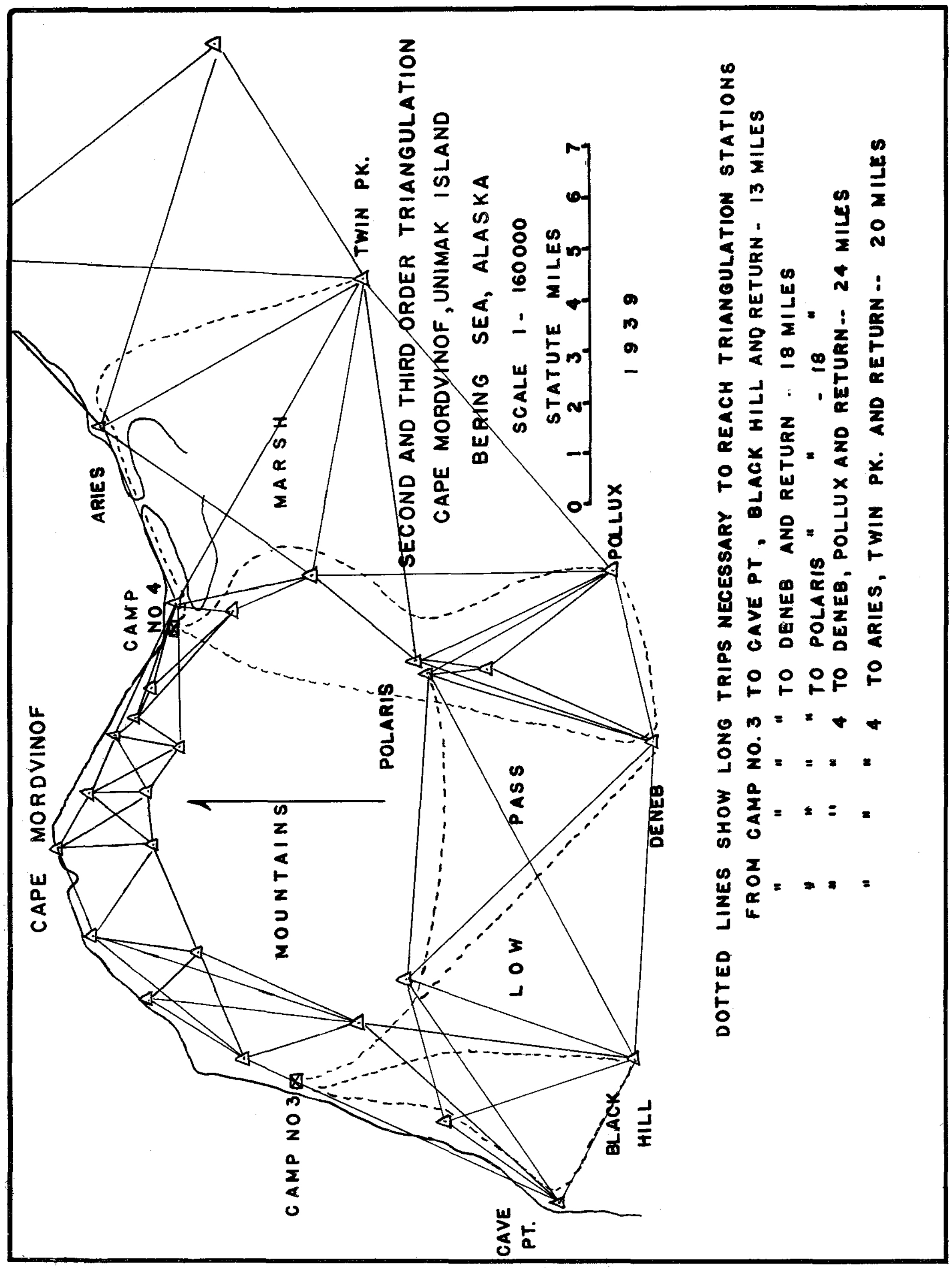
In the spring, camping is rather cold and windy. At the first camp of the season a windstorm, which blew all day long, finally capsized four tents during the night, in spite of the fact that they had been reinforced the previous day. The members of the camp party were equipped with bedrolls and three blankets apiece and still complained of the cold. In the autumn, after a summer's conditioning, the camp parties are better able to withstand the cold, but by this time (September 1st) the northers begin to blow. In these shallow waters an ugly sea arises quickly under a fresh breeze and moving camp by the ship, and landing food and supplies from it, becomes very uncertain. On two occasions we were able to pick up the party but not land them again the same day, because it got too rough in the meantime, and three days elapsed before another landing could be effected.

A camping party has too much gear for it to be moved by horses unless the number of horses available were doubled, which would not be economical. An alternative has been considered to avoid delays in moving. This would necessitate sufficient equipment to establish and supply an advance camp. Then the camp party would need to move only its instrumental equipment, cots and bedding, which could probably be accomplished with five horses in two trips in one day. By this plan no time would be lost in waiting for weather suitable for moving. The quantity of material needed for a camp for nine men and four horses is considerable in itself, as the party is stocked for three weeks, which is calculated to be the average stop between moves. This includes food, coal or gasoline, oats, (and hay before July 1st), lumber for signals, cement, lime, and other supplies and equipment such as cookstoves and heaters. There is practically no driftwood available on the beach, but occasionally there are a few large logs. The latter are even found in the creek beds a half mile from the beach and in one case an estimated thirty feet above high water and one half mile inshore. These are presumably carried inland by the severe winter storms.

Plans are usually made so that the triangulation and topographic parties can operate from one camp and the organization is as follows:

Triangulation	Topography
1 officer	1 officer
3 men	5 men
2 horses	2 horses

1 cook


SECOND AND THIRD ORDER TRIANGULATION
CAPE MORDVINOF, UNIMAK ISLAND
BERING SEA, ALASKA
SCALE 1 - 160000
STATUTE MILES
0 1 2 3 4 5 6 7
1939
DOTTED LINES SHOW LONG TRIPS NECESSARY TO REACH TRIANGULATION STATIONS
FROM CAMP NO. 3 TO CAVE PT., BLACK HILL AND RETURN - 13 MILES
" " " TO DENEB AND RETURN - 18 MILES
" " " TO POLARIS " " - 18 "
" " 4 TO DENEB, POLLUX AND RETURN -- 24 MILES
" " 4 TO ARIES, TWIN PK. AND RETURN -- 20 MILES
TWIN PK.
ARIES
MARSH
CAMP NO 4
CAPE MORDVINOF
POLARIS
POLLUX
MOUNTAINS
LOW PASS
DENEB
CAMP NO 3
BLACK HILL
CAVE PT.

One serious difficulty in separating the triangulation and the topographic parties is that the four horses have to be divided, and since this is their third year together it is difficult to keep them separated. They will invariably break away at night and return to the base camp, leaving one of the parties without a horse.

One outstanding characteristic of the triangulation is the long hikes which are occasionally necessary to reach a station, and which supply the principal argument in favor of horse packing over back packing. The terrain is soft and by midsummer the heavy growth of grass is waist high. Large lagoons, some a mile and a half in diameter, impounded behind barrier beaches make lengthy detours necessary to reach the inshore stations. On occasions Ensign Conerly and his recorder made hikes of twenty miles in one day and once went this distance and occupied two triangulation stations. Obviously, this requires excellent stamina and much determination.

The horses are wintered at False Pass, where they furnish much amusement to the local residents and in turn receive a great deal of attention. When the GUIDE arrived in the spring the horses immediately disappeared and failed to return that evening for their oats and hay. The caretaker said that that was the first night all winter they had failed to return. The conclusion was inescapable that we were not welcome or at least that they knew what our arrival meant in the way of work. Their season started with a 70-mile trip from False Pass to Cape Sarichef, much of it over rocky ground and up and down steep ravines. (It was down one of these steep ravines that "Nip" fell and was killed just before the end of the season).

This trip has to be made "under bare poles", so to speak, with meager food supplies for both men and horses, as it requires about six days. Hay cannot be carried on this trip and the horse feed is limited to oats and what dry grass they can find along the way. The grazing season does not start until the first part of July and prior to this time the ship has to carry a supply of hay and land it at the various camps. Hayseed seems to get into everything about the ship during that part of the season.

The horses act as a sort of connecting link with civilization and afford much amusement to the camp party. At lunch time they usually come over near where the men are eating and stand by waiting for a handout. Their favorite refreshment is a cheese sandwich. At night in camp one or two of them always pay a visit to the cook tent and generally are rewarded with some leftover - they are unusually fond of rice. Also they will occasionally get into a pan of applesauce which has been set out to cool.

In crossing streams too deep to wade, two men get on a horse's back to avoid getting wet. One horse, in particular, has the habit of sitting down right in midstream, having learned that part of his load will slide off when he does this. He may do it to prevent sinking into the sand with his extra load, but it is considered by the men just pure cussedness.

Topography

The topographic work presents no special problems since the work is routine and is being done in the manner of the good old "horse and buggy" days without the assistance of air photographs.

Launch Hydrography

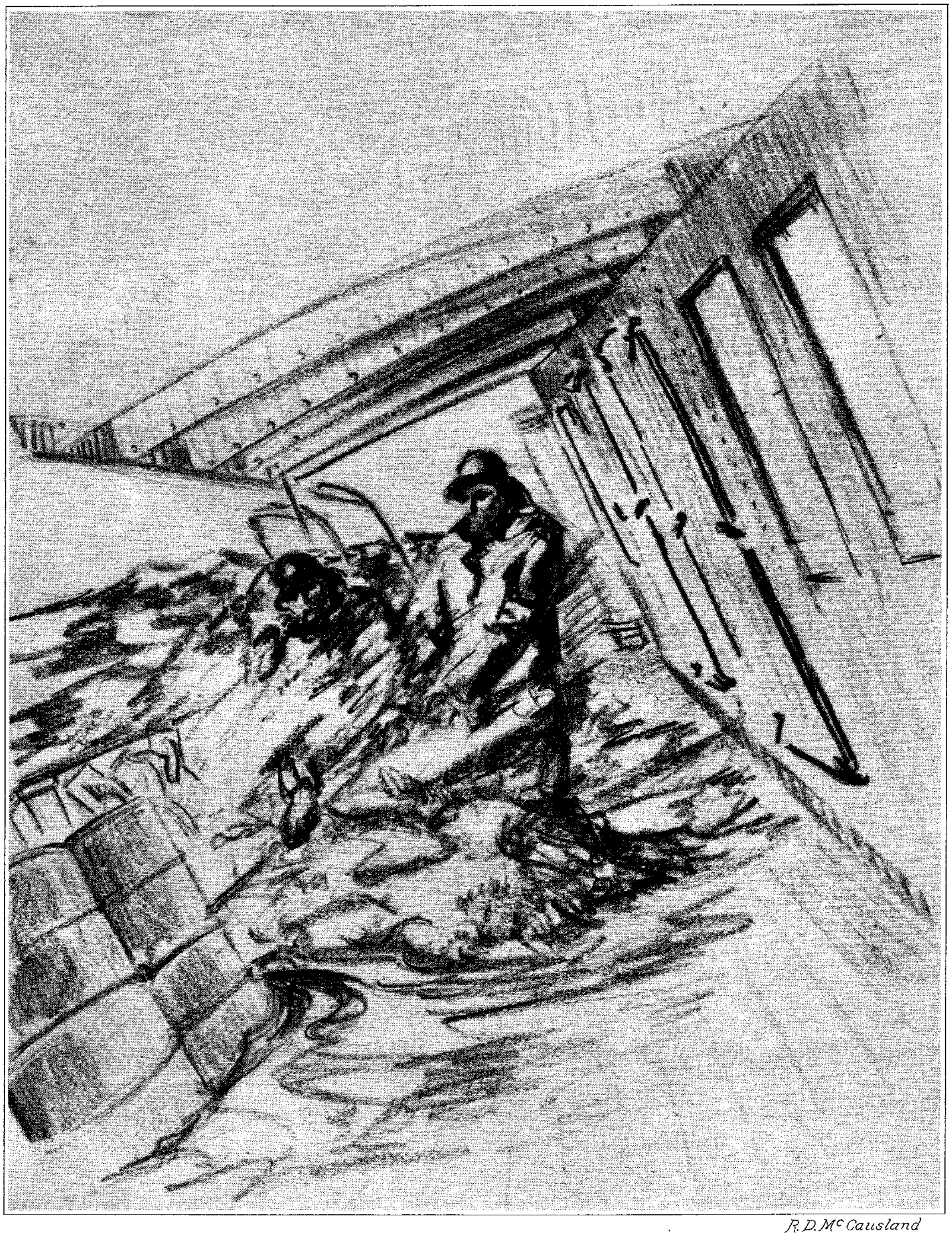
Launch hydrography is also routine, except that the working days are few and far between. An average of about five per month is all that can be expected. Recording echo sounding instruments in the launches would be of wonderful assistance and result in a remarkable increase in efficiency in this area, where the working days are so few. Where such instruments have been used in the Canadian Hydrographic Service the launch output has been increased fivefold and it has been possible to operate with fewer men in the sounding party. It is understood that some portable echo sounders will be supplied to Alaskan parties next season.

Radio Acoustic Ranging

It is most economical to do this work during the foggy months of July and August, when little other work can be done with any degree of continuity. During the past season RAR work was accomplished in the early part of the season because of lack of control at the start of the season for the inshore work. This worked out advantageously as there was a large area northwest of Cape Sarichef where ship hydrography could be based on the previously established control on Akun and Akutan Islands and the triangulation on Unimak Island.

The Vincent-type of sono-radio buoy gave very satisfactory results, returns being received up to 100 seconds, which was as far as the work extended. One shore station was established at Cape Sarichef, but strong currents caused water noises through which it was difficult for the operator to receive the bombs. Late in the season an offshore buoy, in 40 fathoms, was substituted but it was lost. The currents were equally strong in that location, and large islands of floating kelp are prevalent at that time of the year and it is believed that the watch buoy was towed under by one of these, causing its collapse and loss of equipment. A second buoy was later lost during a northwester. The fall of the year is considered a poor time for RAR, since there is usually very little calm weather and the rough seas raise the noise level of the buoys so high and cause so many strays on both the old and new Fathometers that satisfactory operation is almost impossible. Also, there seems to be more static at this time of year. There is considerable interference on the frequency now in use from a Japanese broadcasting station and also from a Russian station sending in code. In addition, if one of the buoys of one ship becomes noisy it interferes with the reception of all other units. This suggests that some slight differences in frequencies may be necessary to prevent interference from noisy buoys which cannot be silenced immediately because of weather or other reasons.

There was quite a range in the velocity of sound between spring and fall, 1462 meters per second in spring and 1476 meters per second in fall. Difficulties, experienced by the PIONEER and GUIDE, in the reception of bomb returns, from both shore stations and buoys, seem to be due to irregular bottom and shoal areas between bomb and hydrophone. The water in the Bering Sea was 38 degrees in the spring and yet cast-iron bombs had to be used to get returns over certain shoals which were only a few fathoms less than the general depth; but they were of large area. It is believed in this case that water temperature is of slight importance in the successful reception of the bomb returns.



Lashing Oil Drums in a Seaway

A LAMENTABLE DITTY

Oh, what a life is the Coast Survey
Through mud and mire to wend my 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 than 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 round
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.

Geo. D. Wise, Assistant,
U. S. Surveying Schooner Franklin,
September 25, 1852.

PACIFIC COAST WIRE DRAG SURVEY - 1939

I. E. Rittenburg, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Instructions issued to the Pacific Coast Wire Drag Party which left Oakland, California, June 7, 1939, provided for wire drag surveys in the vicinity of St. George Reef, northern California, until September 15, 1939. Subsequent to this date, surveys were to be continued southward from the vicinity of Point Arena, California.

The Pacific Coast Pilot states on page 155 that "All the rocks of St. George Reef rise abruptly, and when in its vicinity the lead gives no warning of their presence." This is true also of the subsurface dangers in this vicinity. An abrupt rise of 12 to 15 fathoms is not uncommon; in one instance a ten-fathom shoal rose abruptly from general depths of 30 fathoms.

The party arrived at Crescent City, California, June 11, 1939, and completed the surveys of the St. George Reef and Crescent City areas by the middle of September. The party experienced an amazingly large number of unexpected groundings, and in each case much time was consumed in locating the least water on the obstruction and in clearing it. Had it not been for the unusually good weather conditions which prevailed during the season, very little progress could have been made toward the completion of this area. Five different attempts were necessary before the sweep finally cleared all rocks in several areas and one area was dragged eight times before all rocks were found and cleared.

While some of the pinnacles cleared do not constitute menaces to surface navigation, several, because of their locations and depths, are extremely dangerous obstructions, and many should be avoided. By a strange coincidence, the most important and dangerous of the pinnacle rocks was found on the very first day of the present season. This rock, covered by only 25 feet of water, rose from depths of 100 feet and was situated in the middle of St. George Channel. As an eight- to ten-foot swell is not uncommon in these waters, and as steam schooners regularly use this channel while beating north against the northwesterly winds prevalent in summer, this discovery was sent by radio to the Inspector at San Francisco so that he could issue a "Notice to Mariners". Another sharp pinnacle with a least depth of 22 feet was found just north of the course used in entering Crescent City harbor. Although about 50 yards north of the usual entrance course, it is directly on the course of any vessels leaving Crescent City, bound north through St. George Channel. As the Oakland Tribune reported, "God must have had his arm around the Steam Schooner men!"

Should additional breakwaters be built, as contemplated, to make a safe harbor of refuge at Crescent City, the resultant increase in traffic to and from this port would increase immeasurably the importance of this discovery.

Numerous areas of shoal waters were found, which because of their proximity to other previously charted hazards cannot be considered new dangers to larger vessels, but are important discoveries so far as the safety of the smaller fishing boats is concerned. The most important of these is a pinnacle covered with only five feet of water found about 200 yards northeast of the Great Break. Two others, covered with 12 feet of water, were discovered about one-half to three-fourths mile offshore and about three miles southwest of Crescent City Light.

Every wire drag party whiles away its hours at anchor with conjectures as to how certain shoal areas were missed by hydrographic parties, why they were not found and reported by local mariners or fishermen, and the nature of what has been found. Speculation in this party focused on two areas where wood was found on the bottom. Could the wood be the remains of vessels unfortunate enough to have been the unlauded first discoverers of the pinnacles? Or the wreck of the Steamship BROTHER JONATHAN in 1865, lost off St. George Reef and reputed to have had on board the payrolls for the Army posts of the Northwest? The ship is presumed to have struck Jonathan Rock and the master in an attempt to save his ship and the lives of his passengers is supposed to have turned around and headed for Crescent City. Before this harbor could be reached, however, the vessel filled and sank. Both these areas of wood bottom lie in positions which would logically support such a hypothesis.

St. George Reef was completely resurveyed in 1929 by modern methods and a system of closely spaced sounding lines. In spite of that the wire drag party this season cleared 86 hitherto undiscovered pinnacle rocks. These results emphasize Captain F. H. Hardy's statement that "the assurance of clear channels in Pacific Coastal waters can be attained only by supplementing the usual hydrographic surveys with wire drag work."*

The BROTHER JONATHAN, mentioned above, was a vessel of about 1,200 tons, manned by a crew of 50 officers and men. Commanded by Captain De Wolf, she left San Francisco on July 28, 1865, bound for Portland, Oregon, with a passenger list of 140 and carrying 500 tons of freight. Encountering heavy weather en route, it was decided to seek shelter at Crescent City. Accordingly, the course was altered and 15 minutes later the vessel struck forcibly on a submerged rock believed to be the one now called Jonathan Rock. In striking, the fore part of the vessel was pierced and the hull sprung apart sufficiently for the foremast to slip through. Only one lifeboat, containing 19 persons, got away. The remainder of the 190 aboard were lost when the vessel sank, 45 minutes after striking.

That the rock on which the BROTHER JONATHAN struck was uncharted at that time is substantiated by the official report of the Supervising Inspector of Steam Vessels for the Pacific Coast District. This report states in part: "It is not known with certainty whether the rock upon which the vessel struck has been previously known or not as it is impossible now to determine the exact position of the steamer at the time, but it is generally believed it was farther to sea than any rock or reef now laid down in the charts; and in support of this view it is hardly possible that a commander so experienced on this route, so constant in watchfulness, and so immensely correct in all his habits could have run on any known danger in broad daylight, and the weather so clear that the position and bearings of the ship must have been fully known to him."

* "Wire Drag Surveys, Pacific Coast, 1934-1937",
foreword by F. H. Hardy, Field Engineers Bulletin, Vol. 11, p. 9.

LEAST DEPTHS ON SHOALS EFFECTIVELY DETERMINED

George F. Jordan, Assistant Cartographic Engineer
U. S. Coast and Geodetic Survey

At the close of a shore party field season, there were sufficient funds remaining to operate a skiff party of four men for a month. This permitted a valuable investigation of the most dangerous shoals verified or discovered by the usual hydrographic parties.

The skiff was built in the South, from juniper, for sounding in the shoal bays. It was 22 feet long and had a 6-foot beam and drew only 1-1/2 feet with party and equipment on board. It was propelled by an outboard motor. There were three of these motors available at the end of the season, so two were clamped on the stern of this skiff to permit a very quick run to the shoals to be examined. Only one motor was used during the investigations.

The other equipment consisted of the usual position-determining instruments, an anchor, oars, the lead lines and buoys, which latter were important accessories. Seven lead lines were prepared in advance, each with a float attached a few feet farther from the lead than the least sounding previously obtained.

The shoal area was then located in the usual manner, except that intersecting ranges were carefully noted for use in relocation. After what was probably the shoalest spot was determined, the skiff was run up into the wind or tide, the course of drift having been previously noted. One man remained in the stern with an oar and the other three lined the upstream side of the skiff with a lead line in each hand, six in all. Each man watched the ranges while feeling for least depth, calling to each other the depths obtained. After the shoal had been drifted over, the ranges of the least depth were noted. The skiff was then run up into the wind and allowed to drift over the shoal again with a half boat length overlapping the previous drift. This was repeated until the shoal had been fully covered.

The shoalest spot had now been narrowed to the least depth found in these driftings. The skiff was now run up to that spot and anchored with only a few feet of the anchor line. The helmsman now sculled the skiff in an arc around the anchor. The anchor line was then let out half a boat length, and the operation repeated, the three leadsmen with their six lead lines feeling the bottom all the time. If the shoal was a rock, any sudden rise was marked by immediately letting go of the lead line, with the float attached. If that spot marked the shoalest depth found, it was a matter of a few minutes to investigate thoroughly the least depth.

In the absence of a wire drag, or any drag, this method proved valuable in our survey, where a pinnacle rock with a least depth of 17 feet was found on the edge of a shipping lane where the least depth previously charted was 21 feet. I believe that this is a good way to clean up the season's work, if funds and other circumstances permit.

THEODOLITE MICROMETER TESTS

Carl I. Aslakson, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Recently the writer, assisted by Mr. C. A. Whitten, Assistant Mathematician, made extensive tests on a number of theodolites which revealed certain mechanical imperfections in micrometers. The results of these tests and the conclusions drawn from them are herewith described.

The micrometer on the Parkhurst theodolite is greatly improved over that used on early theodolites of the Coast and Geodetic Survey. The principles involved in the earlier type of micrometer are illustrated in Figure 1. The exact mechanical details are not shown, but the sketch illustrates the sources of the imperfections discovered.

The slide S (Figure 1) holding the crosshairs moves horizontally in slots in the frame F propelled by the micrometer shaft T, on one end of which is attached the graduated drum D. The compression springs C maintain a pressure on the crosshair slide to eliminate backlash. The principle sources of error in a micrometer of this design were in (a) an imperfectly fitted slide which bound and distorted at portions of the track and (b) mechanical defects in the bearing surface B.

The imperfections in the bearing surface were the greater source of error, and the reason for this error is illustrated in Figure 2. If the bearing surface on the plane x-x' (Surface B in Figure 1) is perfectly true and exactly normal to the axis of the micrometer shaft y-y', the rate of the rotary micrometer drum movement is exactly proportional at all times to the rate of the movement of the crosshair slide in the plane of the frame. However, when the frame bearing BF and the drum bearing BD (Figures 2a and 2b) are not parallel to the plane x-x', a variable rate of motion of the crosshair slide will result which is a function of the rotary motion of the crosshair drum. In Figure 2a, this tilt of the bearing is shown greatly exaggerated. The two bearing surfaces are tilted with respect to each other forming the angle θ. The frame bearing surface BF is fixed in position, but the bearing surface BD of the drum is free to move horizontally against or with the springs as the drum is rotated. Assume (see Figure 1) that one complete revolution of the micrometer drum moves the crosshair slide a distance Z in the frame. Now it is evident that with the bearing surfaces tilted as in Figure 2a the slide will also be moved a distance Z for one complete revolution. However, for one half a revolution there is a translative movement of the point P on the axis of the micrometer drum to P'. This translative motion is transmitted to the crosshair slide also, so that for 180° of rotation or one half revolution of the drum, the movement of the crosshairs becomes

$$\frac{Z}{2} - d.$$

During the second half revolution of the drum (Figure 2b), the crosshair movement becomes

$$\frac{Z}{2} + d.$$

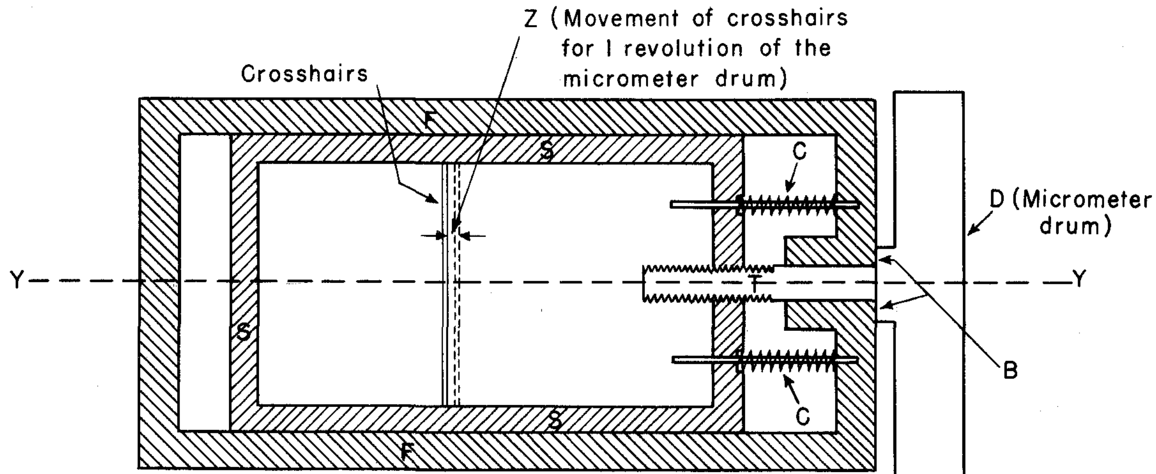


FIGURE 1
EARLY TYPE OF MICROMETER

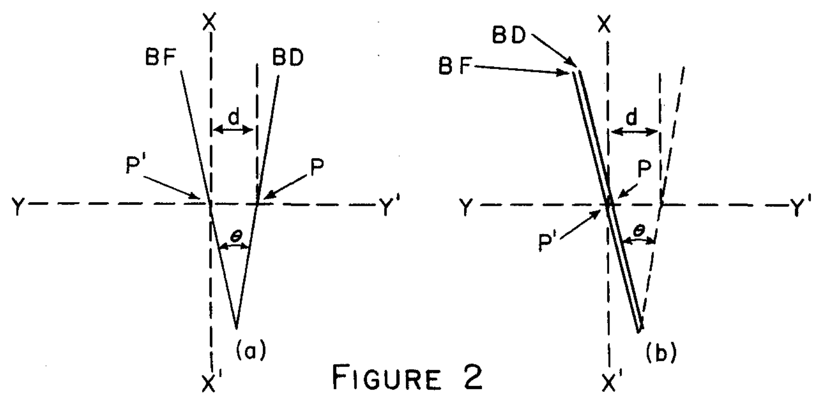


FIGURE 2

BF = Bearing surface at B (FIG.1) on frame
BD = Bearing surface at B (FIG.1) on micrometer drum

The drum reading, being a function of the angular movement of the drum, can therefore be represented by a simple sine curve.

Mechanical defects in the screw or bearing surfaces such as irregular depressions and protuberances cause irregularities in the readings which cannot be represented by a simple sine curve but would, in general, be of a cyclic nature.

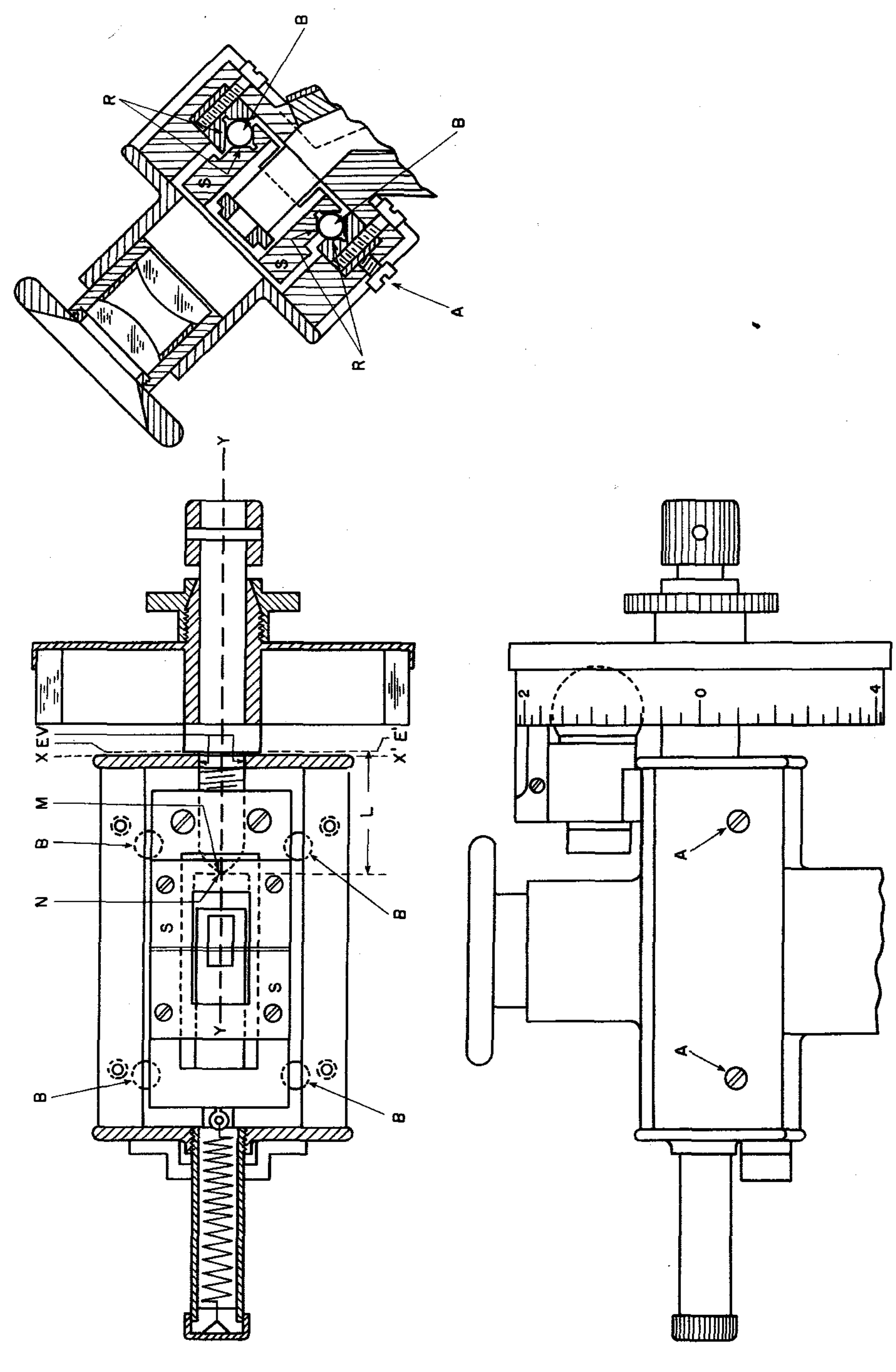
The micrometer of the Parkhurst theodolite is an improvement over the older design in two important respects: (a) The crosshair slide moves on ball bearings, eliminating the trouble arising from friction in the slide, and (b) the design of this micrometer is such that the bearing surface on the plane B (Figure 1) is eliminated. A reference to Figure 5 illustrates this change in design. The crosshair slide moves on the ball bearings B which run in the track R. A single tension spring is used instead of the two compression springs which formerly tended to cause uneven movement of the slide.

There is no bearing at the line x-x' (Figure 3). The point of the micrometer screw M bears against a hard plate N beneath the micrometer slide. The length of the micrometer shaft L is sufficient so that the only point of bearing is at M. The bearing around the circumference of the shaft at V is merely a guide bearing and takes no thrust.

The advantages of this improved design are apparent, but excessive wear or abuse can decrease these advantages to a point where the new micrometers exhibit the characteristics of the early type. For example, the track of ball race may be damaged, and this damage has been serious on several theodolites recently returned to the office from the field. Again referring to Figure 3, two adjusting screws A may be seen. There are two of these screws on the forward and under side of the micrometer box. <u>These screws should never be touched in the field except in an emergency and then only by one entirely familiar with the design.</u> A glance at Figure 3 shows the purpose of these screws. They simply take out the play in the ball bearing track until the motion is smooth and even. They do not take up any lost motion in the micrometer shaft. In the case of one instrument returned from the field these screws had been tightened, evidently with the intention of removing lateral play in the threaded micrometer shaft, until the hard steel ball bearings had made dents in the grooved track which were plainly visible under a magnifying glass. Extensive instrument work was required to refinish the surface of this track and remove the dents. A micrometer with the tracks dented in this manner will give irregular readings which may result in errors of a secondary order.

Another source of error may arise if the point M of the micrometer shaft wears until the surface E-E' in Figure 3 bears against the surface X-X', in which case all the characteristics of one of the early micrometers with a defective bearing will be exhibited. Recently an instrument was returned from the field with the point M Figure 3) worn to the extent that there was a bearing at E-E' and X-X'. Since this surface was not designed as a bearing, a serious periodicity was exhibited in the micrometer readings as the index line progressed between two adjacent marks on the plate. The error was corrected by removing some of the material on the end of the micrometer box until the offending surfaces were no longer in contact.

From the foregoing it is evidently desirable to have a micrometer test which will reveal irregular translative motion of the



PARKHURST THEODOLITE MICROMETER

FIGURE 3

crosshairs with reference to the rotary motion of the micrometer drum.

There are two types of micrometers:

(1) Those which make only one half revolution of the drum between the forward and backward readings, such as those having 2-minute drums.

(2) Those which make one, two, or more complete revolutions of the drum between the forward and backward readings of the micrometers, such as those having 1-minute, 5-minute, and 10-minute drums.

It is evident that in the second class of micrometers, the error becomes serious. If the micrometer is being read at a point on the drum which gives a very high or very low reading on the backward reading, this figure will be duplicated on the forward-reading since the drum is read at the same point and the micrometer shaft occupies the same angular position at each reading.

The first type of micrometer requires only one half turn between the forward and the backward readings, and if the forward reading is high, the backward reading is low by a corresponding amount. This may nullify the type of error due to imperfections in the bearing surface of the shaft.

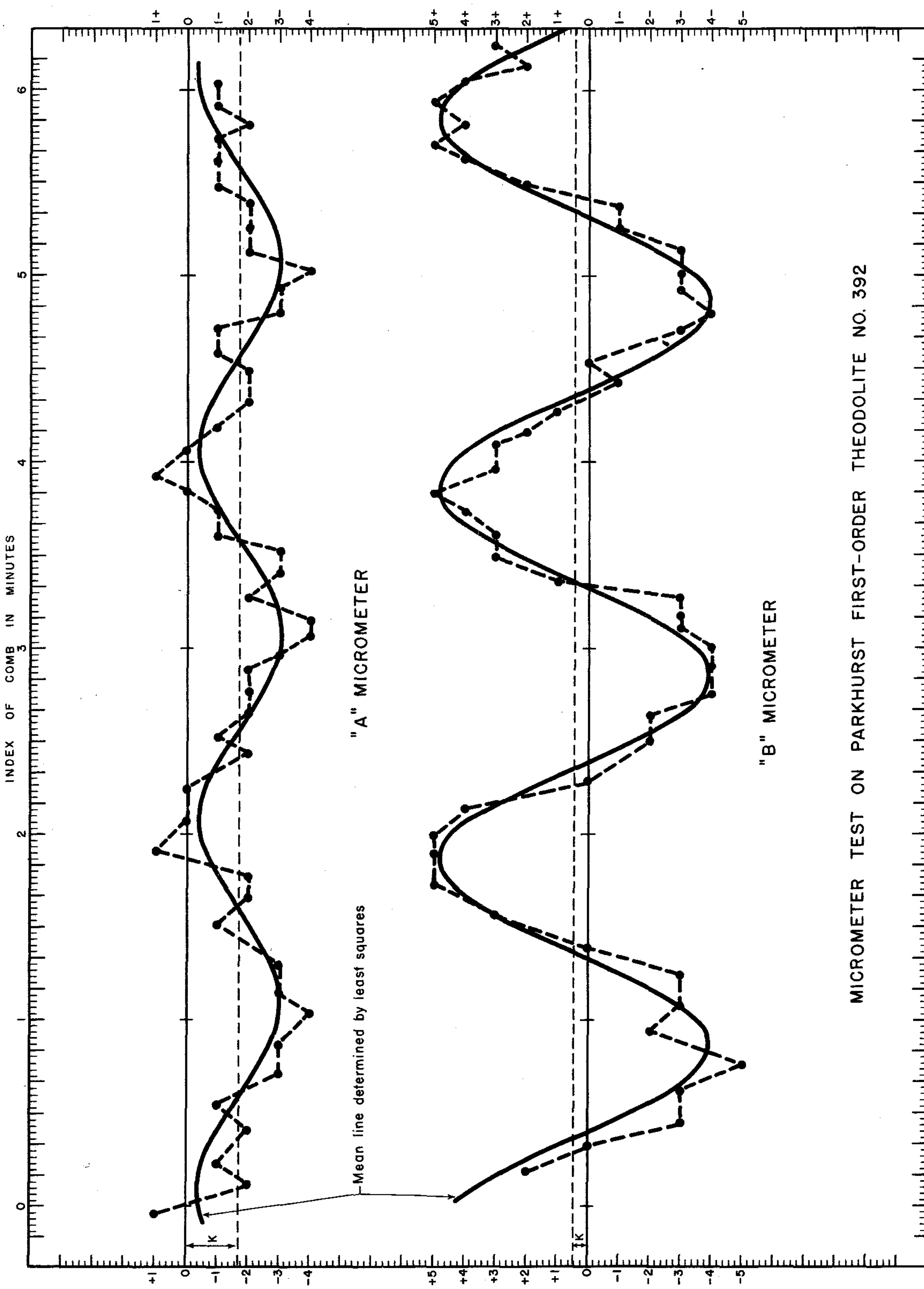
This immediately suggests a test for the first class of micrometers:

Test No. 1 for the Micrometers of Parkhurst, Kern and Hildebrand First-Order Theodolites

With the index line set at any 5-minute division of the circle, keep the plate in the same position and read both micrometers at about 10-second intervals until six minutes of the circle have been covered. Subtract the forward readings from the backward readings and plot the differences for each micrometer against the rotary movement of the drum (or the horizontal movement of the index line of the comb).

Such a test made on Theodolite No. 392, a Parkhurst first-order instrument, is illustrated in Figure 4. This instrument had been returned by a field party with the complaint that there was difficulty in making the backward and forward readings of the micrometer agree. Figure 4 shows the differences of the backward minus the forward readings plotted against the position of the index line of the comb. It is plainly evident that the plotted curve closely approximates a sine curve. The full line is the sine curve computed by least squares from the plotted points.

A very important feature of the 2-minute micrometer is evident from an examination of the facts. To obtain the plotted difference of the B-F, the drum is rotated through an angular motion of 180°. Hence, the error is equally distributed above and below the horizontal axis. Therefore, the mean reading is correct and the micrometer error on the backward reading will be canceled by a similar error of the opposite sign on the forward reading. Hence, this type of micrometer error will not be introduced into the final results. This is true of all micrometers which require a half turn to obtain the second reading.



MICROMETER TEST ON PARKHURST FIRST-ORDER THEODOLITE NO. 392
"A" MICROMETER
"B" MICROMETER
Mean line determined by least squares
K
INDEX OF COMB IN MINUTES
DIFFERENCE OF MICROMETER READING IN SECONDS OR BACKWARD—FORWARD
0
1
2
3
4
5
6
+1
0
-1
-2
-3
-4
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
-5

FIGURE 4

The undesirable feature of this type of error lies in the erratic appearance of the readings. At times the forward reading will be higher than the backward reading. At other times the two readings will be the same and again the backward will be higher than the forward reading. This tends to make the instrument slow to operate as it makes erroneous readings difficult to detect without re-reading.

Test No. 2 for 1-, 5-, and 10-minute Drums

In micrometers which require one complete revolution of the drum to obtain the second reading, the above type of error is not eliminated from the result and a wide spread of observations on the abstract of directions results.

When a reading is made at a high or low point of the curve on the forward reading, a similar high or low results on the backward reading. All Fennel and Parkhurst second-order instruments and all of the older theodolites with 1-minute drums fall into this class. An extreme case occurred in the testing of second-order Parkhurst No. 341. Using a 5-second rejection limit, about 35 per cent of rejections occurred. All of the trouble was found to lie in the micrometers, one of which revealed a 5-1/4-second error. The mechanical defect lay in the fact that the point M (see Figure 3) was worn flat, the surface N upon which M rested was not perpendicular to the axis Y-Y' and the surfaces X-X' and E-E' touched each other.

Obviously the test employed on 2-minute drums is not applicable to drums of the above type, so the following test was devised. A series of readings was made of a small angle which closely approximated one half the value of a complete drum revolution. In the case of theodolite No. 341 which had a 5-minute drum, a 2-1/2-minute angle was read repeatedly, changing the plate about 15 seconds each time. The directions were computed separately for each micrometer. The net effect of this test is to make the micrometer readings fall on different portions of the drum. Thus the angle or the direction of the right hand object is sometimes too large, sometimes correct and at other times too small. The variation of this angle from the mean angle will exhibit the periodicity of a sine curve if the previously mentioned imperfections are present in the micrometer.

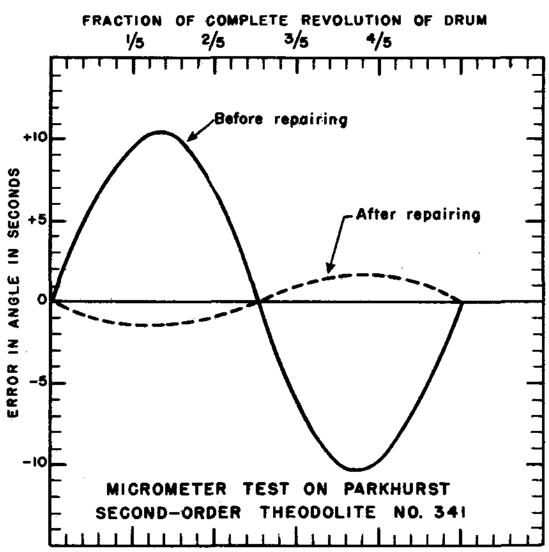


FIGURE 5

At first thought it would seem that the error of the micrometer in this case is represented by the amplitude of the above curve, or 10-1/2 seconds. (Figure 5). Actually, it is only one half this amount or 5-1/4 seconds. To understand this it is necessary to consider the mathematical analysis of the error.

Let A represent the error constant or the amplitude of the sine curve representing the error. The error at any position of the drum is A sin ϕ where ϕ is the angle through which the drum is turned. Now consider what we have plotted to obtain the curve in Figure 5. The error on the initial light is represented by A sin ϕ. The error on the second light is represented by A sin $(\phi + \alpha)$ where α is the additional angle through which it is necessary to turn the drum to make a micrometer reading on the second light. Now on a 5-minute drum the angle read is 2-1/2 minutes since the error is a maximum for that angle. Therefore α = 180° and A sin $(\phi + \alpha)$ becomes

$$A \sin (\phi + 180^\circ)$$

The total micrometer error in the measurement of the <u>angle</u> is the micrometer error on the initial light subtracted from the micrometer error on the second light or

$$\text{Error in angle} = \pm \left[A (\sin \phi + 180^\circ) - A \sin \phi\right]$$
$$= \pm \left[A (\sin \phi \cos 180^\circ + \cos \phi \sin 180^\circ) - A \sin \phi\right]$$
$$\text{or Error} = \pm\ 2\ A \sin \phi.$$

This is twice the error of the micrometer for a given position of the drum. This is clearer when it is realized that the correction to the <u>angle</u> is twice the correction to a <u>direction</u>.

From the foregoing it is apparent that it is important to have the angle used to test a micrometer close to one half the value of the drum. On a 5-minute drum this angle should be between 2'-20" and 2'-40" to show the maximum error. A convenient target to use in the above test is a set of parallel lines drawn on white paper. The spacing of these lines to obtain the proper angle can readily be computed or may be determined in a few minutes by experimental readings. Since the focus of the instrument need not be changed during the observations, the target may be placed any convenient distance from the instrument.

With the double pairs of hairs used in the Parkhurst first-order theodolites, the micrometer test for the 2-minute micrometer will yield as a by-product a figure which represents the error of spacing of the two pairs of hairs combined with the error in the spacing of the marks. This error is represented by the distance K in Figure 4. It is noted that the two pairs of crosshairs in "A" micrometer are spaced too far apart or the marks are too close together, making the B minus F consistently negative. The combined error is about two seconds, but since it is constant it does not enter into the final results. It is possible to devise a test which will isolate this error in spacing of the crosshairs from the error in the spacing of the graduations, but the test would require a least square computation too elaborate for an ordinary field test. The specifications for the circle graduation require that the error in spacing of consecutive graduations shall not exceed one second. However, if a large number of micrometer tests are made on a 2-minute micrometer, each test being made using a different pair of graduations, the mean value of K as represented in Figure 4 should approach the error in the spacing of the crosshairs.

These simple tests for the two different types of micrometers are easily made in the field. Each observer using a micrometer theodolite should make them. For convenience they are summarized below.

Test No. 1 is used for theodolite micrometers having drums which make one half revolution, or a rotary movement of 180 degrees, or any odd multiple thereof, between the forward and the backward readings.

With the index line set at any 5-minute division of the circle and without moving the plate during the test, read both micrometers at about 10-second intervals until six minutes have been covered. Then plot the differences between the backward and the forward readings for each micrometer against the rotary movement of the drum or the horizontal movement of the index line of the comb. If bearing imperfections exist the curve obtained will approximate a sine curve.

Typical theodolites which require Test No. 1 are:

Parkhurst first-order (with 2-minute drum)
Kern first-order (with 2-minute drum)
Hildebrand first-order (with 2-minute drum)

Test No. 2 is required for theodolite micrometers having drums which make a complete revolution or any multiple thereof between the backward and the forward readings.

Select an angle which is nearly one-half the value of the drum, that is, a 30-second angle for a 1-minute drum, a 2-1/2-minute angle for a 5-minute drum, etc. Make a series of readings of this angle, setting the plate about 15 seconds higher each time the angle is read until the amount the plate has been moved is equal to the value of one revolution of the drum. Then plot the variation in the angle as computed separately for each micrometer, against the setting of the circle. If the plotted results show the periodicity of a sine curve, the bearing defect is almost certainly present.

Typical theodolites which require Test No. 2 are:

Early U.S.C. & G. Survey first-order theodolites
(with 1-minute micrometers)
Parkhurst, Kern, and Fennel second-order theodolites
(with 5-minute micrometers)
Cooke, Troughton & Simms second-order micromatic
repeater (with 10-minute micrometers)

In addition to the above tests, the observer should always test the micrometer for binding of the slide that holds the crosshairs, or for dents in the ball race by slowly pulling the drum out against the tension of the spring. The uneven motion caused by the ball bearings slipping in and out of the depressions can easily be felt.

The results of Lieutenant Aslakson's studies and tests on theodolite micrometers initiated Field Memorandum No. 2 - 1939, which was sent to all officers of the Bureau. This memorandum is reprinted at the conclusion of the articles in this number of the Bulletin.

HEELING ERROR IN RADIO DIRECTION FINDER BEARINGS

Professor Crawford F. Failey
Terre Haute, Indiana

Some three years ago, while cruising under sail, a series of bearings by radio direction finder were taken off Cape Lookout. The bearings failed to agree satisfactorily among themselves, and in discussing this disagreement, the question of a possible heeling error arose.

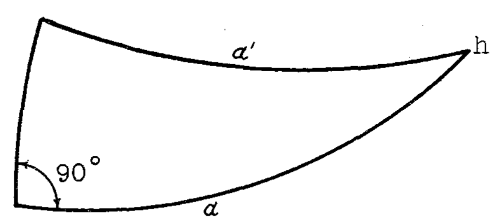
By the use of analytic geometry, such an error was shown to exist and to have the value

$$\text{Sin}\,\alpha' = \frac{\text{Sin}\,\alpha}{\sqrt{1-\cos^2\alpha\ \sin^2 h}}.$$

Where "h" is the angle of heel to starboard or port;
"α" is the acute angle between the sending station and the bow or stern of the vessel;
and "α'" is the corresponding angle as read on the radio direction finder.

Professor Shirley L. Quimby of Columbia University, suggested that this may be put in a more convenient form by solving a right-angle spherical triangle formed in the following manner, assuming the ship heeled to port and the sending station on the starboard bow.

The pointer on the radio direction finder dial is perpendicular to the plane of the antenna loop. When no sound is heard in the receivers the magnetic flux through the loop is nonexistent and the plane of the loop contains the magnetic vector. Therefore a perpendicular, in the horizontal plane, to a line between the ship and the sending station also lies in the plane of the loop. The pointer on the radio direction finder then lies in a vertical plane through the ship and the sending station. The angle which this plane makes with the ship's head is "α" and the angle between the pointer and the keel of the ship, measured on the dial, is "α'".



In the right-angle spherical triangle thus formed,

let h_c = complement h
and α'_c = complement α'

Then by Napier's rule

$$\sin h_C = \tan \alpha' \; \tan \alpha$$

$$\text{or } \tan \alpha' \quad \frac{\tan \alpha}{\cos h}$$

Dr. O. S. Adams, Senior Mathematician, Coast and Geodetic Survey, has pointed out that the heeling error, expressed by " $\alpha' - \alpha$ "; may be written

$$\alpha' - \alpha = \tan^2 \frac{h}{2} \sin 2\alpha + 1/2 \tan^4 \frac{h}{2} \sin 4\alpha + 1/3 \; \tan^6 \frac{h}{2} \sin 6\alpha + \text{--}$$

or, in degrees,

$$(\alpha' - \alpha)^\circ = 57.296 \quad \left(\tan \frac{h}{2} \sin 2\alpha + 1/2 \; \tan^4 \frac{h}{2} \sin 4\alpha + 1/3 \; \tan \frac{h}{2} \sin 6\alpha + \text{---} \right)$$

with the first term sufficient in practice for most cases.

That the error may become quite significant is shown by the following values of " $\alpha' - \alpha$ " for certain angles of "h" and " α "

h	α	$\alpha' - \alpha$
10°	45°	0°-26'
20°	45°	1°-47'
30°	45°	4°-06'
40°	45°	7°-33'

When the sending station is directly ahead, astern or abeam, or when the vessel is on an even keel, the error reduces to zero. When one of these conditions is not met, the effect always is such as to make the sending station appear to be more nearly abeam.

Heeling errors in radio direction finder bearings would apply primarily to sailing vessels. However, the knowledge of such errors should caution navigators of steam vessels to make sure the vessel is on an even keel when taking bearings.

In connection with the Bureau's radio acoustic ranging method of position finding, it is interesting to note that a new use for radiobeacon signals is reported to have been found by a Norwegian concern. This firm is offering Norwegian whaling vessels a battery-powered radio transmitter sealed in a steel drum, to be attached to a lance which is hooked to the floating carcass after a whale has been killed by harpooners in a small boat. The radio transmitter will broadcast on the 600- to 800-meter band an automatically recurring signal so that a mother ship, fitted with a radio direction finder, can track down and recover the catch.

SURVEY PESTS*

C. D. Brown, President
Manitoba Land Surveyors' Association

This is a big subject and I shall not attempt to deal with it in all its branches in one short paper.

I shall have very little to say about what might be termed the divinely appointed pests. There is no cure for these. Nothing we can do about them. We have, for example, the mosquito, the black-fly, sand-fly, hornet and wasp. We can't blame them when they sting and bite and probe and burrow. They are only doing their duty, merely carrying out their appointed mission and fulfilling the obscure designs of an inscrutable Providence. Some of you may still cling to the idea that these pests can be fought by mere language. A fallacy I can assure you. I flatter myself that I have at least an average command of certain branches of the English language. After a long series of experiments conducted over many years I have proved beyond doubt that the mosquito does not "give a damn" for a "damn."

There are also the human varieties of the divinely appointed pests. It is with fear and trembling that I refer to these for they include such sacroscant personages as surveyors-general, chief surveyors and engineers, directors of surveys, assistant directors of surveys, chief accountants and all those darlings of the gods who from soft-cushioned chairs in their steam-heated, Persian-rugged and mahogany-desked boudoirs direct our activities in the field. We can't blame them for the shower of letters that descends upon camp every mail day. Tart, sometimes acid, occasionally vitriolic enquiries as to when we will finish. Why was so and so not done and so and so done? When will we finish? How is it that a certain angle appears in the notes as 90° 01' 11-1/2" when it calculates 90° 01' 11-3/4" and again--when do we expect to finish?

Then there is the letter from the chief accountant pointing out that we used form 86390, A-1 where we should have used 86390, A-2 and that we only sent 24 copies of the payroll and that 25 are required. He also informs us that he is striking a certain item off our expense account, one appearing on our hotel bill, an item about which we ourselves have only hazy recollections, namely, "6 cocktails served in room." I say we can't blame them. Like the mosquito and black-fly they are merely fulfilling their mission in life.

Now we come to the self-appointed or volunteer pests. Let us consider first "the short-cutter." He's usually adolescent. To put it mathematically, his self confidence divided by his knowledge of the bush equals infinity. (If this is beyond any of you, consult Hall and Knights Algebra--for beginners). The party finishes the day's work two or three miles from camp and heads home in Indian file. After a while you miss Bill and are told that he went another way, said he was taking a short cut. Arriving at camp and finding no Bill you begin to suspect that he has been guilty of under-statement. Supper over and still no Bill, you are convinced of it. You have now two choices,--either to let Bill freeze to death or be bitten to death whichever is in season, or to send out search parties. Figuring that Bill will be less of a pest alive than dead, a search is begun. The hour grows late. Just as you are mentally composing a letter of condolence to Bill's mother, citing all his virtues, in

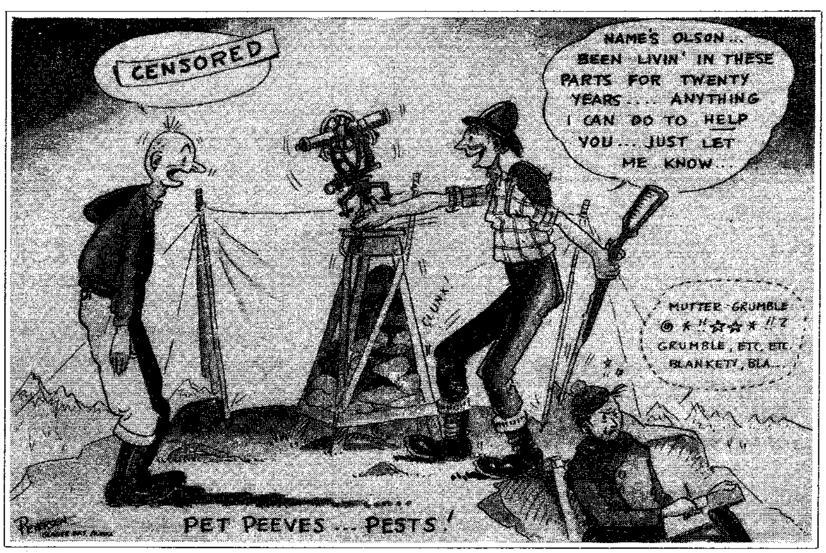
* Reprinted through the courtesy of The Canadian Surveyor.

he comes staggering at the heels of a disgusted axeman and you are saved from the innocent perjury of that letter. Fortunately the short-cut disease usually carries its own remedy. A few such experiences cure all but the worst cases. There is only one way to deal with these. Some evening call your "short-cutter" into your tent and tell him to figure out a short-cut from camp to his home town and to start early next morning. I did this to one bright lad I had up in the Peace River country. I guess he spent a sleepless night. His home town happened to be Montreal. However, I took pity on him to the extent of having my teamster deliver him to rail-head at the east end of Lesser Slave lake. I never heard what happened to him after that but I suspect that he scorned the indirect railway route and took a short-cut. As this happened about twenty-four years ago he should be due in Montreal any day now.

Next on my list is "The Pessimist." You will agree that a survey is no place for a pessimist. There are too many opportunities for the exercise of his talents. For example, a nice warm sunny day gets lost from May and comes to cheer you in January. "Lovely day" you remark. "Not so bad" he'll reply.--"but we'll have to pay for it later, we'll get some 60 below to make up for it." Tell the pessimist that you want to get two miles done today to save a long walk again next day and he'll retort, "We'll never do it. There's lots of big spruce in that country, 6' through if they're an inch. I seen them from that high ridge the day we moved camp." If the freight canoes are a day or two overdue, the pessimist is in his glory. Hints darkly at "Them rapids," "three men drowned there two years ago." "Maybe the freighters got drunk in town and are all in jail and the whole lot of us will starve to death." Gloomier and gloomier grow his forebodings and his face gets so long that if it could be marked off "in feet and decimals thereof" it would serve as a stadia rod. You will be pleased to hear that I have discovered a sure cure for this disease and that is to out-pessimist the pessimist. Always go him one better. If he says it's 40 below retort that it's 60 below and will be 70 before night. If he says you should do two miles today tell him he's crazy, you'll be lucky if you do a mile. No doubt there is an explanation for the effectiveness of this cure but never having explored the mysteries of psychology, (I hope I have spelt that word right)--I am unable to give it. I know it works because after a three weeks' course of treatment I once overheard one of my worst patients remark to another of the party, "The Chief makes me sick. Always looks on the worst side of everything. That's one thing I can't stand." That's what I call a cure. I am a little uneasy about this particular patient. I am afraid I gave him an overdose and have turned him into a dangerous optimist. He now buys wheat on a 2¢ margin, dabbles in penny mining stocks, in his home town he is president of "The Boosters Club" and--so I hear-- is now even contemplating matrimony.

Lastly--do I hear sighs of relief at the lastly and are you feeling in your pockets for the offertory nickel, or if plates are used in your church, the offertory quarter. Lastly--as I said before I got off the trail--we will consider the most poisonous and deadly of all our pests,--"The man who has worked for Mr. X". Mr. x being some other surveyor, usually one whom you have not met. This scourge makes his presence felt from the very start. Pitching your first camp he eyes your outfit with scorn. "Mr. X never uses tents like them." "Mr. X doesn't pitch his tents that way." He sizes up your instruments. "Them's not like the ones Mr. X uses." Not wanting to start anything the first day you let this pass in spite of forebodings that worse is to come. Let us say that your scourge--

on account of previous experience--has been appointed picket man. You give him careful instructions as to how you wish hubs to be set which he receives in cold silence. Next day you start running line. Things go wrong when he comes to set his first hub. You chase up the line to ask what the--let us say dickens--he is doing, only to be told, "I was just doing it the way Mr. X does it." What are the consequences of this? First you devote a few minutes to conquering a fierce lust for murder, deterred only by the consideration that the only jury likely to acquit you would be one made up entirely of land surveyors. Secondly, you conceive a violent and undying--so you think—hatred for Mr. X. Thirdly, you tell your scourge to head for camp and to practise packing up his belongings the way Mr. X packs his and that in the morning you'll send him to town by your team and that you are sorry the team is not like Mr. X's. That is what happens if you are acquainted with this type of pest. If you are not and are inclined to be weak-minded you patch things up and carry on and you suffer for it. By the end of the season you are a mere ghostly shadow of yourself, your hatred for Mr. X has developed into a homicidal mania, and on moving days your inferiority complex provides a load for two pack-horses. The only bright side of an affair like this is that when you finally do meet Mr. X you are astonished and delighted to find that he is "one of the best", that is to say he is a "regular land surveyor."



BASIC BENCH MARKS IN NEW ORLEANS

Karl B. Jeffers, Junior Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

At a meeting of engineers in New Orleans, Louisiana, in January, 1938, during a discussion of bench marks and datum planes, Lieutenant Commander G. C. Mattison, Inspector of the New Orleans Field Station, made the suggestion that a new survey should be undertaken to establish a system of levels on a sea level datum to which existing surveys could be tied and all elevations be reduced to a common datum.

Acting upon this suggestion, the Second New Orleans District of the U. S. Engineer Office, in cooperation with the New Orleans Sewerage and Water Board and various other organizations, requested the Coast and Geodetic Survey to run a line of first-order levels from Biloxi, Mississippi, via New Orleans to the Head of Passes, Louisiana, and from New Orleans to Baton Rouge, Louisiana. The writer was assigned this duty and while field work was in progress an additional request was made for a complete loop of levels around the city of New Orleans. This loop and a cross line were run in July 1938.

New Orleans is drained by an elaborate system of canals and pumping stations maintained and operated by the Sewerage and Water Board.* Stable bench marks, with accurately determined elevations, are, therefore, of prime importance to this organization. In order to establish and perpetuate basic first-order elevations the Sewerage and Water Board established six bench marks of rather unusual construction. A twenty-five foot reinforced concrete pile was driven into the ground with the top approximately one and one-half feet below the natural ground level. A standard Coast and Geodetic Survey bench mark disc was cemented in the top of the pile which was encased in a brick masonry manhole covered by a twenty-four inch cast-iron frame and cover which bears the letters "B M". Five of the marks were established in the above manner. A sixth mark consists of a concrete pedestal erected on the top of a reinforced concrete lined and covered drainage canal or storm sewer which is supported by thirty-five foot piles.

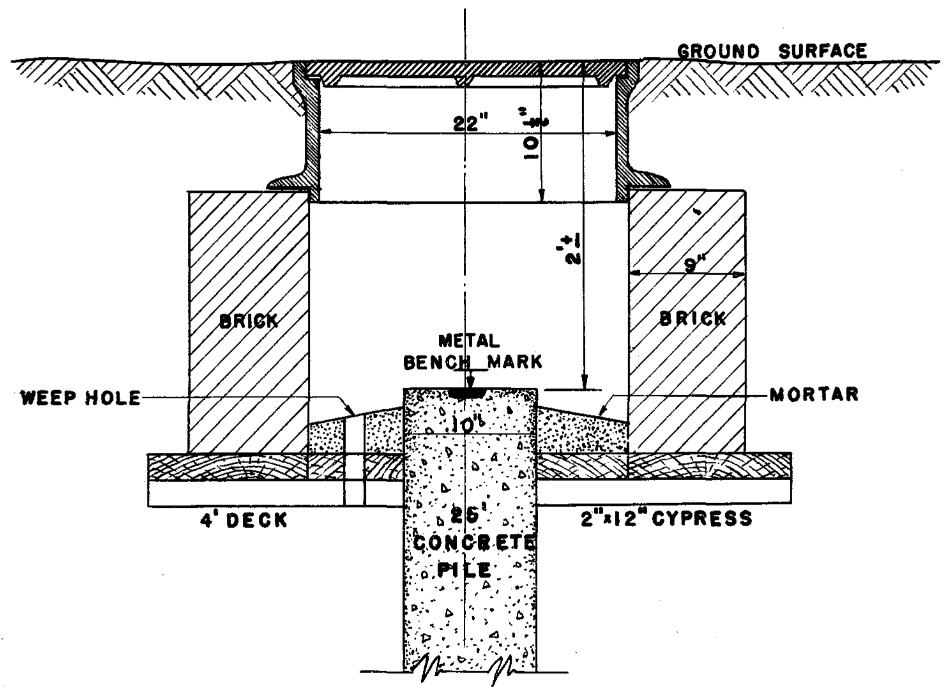
Mr. A. B. Wood, General Superintendent of the New Orleans Sewerage and Water Board, expresses their purpose in establishing these bench marks as follows: "The objects and purposes for the establishment of these bench marks were to afford primarily to the Sewerage and Water Board, and, also, to the several engineering agencies throughout this locality, permanent and imperishable benches on a universal datum plane so as to eliminate in the future the confusion and chaos which has heretofore resulted from a conglomerate system based on no precise, accurate, and universal datum."

The Engineers of the Second New Orleans District also established three basic bench marks. These marks are spaced at intervals of 1,000 feet along the foot of the levee in front of their offices. Each consists of a thirty-foot wooden pile driven to a depth approx-

* This elaborate system of canals and pumping stations is necessary because New Orleans is from five feet below to 15 feet above sea level and at extreme flood stages the entire city is below the level of the river.

(Editor)

imately two feet below ground, level, and the top incased in an irregular mass of concrete about five feet deep and three and one-half feet in diameter with a Coast and Geodetic Survey bench mark disc cemented in the top, which is flush with the ground.



SECTION OF BENCH MARK MANHOLES

Anyone familiar with New Orleans will realize the necessity for such substantial bench marks there. As the drainage system has been perfected the general level of the water table has been lowered, causing a shrinkage of the ground, evidenced by protruding manhole covers, broken pavements, and settling steps in front of many houses. The ground is soft and unstable and considerable trouble with movement of bench marks has been experienced. It is hoped that the basic marks established during the summer of 1938 will not be subject to such disturbance and will be of more lasting value.

PORTABLE DEPTH RECORDER

Dr. Herbert Grove Dorsey, Principal Electrical Engineer
U. S. Coast and Geodetic Survey

Recording ocean depths on a strip of paper to give a continuous profile of the bottom is not new. It was done by the French as early as, or before, 1922 and the Marti recorder has been described in great detail in French publications and in the International Hydrographic Bureau Special Publication No. 14, of August 1926. Commander K. T. Adams, U. S. Coast and Geodetic Survey, made a special trip on the S. S. OREGON in November 1931 to observe operations of such a recorder, and a copy of his report was published in Field Engineers Bulletin No. 4, December, 1931.

Consideration was given to the purchase of a French depth recorder in 1932 but certain patent complications made this unfeasible.

During the development of the Fathometer, I devised a plan for a recorder for use with the 312 type Fathometer in which repeaters for both the indicator and the recorder could be used at different parts of the ship. However, neither the manufacturers nor the public were interested in recorders at that time, so all efforts were concentrated on the improvement of the visual indicator.

In the past few years, more and more favorable reports were received concerning the successful operation of a British depth recorder. Demonstrations witnessed by Captain G. T. Rude and Lieutenant Paul A. Smith led to the conclusion that this type of echo sounding machine had now reached the stage of development where it had practical use in hydrographic surveying.

Since echo sounding machines for launches are one of the most pressing needs of the Bureau, it was decided to include in the equipment for the new EXPLORER a depth recorder of a portable type which could be used in launches. Accordingly, specifications were drawn and bids invited. The following excerpts from the specifications show what was contemplated:

> "It is the intent of these specifications to describe a complete, portable automatic-recording depth sounder, for use in hydrographic surveying, which is capable of producing clear, accurate, legible and permanent records of depth when the instrument is operated in a motor launch or other small boat from 24 feet to 32 feet long at any speed up to at least ten knots in all water depths between three feet and 90 feet in clear or muddy water which may be fresh, brackish, or salty.
>
> "This recorder is to be used on small boats having no electrical power supply of their own and, consequently, must be capable of operating from storage batteries of not more than 12 volts which will furnish all power for operation. The total power consumed should not be over 250 watts. Each part shall be ruggedly constructed and seaworthy but also easily portable.

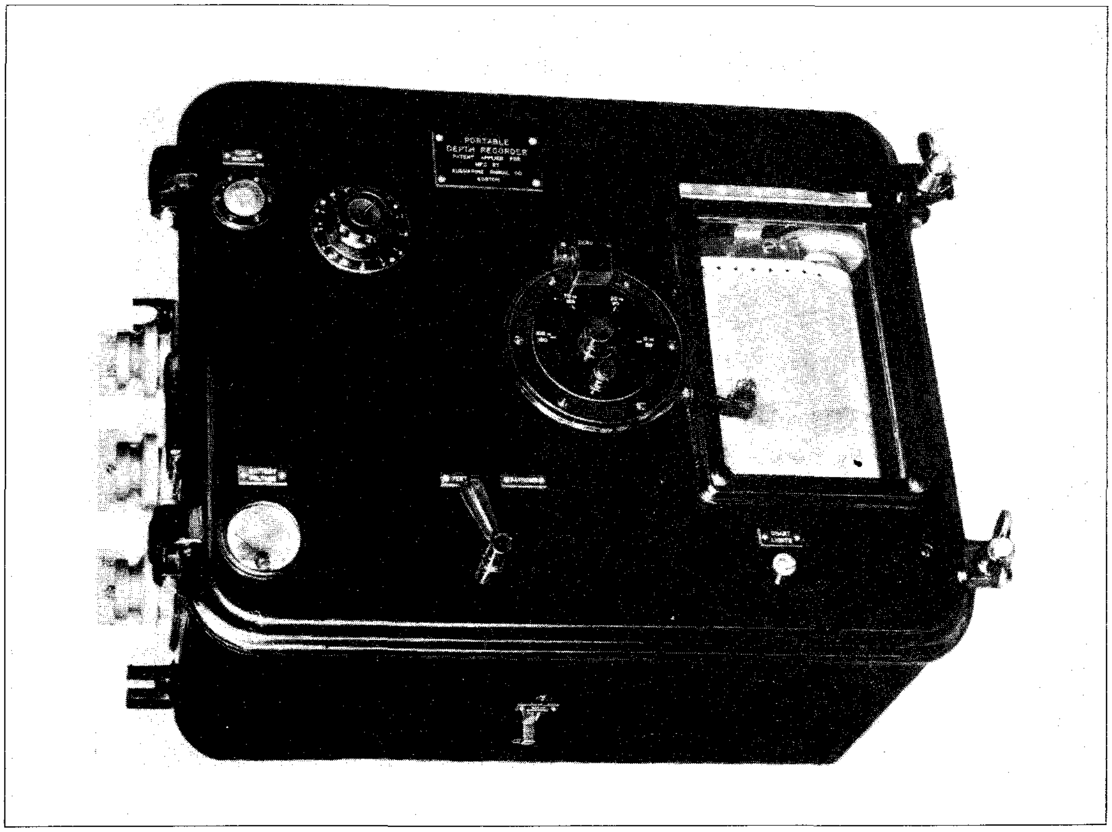
"The recorder mechanism shall be enclosed in a case which includes the recording paper, stylus for making the record, motors to drive all moving parts, take-up on. paper roll, signal-sending contacts, motor governor to prevent variations of motor speed of more than a fraction of one per cent even with voltage variations of 20 to 30 per cent; a battery-operated motor generator to supply the high voltage for charging the condenser to send the signal and for anode supply in the amplifier. Also, any other parts necessary for smooth functioning to produce a reliable record in any depths from three feet to 90 feet under the sending and receiving oscillators.

"The recording mechanism shall be such that the record itself may be plainly seen at the time the depth is recorded and the accuracy of the recorder shall be such that the errors of recording shall be less than one foot in depths of 100 feet. Means shall be provided for making notes on the recording paper at the time the record is made or shortly thereafter; also for making a mark on the record by pressing a button to register the occurrence of any event, such as when a fix or surveying position is made."

The Submarine Signal Company of Boston, Massachusetts, was the successful bidder for the portable depth recorder, and a demonstration of a completed model aboard their experimental launch, the RODMAN SWIFT, on October 26, 1939, was witnessed by Captain G. T. Rude, Lieutenant H. C. Warwick, and me.

There are three parts for a complete recording system, an amplifier and recorder, an underwater unit, and a 12-volt storage battery.

The underwater unit consists of two identical rectangular bundles of nickel laminations, each interlaced with a few turns of rubber-covered wire. These are held in a brass casting inserted into a mahogany casing about eight inches square and 30 inches long with corners and ends rounded to make it streamlined. Each of these groups of nickel punchings acts as a magnetostriction device having a natural frequency of about 20,000 cycles per second, well above the audible range of most persons. One acts as a sender of compressional waves and the other as a receiver. They are only nine inches apart so that the error introduced by their separation will be very small even in the shoalest water. The brass compartment in which they are clamped is closed at the bottom by thin rectangular diaphragms; not watertight, however, since it is desirable to keep the laminations and wire windings wet. The wires are brought out through two pipe fittings at the top of the brass compartment. When in use, these wires are passed up through two iron pipes screwed into the pipe fittings, the pipes being secured to athwart-ship members so as to support the "fish", as the unit is called, in the water. In the demonstration the "fish" was placed about three feet under the surface of the water, a little aft of the amidship section and perhaps two feet outboard from the hull. The estimated weight is about 80 pounds out of water and about 30 pounds when submerged.



Portable Depth Recorder

The recorder is housed in a cabinet 10 inches deep and 17 inches high by 21 inches wide, the longer dimension being in the direction of motion of the recording paper. This cabinet contains the entire recording element, paper, and amplifier. It is made of aluminum castings, with a glossy black finish and the cabinet, mechanism, and amplifier weigh about 125 pounds. It may be mounted on a vertical bulkhead or panel, or placed face up on deck or on a table. The latter method was used for the demonstration. The main door of the cabinet is hinged on the left, as one faces it, and accordingly opens from right to left. It is secured by two large and convenient wing nuts at the right side. A glass door near the right covers the recording paper, exposing the record as it is made and about 2-1/2 inches of the completed record which is automatically wound on a take-up reel at the right. Looking at the record in this position, with paper moving to the right, the profile of the bottom is disclosed in its natural position, that is, with the zero line or sea surface at the top of the record, which enables one to read depths readily without any mental gymnastics.

This cabinet is practically watertight and could probably endure rather severe weather, either rain or waves, without harm to paper or mechanism. Rubber gaskets are inserted in grooves around the edges of the main door and the glass door. The latter is secured by a thumb screw and when raised permits access to the record as noted above, on which may be made any desired notes either by pencil, black or colored, or by fountain pen. By leaning over the cabinet, when this glass door is opened to make brief notes, one's body would probably furnish sufficient protection to prevent the record from getting wet, even in a rather heavy rain.

All controls are mounted on the front of the cabinet door; they include the start-stop switch, a voltmeter to show battery voltage, a gear shift for changing from feet to fathoms, a phasing lever, the sensitivity control, a position marker, and the zero adjustment hand screw.

All of the moving mechanism is mounted on the inner surface of the door; the driving motor, governor, gear box rotating arm, contactor, and a motor generator supplying 300 volts used for B-battery current for the amplifier, and which also actuates the magnetostriction sender. The driving motor operates a train of gears to rotate the arm and contactor approximately 11 times per second at fast speed and 1/6 that at slow speed. The rotating arm of 4.5-inch radius carries at its end a stylus of fine steel piano wire which sweeps across the recording paper in an arc. A condenser is charged continuously through a resistor by the 300 volts from the motor generator. Once each revolution, contactors are closed by the rotating arm, normally at the instant the steel wire passes the zero of the paper scale. These contactors discharge the condenser into the magnetostriction sender, producing a short pulse of vibrations at the rate of 20,000 per second and thus the signal is sent. The position of the contactors, with reference to the zero of the scale may be changed in two ways. Slight adjustment may be made by means of a knurled thumb screw while the machine is running, so that the record on the paper may be easily and quickly adjusted to the exact zero, or if desired, to a position giving depths from the water surface, thus compensating for the draft of the "fish".

At the high speed (11 soundings per second) the scale reads from zero to 55 feet or at slow speed it would be zero to 55 fathoms. Suppose, however, that the contactors were advanced in the cycle of rotation, so that the signal was sent the equivalent of 35 feet (or fathoms) before, the stylus reached the zero of the paper scale; the scale then would read depths between 35 and 90 feet (or fathoms). This advancing of the contactors is called "phasing" and it is accomplished on the face of the indicator simply by lifting a little knob and turning an arm to the respective phase desired, there being four phases in all, 0 to 55, 35 to 90, 70 to 125, and 105 to 160 feet or fathoms. This knob has a plunger which drops into a hole when the pointer is moved to the selected setting so that there is no danger of not having the exact position. Each phase overlaps the preceding by 20 feet (or fathoms) so that no soundings need be lost when changing from one phase to another. The phase may be shifted quickly from any position to another either forward or backward. No mark at the zero of the paper is made except for the zero to 55 scale. Even then the zero mark may be suppressed by a switch, so that the zero marking will not interfere with extremely shoal depths, for example, depths less than three feet under the "fish".

The recording paper is a standard type used in some of the facsimile systems. It has a black body coated with a light gray surface. It is seven inches wide with 6-1/4 inches of the width ruled into 55 sub-divisions, each representing one foot or one fathom depending on which speed is used. Since the scale must lie along the arc of a circle due to the rotating arm, the graduations are closer together near the edges, but the distance between lines, measured along the arc is 1/8 inch. The ruled lines and four numerical scales of depth, 0 to 55, 35 to 90, 70 to 125, and 105 to 160 are printed on the gray surface with black ink. The numerals of the individual scales are about 1-1/4 inches apart and are repeated in the sequence stated above. Regardless of which scale is being used the printed numerals will always be within 2-1/2 inches of any point of the record, facilitating easy reading. This does not apply to the visible portion of the record while being made, since the linear length of only about 2-1/2, inches is then exposed to view. However, every fifth line is printed heavier than the others, and as the observer should know which phase is being used and as proximate figures of separate scales differ by 15, it is easy to read the actual depth. It is, of course, necessary to mark on the record at the time, which phase is being used. Depths recorded in fathoms are readily distinguished from those in feet, the former being blacker and the trace of the stylus, along its natural arc, shorter.

The record is actually produced in a rather unique manner. The magnetostriction receiver is connected to an amplifier which is located inside the cabinet of the recorder. This greatly simplifies the wiring, there being only two wires running into the cabinet from the battery, sender, and receiver. The amplifier is a three-stage tuned push-pull type, completely shielded, with a total of six tubes having their six-volt heaters grouped in three pairs in series on the 12-volt storage battery. No other batteries are required as all other voltages are supplied from the motor generator. This is extremely convenient as there are no dry batteries to deteriorate gradually and be forgotten until trouble appears, such as frequently happens with "C" batteries. The total load on the battery is ten amperes (120 watts). With maximum gain the amplifier is sensitive to 0.2 microvolt. A graduated gain control knob is located on the front of the cabinet door. The echo is amplified until the third pair of tubes develops a voltage of about 180 volts across an output transformer. This voltage is applied between the stylus and the metal plate under the paper so that a series of sparks of diminishing intensity pass through the paper at the time the signal is sent, and upon reception of the echo. These sparks either burn off the gray surface of the paper or disintegrate it so as to leave the black paper visible, as though a series of closely spaced dots had been made in black on the gray surface. The dots are scarcely discernible unless magnified and consequently the record appears as a rather broad band with more or less smooth contour at top depending on the roughness of the bottom passed over, as shown in the reproduction of some of the trial records. (See Figure 1 of Lieutenant Smith's article, "Some Reflections on Echo Sounding", in this issue.) No trigger tube action is used such as that in the Fathometer to produce the red light, and the intensity of the record appears to be proportional to the strength of the echo. Second echo records were fainter than those of first echoes and decreasing the gain decreases the intensity. Rubbing the face of the paper with a pencil eraser will remove the gray surface, exposing the black beneath. The sparks from the stylus are visible in dim illumination. A small lamp may be switched on to view the record. Position fixes may be recorded by pressing a button at the left side of the cabinet face and when this is done one or two revolutions of the rotating arm produce a black arc clear across the record.

The paper moves about two inches per minute under the stylus. Thus a 50-foot roll of paper will last for five hours when soundings in feet are being recorded or 30 hours for soundings in fathoms.

The paper is used dry, with no treatment before or after recording. The new roll is placed in a convenient holder beneath the rotating arm whence it passes across the recording plate to an automatic take-up reel at the right. These rolls are readily accessible by opening the cabinet door, to which the holders are secured inside. Tests were made in the Chart Division of the Survey to determine how much the dimensions of the paper changed with variations in humidity. From "bone" dry to normal humidity the change in width was 0.6 mm.; from dry to saturation by steam it was 1.5 mm. In terms of the scale this would mean 0.6 foot in 55 feet or 0.6 fathom in 55 fathoms or a trifle more than one per cent change, under extremes probably never encountered in practice.

Excessive heat does not seem to affect the color. Even burning a hole with a cigarette only darkens the paper about a sixteenth inch around the hole. The black back has a slight tendency to rub off on white objects or one's hands. Some facsimile paper has the back coated with thin aluminum and it is probable that some way of overcoming the smudging quality may be found.

The speed of the motor is controlled by a governor built by Leeds & Northrup of Philadelphia. This is a highly reliable type of centrifugal governor which has been tested and proved its reliability on delicate instruments used by the federal government. The governor is enclosed and its adjustment cannot be changed unless the motor is stopped. No device is used to show that the motor is running at its correct speed. However, by changing the gear to slow speed the revolutions may be easily counted while timing by a stop watch. An accuracy of timing of at least one per cent should be attained over a three-minute period. If this is not a sufficiently accurate method of checking the speed, or if it proves desirable to have a continuous check, it will be a simple matter to install somewhere on the cabinet a vibratory tachometer, mechanically operated, such as have been used on the 312 Fathometers. These are accurate to about three parts in 1,000 and have given excellent service. With the yearly check-up which is now standard practice they probably give the most constant and accurate indication of correct speed attainable without going to a complicated system involving a tuning fork.

The RODMAN SWIFT moved around the harbor at five to six knots crossing and recrossing a dredged channel in a depth range of about 15 to 55 feet and passed through the wakes of several steamers. Gears were shifted, phase changed, sensitivity varied, positions "marked"; nothing went wrong. I listened particularly for changes in motor speed when shifting from low to high gear but could detect none whatever.

"Bar-checks" were made by lowering a thin aluminum plate covered by a rubber pad to different fixed distances from three feet to 16 feet below the "fish". The various depths gave corresponding values on the record. The aluminum plate was very convenient. The sheet of rubber was necessary to reflect the sound, as it would otherwise go right through the aluminum without sufficient reflection.

The entire construction appears to be first class. It is ruggedly built and finely finished. There is no crowding of the various parts and all seem readily accessible. I predict for it a brilliant future in coastal surveys.

TRACKING DOWN SURVEY BUOYS

R. P. Eyman, Hydrographic and Geodetic Engineer
Commanding, U. S. Coast and Geodetic Survey
Ship LYDONIA

The results obtained by modern methods of offshore hydrographic surveying are, of course, by this time fairly well known and recognized as the data on the configuration of the ocean floor which, when adequately reproduced in the form of a nautical chart, can give valuable and oftentimes necessary information to the navigator for determining his position by means of a series of accurate soundings.

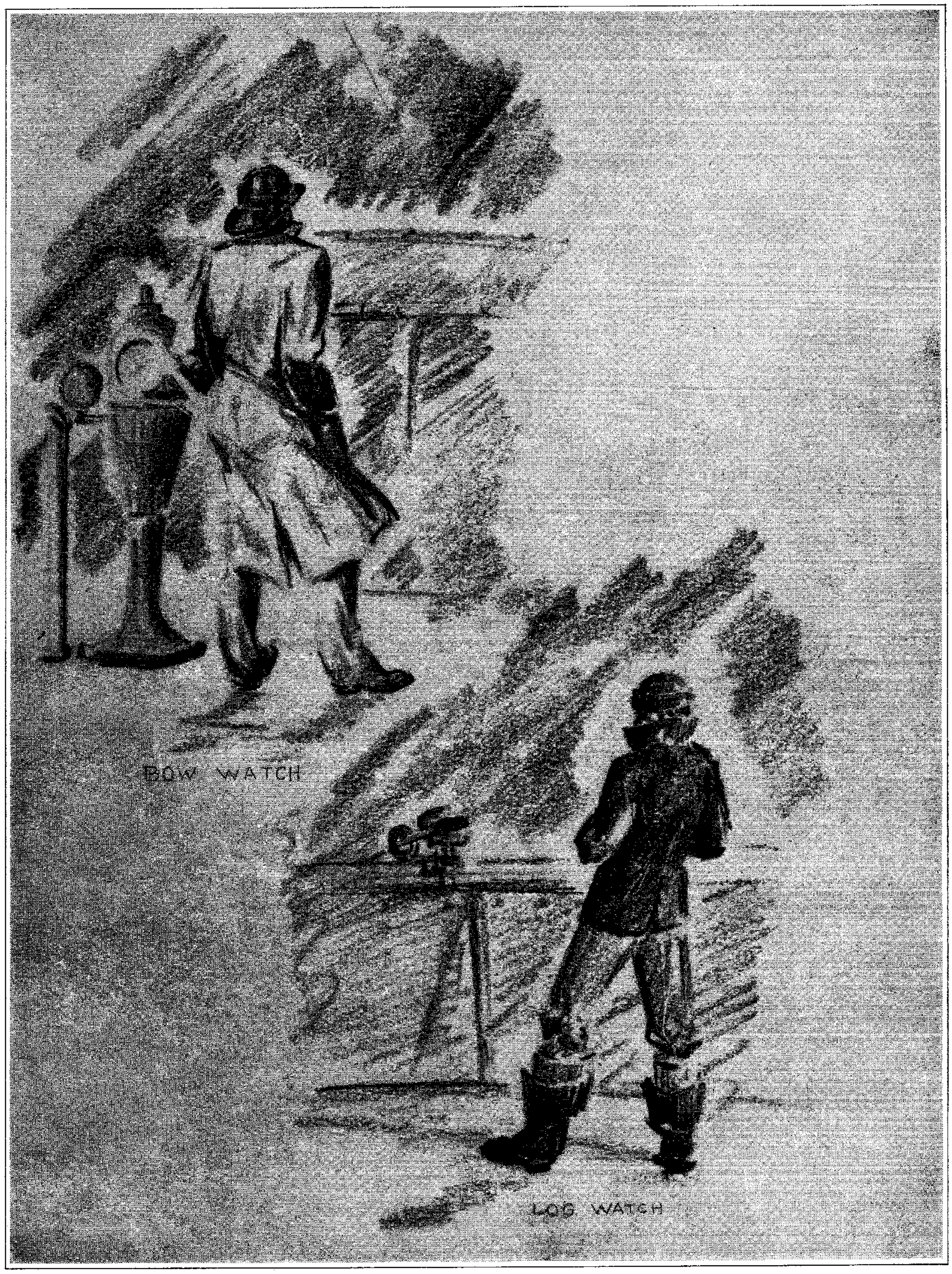
What may be considered a by-product of these results has developed into a sort of "game" the past two seasons - the word "game", rather than "gamble", is used advisedly as the former indicates that skill is required, whereas the latter term implies an element of chance or luck, which, experience has shown, is practically non-existent, although both offer inducements or rewards to the winner.

The "game" is the routine searching for survey and sono-radio buoys in dense fog when visibility may be reduced to a mere few yards. It is "played" by the sounding watch with a high degree of interest that extends to the deck and other personnel.

It has been found frequently necessary to service sono-radio buoys or to move a series of survey buoys at times of low visibility ranging from a light haze to a "pea-soup" fog. In thick fog the same procedure is almost invariably followed. It consists of navigating by dead reckoning, bomb fixes, or single bomb arcs to the general neighborhood of the desired buoy and then maneuvering the ship so as to follow the precise depth curve on which the buoy was anchored. At the time a buoy is placed in position an accurate sounding, corrected for tide and other elements, is taken and recorded; this gives the exact contour, or one might say a line of position, on which the buoy may later be found. The task is less difficult if the area surrounding the buoy has already been developed on the boat sheet and the precise trend of the various contours in the vicinity is thereby known. It is then only necessary to watch the soundings (also corrected) on the Fathometer and keep the ship within the desired depth limits (usually about one foot), and by steaming slowly along closely spaced lines in the area the buoy is soon found.

Up to the present time not a single buoy has been missed and very little time has been consumed in making the searches. The thrill of sighting the hunted buoy looming out of the fog is a suitable reward for once more winning at this new "game". Another interesting feature is the conduct of the crew when word is passed that a buoy is to be picked up. They take their stations, man the falls and windlass, and with boat hooks in hand stand by with all the confidence that would normally be expected in clear weather; even the ship's cat is underfoot looking for a fresh supply of eels.

On one occasion the site of a supposedly "dead" sono-radio buoy had been combed without results and as a last bomb was fired to check our position a faint chirp was heard about three seconds distant and in a short time, after firing additional bombs, the truant buoy was run down and retrieved. It had gone adrift during the preceding night and was recovered about 2-1/2 miles from its station.



R. D. McCausland

On Watch

SERIAL TEMPERATURES BY BATHYTHERMOGRAPH

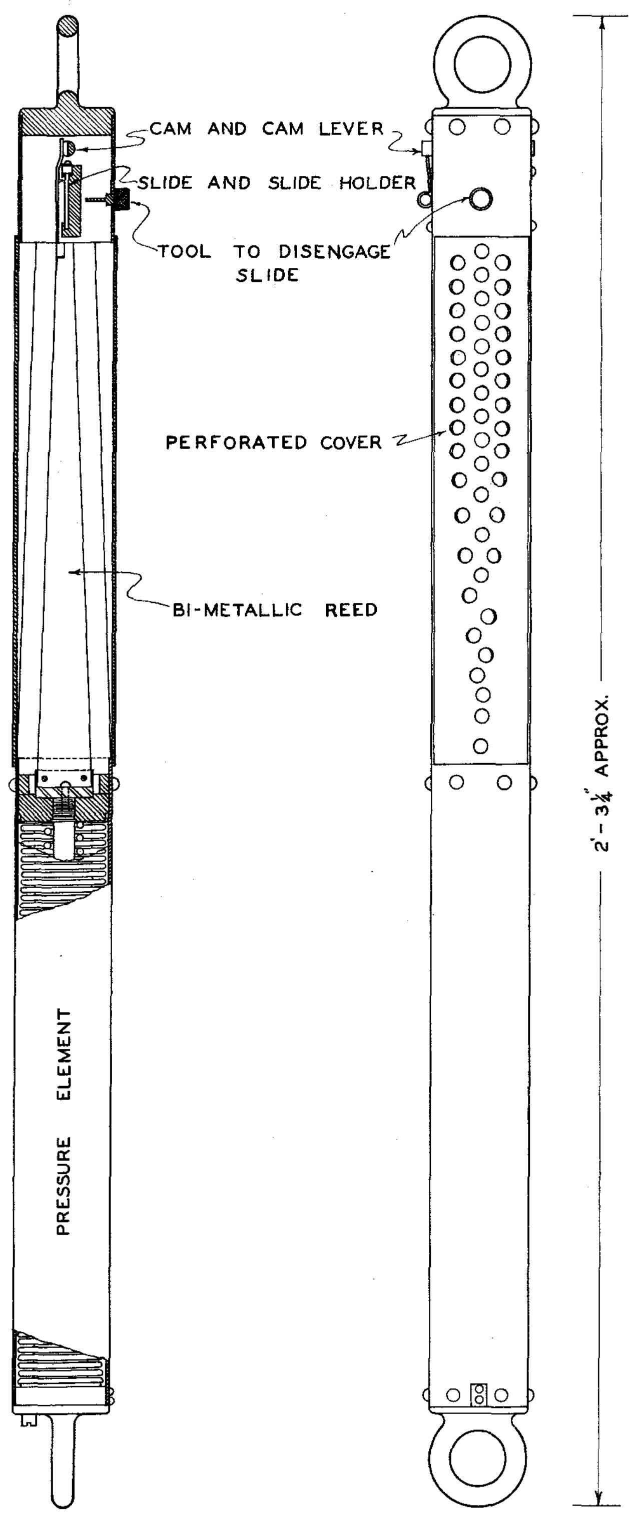
John C. Mathisson, Jr. Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

It is often necessary to obtain serial temperature observations at frequent intervals during hydrography, and it may seem that these times always come when the weather is none too favorable or when it is inconvenient to interrupt the survey. When they are taken on the lee side the wire has a natural tendency to get under the keel, and every sailor knows the disadvantages of the weather side! The need for a simple device that will produce a continuous graphic trace of the temperature depth curve has long been felt. It is particularly needed in regions where the temperature-depth curve has reversals, and this condition is frequently encountered on the Atlantic Continental Shelf during summer months, as was shown by H. B. Bigelow, in his "Studies of the Waters on the Continental Shelf, Cape Cod to Chesapeake Bay" which was published by the Woods Hole Oceanographic Institution, 1935, and also in the numerous records of past surveys by the Coast and Geodetic Survey. At times the temperature may change as much as ten degrees, centigrade, in less than five fathoms change in depth, and in these instances where accurate record of actual conditions is especially important, it is practically impossible to obtain satisfactory observations by the use of reversing-frame thermometers.

Emphasis is often placed upon efficiency of survey to the extent that hydrographers, although they recognize the need for more complete velocity-of-sound information, may be reluctant to take sufficient time from actual sounding to obtain adequate velocity data. The Bathythermograph promises to be the answer to most of these problems. A preliminary form of the instrument was developed by Professor A. F. Spilhaus of New York University in cooperation with Woods Hole Oceanographic Institution. One was built for the Coast and Geodetic Survey by the Submarine Signal Company, and it was used on the OCEANOGRAPHER, F. S. Borden, commanding, during the season of 1939. A brief description of the instrument and a preliminary summary of the results are given here pending a more complete report which may be compiled after the analysis of velocities is made.

With this instrument it is possible to obtain a continuous serial temperature record up to depths of 75 fathoms while the party is performing other routine tasks, for example, picking up a buoy. Ample time is afforded, since experience indicates that the speed of lowering or raising the instrument may be as much as ten fathoms per minute. While it is a very practical and simple device, producing results of an accuracy adequate for determining velocity of sound for use in radio acoustic ranging or echo sounding, it is still necessary that the vessel be stopped to use the Bathythermograph described in this report. It is understood, however, that a more recent development by Professor Spilhaus may be used while the vessel is underway at moderate speeds. We shall await details of this new improvement with interest, but, meanwhile, the existing instrument has an important advantage in shoal water echo sounding surveys, or in areas where large and abrupt regional temperature variations are encountered.

Referring to Figure 1 it may be seen that the Bathythermograph is essentially a metal tube containing a pressure element and a bi-



TYPE 780 B

BATHYTHERMOGRAPH

FIGURE 1

metallic reed fitted with a stylus which makes contact with a piece of special smoked glass. The lower half of the tube contains the pressure element which is made up of a series of metallic bellows enclosing a spring and guide mechanism. The lower end of this pressure element is secured to the lower eye-casting while the upper end is fitted with a plunger having a serrated periphery, making a watertight assembly.

The upper half of the Bathythermograph permits the free entry of sea water through perforations. This part contains the bi-metallic reed and recording mechanism. The lower end of the reed is attached to the pressure element through heat insulating material while the upper end is fitted with a light cantilever spring carrying the stylus. The slide holder is placed opposite the stylus and contains the smoked glass on which are recorded the elements of depth and temperature. The cam is a simple device used to lift the stylus clear while the glass is inserted or removed. The cam lever, attached to the cam on the outside of the tube serves also to indicate that the stylus is clear when the lever is at right angles to the axis of the instrument. When the lever is turned to snap into the opening in which the glass is inserted, the latter is locked in place. The special tool for disengaging the glass is screwed into the tube near the top so as to be readily accessible. To remove the glass the tool is inserted through a small slot diametrically opposite the slide opening, slight pressure is exerted, and the glass ejected far enough so it may be grasped between finger and thumb for complete removal.

The principle of operation is simple. When the Bathythermograph is submerged, the water pressure compresses the pressure element and carries the bi-metallic element with it longitudinally along the tube, thus causing the stylus to make a straight mark, parallel to the tube axis, across the smoked glass. The length of this mark is proportional to the pressure acting on the bellows assembly. The bi-metallic element is continually exposed to the water, and as the temperature of the water varies this reed will bend. The amount of bending will be proportional to temperature changes in the water, and the stylus will produce a curve on the glass varying with temperature and depth, the latter being independent of direct measurement once calibration is made.

The range of the instrument is from 0° to 30° C. of temperature and depths between sea surface and 82 fathoms. The record is made on a piece of non-corrosive glass which is one inch wide and 1-21/32 inch long, smoked on one side where the record is traced by the action of the stylus. It is completely exposed to the water which does not affect the coating.

Reproduced with this report are four enlargements of the original smoked-glass records. (Figures 2 to 5). The trace obtained on the glass is small, and of course cannot be interpreted conveniently without enlargement. For this purpose a commercial enlarging camera, the type used for 35 mm. film, fitted with a good lens was obtained to enlarge and project the trace. A variety of such projectors will be found in any camera supply store. Each of the records made this season was compared with at least three simultaneous observations made by reversing thermometer. After calibration of instrument and projector, one temperature and one depth would be adequate; for example, surface temperature and bottom depth. These data would provide a satisfactory check on the orientation of the slide on properly prepared graph paper.

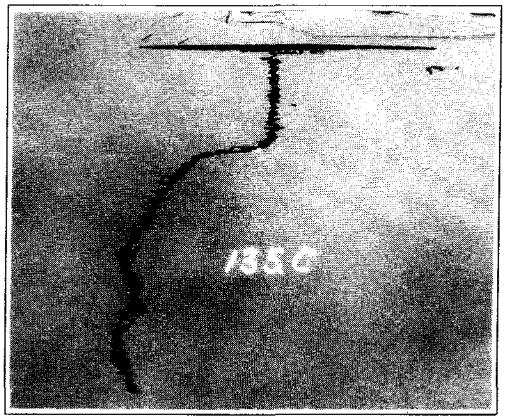


Figure 2.

Normal record under good conditions. Maximum depth 65 fathoms. Temperature range 9.4 C. to 18.6° C.

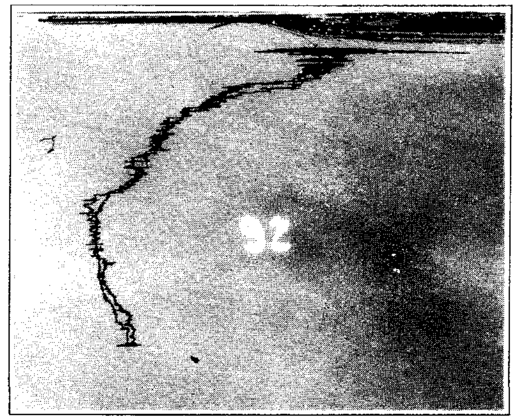


Figure 5.

Record showing duplicate trace with excessive vibration of reed near surface due to choppy sea. Bottom depth 54 fathoms. Temperature range 8.2° C. to 21.3° C.

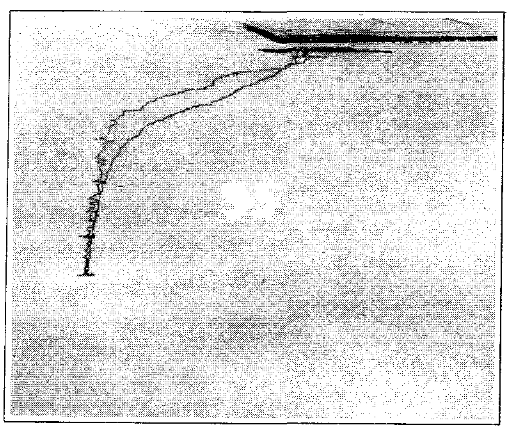


Figure 4.

Double trace caused by lowering or raising instrument too rapidly. Bottom depth 42 fathoms. Temperature range 7.9° C. to 20.7° C.

Figure 5.

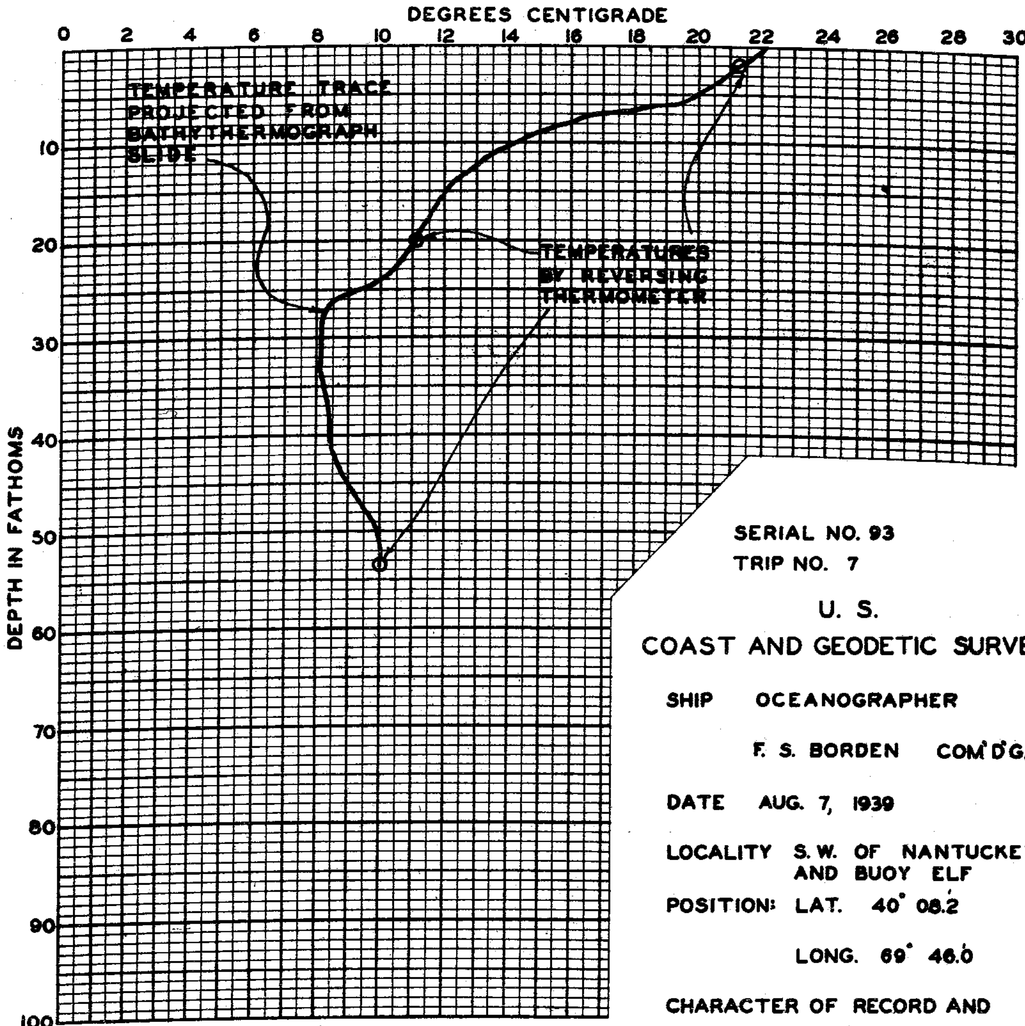
Excessive vibration caused by heavy chop and long swell. Temperature curve obtained nevertheless. Bottom depth 42 fathoms. Temperature range 6.7° C. to 19.5° C.

CALIBRATION GRAPH

NO.7803B

BATHYTHERMOGRAPH

RECORD OF SERIAL TEMPERATURES



SERIAL NO. 93

TRIP NO. 7

U. S.

COAST AND GEODETIC SURVEY

SHIP OCEANOGRAPHER

F. S. BORDEN COM'D'G.

DATE AUG. 7, 1939

LOCALITY S.W. OF NANTUCKET SH. AND BUOY ELF

POSITION: LAT. 40° 08.2'

LONG. 69° 46.0'

CHARACTER OF RECORD AND REMARKS: CONSIDERABLE VIBRATION BETWEEN SURFACE AND 5 FM. DOUBLE TRACE IN VICINITY OF 20 AND 27 FM. AND FROM 37 FM. TO BOTTOM.

OBSERVED TEMPERATURES FOR REFERENCE

DEPTH	TEMP.
53.2 B	10.0
2	21.3
20	11.1

Figure 6. Graph traced from projected record.

The Bathythermograph was supplied without calibration, and before the records were used it was necessary to calibrate it. Eight by 10-1/2 inches was selected as a desirable size for the graph to be prepared for the enlarged trace, and an enlargement of approximately eight times was found desirable. It will be noted from the sample graph, Figure 6, that the abscissa, representing temperature, varies on the arc of a circle. This is due to the bending of the bi-metallic reed with the varying temperature. The radius of this circle on the enlargement is equal to the length of the reed times the amount of the enlargement. For the graph illustrated it is seven feet four inches (eight times the 11-inch length of the reed between fixed base and stylus). With these arcs constructed so as to cover depths up to 100 fathoms, the scale for subdivision of the arcs in degrees of temperature, was determined by projecting a series of 18 or 20 slides for which the ranges of temperature had been accurately determined. Using the mean values the arcs were graduated into the proper subdivisions and the form shown in Figure 6 prepared. It was reproduced accurately to scale by the Division of Charts (Washington, D. C.) and a supply for the season prepared for the OCEANOGRAPHER.

Approximately 75 temperature records were obtained with the Bathythermograph during the summer field season of 1939 and a study of the results shows that the instrument is satisfactory for the purpose intended. It is difficult to make a definite statement as to its accuracy because in this case the comparisons available depend upon the temperature obtained by the same reversing thermometer that was used for reference. But an analysis was made to see how the projected trace agreed with three temperatures which were generally taken at each serial. This comparison shows that 39 per cent of the projected images fit within plottable limits, 73 per cent are within 0.1 , 82 per cent are within 0.2° and only 18 per cent are 0.3° or larger. The maximum difference obtained was 0.8° and this occurred where the temperature gradient was steep and where it would be reasonable to doubt the accuracy of the temperature obtained by the reversing thermometer rather than that of the Bathythermograph.

Beginning on page 137 is an article which deals with the verification of geographic names. The writer's observation that a misapplied name, while relatively unimportant, might tend to lessen the respect of a chart user for the efforts expended to produce an accurate chart, is substantiated by the following which is quoted from a review of a guide book for one of the New England states. Except for this criticism concerning names, the reviewer praised the work highly.

> "The hurried guests of my State are apt to find a lot of misinformation stuck to their fingertips. That is, if the description of my own town is a fair sample of the book. There is a map of B________, at page 142 with four mistakes in it. I was surprised to find that I, myself, live on Pine Street, not on Harpswell Street as I always thought, that Noble Street has become Neale Street overnight, that Cleaveland Street is misspelled, and that the wood road I used to drive home my village cows on, when I was a boy, is McClelland Street and not Longfellow Avenue."

CONTROL SURVEY CRITERIA*

Are Our Survey Specifications too Exacting?

Hugh C. Mitchell, Senior Mathematician
U. S. Coast and Geodetic Survey

Sometimes an engineer, following the instructions prepared by the Coast and Geodetic Survey for the guidance of its field parties, is surprised at the high accuracy of the results obtained. If he is scanning his costs book, and if, as has been all too common in the past and still holds in a much lesser degree at present, he considers surveys as a sort of necessary evil on which as small a portion as possible of his engineering appropriation is to be spent, he may undertake to make suitable surveys at smaller cost by preparing and using less rigid instructions. In this he may sometimes be successful; and sometimes he will fail, and though his costs book may show only the added items for revisions and resurveys, there also may be intangible costs incurred in delays in planning and building the engineering project while the resurveys and revisions are being made.

The following paragraphs attempt to show why the engineer may sometimes secure good results with instructions less rigid than those used by this Bureau and why he may sometimes have to do some or all of his work over again.

The instructions issued by the U. S. Coast and Geodetic Survey for the execution of surveys of various classes are prepared for the purpose of securing in those surveys certain selected qualities of result: standard accuracy, proper distribution and placing of stations, perpetuation of survey data through suitable marks and descriptions of stations, et cetera. Being general instructions, they take into account the fact that the field surveys are made under a great variety of conditions, unfavorable as well as favorable: conditions of weather; the wide variation in character of the country, its relief, its cultural and other surface conditions; the instrumental and accessory equipment available; the training and experience of the men who are to do the work; and, since surveying is an engineering art and must be conducted along lines of approved economic administration, such factors as roads and the character of the transportation available necessarily enter into the planning of the work.

In control surveys, the frequency and placing of the stations are most important items. If a control survey is to furnish basic data for detail surveys, its stations must be so placed that the plane table survey and the air photograph will be adequately controlled as to scale and position. And in triangulation we have also the fundamental condition that certain minimum standards of strength of figure must be maintained; the accuracy gained by careful work with good instruments should not be dissipated by poorly shaped triangles and too few observed lines.

One is apt to misinterpret the criteria for the various classes of control surveys approved by the Federal Board of Surveys and Maps

* The information contained in this article was originally prepared as a reply to an engineer who questioned the necessity for such exacting instructions as are issued to our field engineers. Because of the extensive application of and wide interest in this subject it was rewritten in its present form for publication herein.

(Editor)

and regard them as strict definitions, which they are not. Thus, to say that first-order triangulation is work having an accuracy of 1 part in 25,000 means that such work must be at least as good as that criterion indicates. Third-order work is indicated by a criterion of 1 part in 5,000, and since the criterion for second-order work is 1 part in 10,000, it is between these two criteria that third-order work lies.

It is very unusual today for first-order work not to be a great deal better than its criterion calls for; the results actually obtained are often better than 1 part in 50,000 or even than 1 part in 75,000. Also, cases occur where work executed under second-order instructions gives results better than the first-order minimum, and third-order work approaches and sometimes attains second-order accuracy. These are, in part, the natural results of using instructions which are designed to secure results meeting minimum requirements even under adverse working conditions, or perhaps it were better stated, to secure results, on the average midway between the minimum requirements for that class and the next higher class. So, of course, when all conditions are good they combine to produce better than average results.

It is interesting to note that the prescribed accuracy is being more easily attained today than it was a few years ago. Without changing the instructions for doing the work, the quality of the work is improving. This is as it should be; it is the result of better field conditions -- shorter lines in triangulation and more suitable signals -- and of improved instruments and accessories. There will always occur sporadic cases where the prescribed minimum accuracy is barely obtained or just missed, but these are due to conditions difficult or impossible to control or neutralize. For instance, triangulation straddling a long body of water with prominent shores making necessary some lines that might almost be classed as "grazing" may introduce unusual refraction effects which will tend to accumulate; or a warm ocean current flowing continuously along a shore may cause abnormal refraction, cumulative in effect and, for work done at night, complicated by diurnal changes. But these are abnormal conditions, not to be overcome by the usual methods of reconnaissance and observing. They are possibilities, however, of which the reconnaissance engineer should always be aware.

The high quality of the results obtained by the Coast and Geodetic Survey indicate that the instructions issued succeed in their purpose. This is most satisfactory. Results of too low an accuracy are expensive in that additional work is required to make them acceptable or the entire project must be reobserved. On the other hand, the attainment of results of a superior quality, approaching or even reaching the limits of the next higher class, offends no one. The superior results being obtained in this Bureau without increasing the rigidity of the observing conditions is most gratifying to all concerned, since the present trend in surveying and mapping is toward more accurate results. This is the result of growing demands for maps for engineering purposes--for planning of all kinds, and for charts of increased accuracy and detail which improvements in navigational methods have made necessary. This trend toward surveys of a higher accuracy is manifested in the work of the Coast and Geodetic Survey by second-order work now being specified in many areas where third-order work was formerly considered adequate.

It is not surprising that the improvement in control surveys has been secured with little modification of the instructions for that work. After all, the difference between two adjacent classes of work is largely a difference in degree. Using good instruments and third-order instructions, but taking more pains at every step, possibly including a few minor corrections which are ordinarily neglected, second-order results may be obtained.

The engineer, using instructions for a certain class of work and obtaining a higher grade of results than was expected, must not be misled into thinking the instructions too exacting. Those same instructions under less favorable conditions might produce results of a far lower quality. Rather he must consider the conditions attending his work and, remembering that extra good work is never objected to if instructions are followed, endeavor to evaluate his working conditions--the character of the terrain and its possible effect on refraction, the behavior of the instruments, the training and experience of his assistants, even the living conditions of his personnel--and if all are unusually favorable, then expect superior results. And should adverse conditions be revealed, correct them if he can; otherwise, minimize their effects as much as possible, and be not surprised at results of a lower order of accuracy.

While the general statements in the foregoing paragraphs are applicable to all surveying operations, they acquire additional emphasis when traverse surveys are considered. The natural difficulties encountered in traverse work are greater and more variable than in triangulation, and the mathematical conditions being less rigid, the usual distribution of the errors of observation is correspondingly less satisfactory. In length measures of a traverse there is no practical way of knowing with certainty that a line is free from blunders, while in angle measures local conditions, under which observations are sometimes necessary, may introduce refraction effects so large that, if isolated, they might pass for blunders.

For several years this Bureau used first-order traverse in areas where flat terrain and high timber made triangulation very costly. But traverse was never thoroughly satisfactory, and little of it is done now, since portable steel towers make triangulation in those areas relatively simple and economical. In some long lines of first-order traverse executed by this Bureau and adjusted between first-order triangulation stations, considerable difficulty was encountered later when new arcs of first-order triangulation divided the traverse into sections. The accumulation of errors in the traverse proved so irregular that their distribution by standard methods of adjustment proved unsatisfactory and new adjustments had to be made, holding fixed all positions determined by triangulation.

Although, as just mentioned, the Coast and Geodetic Survey no longer uses first-order traverse for control, the Bureau is required frequently to furnish specifications and advice to other organizations who wish to carry on such work. Further comment on the subject may be of value.

If the instructions issued by this Bureau appear unduly exacting to an engineer who, using them, closes a loop of traverse with unexpectedly high accuracy (as judged by the closing error), it is suggested that he be patient until he has hung several successive loops onto the first, and possibly divided the first loop with a cross line. He then is apt to find that for any single loop considered by itself he has a splendid closure, but that adjacent loops have closing errors of opposite signs, and the adjustment of a section common to two loops will take on contradictory aspects. And when he has finished, he may find that portions of a loop originally-run as an entity will have received unexpected corrections in their different parts. But if the work is according to standard instructions, the final results are reasonably certain of satisfying the specifications laid down for such work.

The troubles encountered in angle measurements along a traverse may be visualized without the aid of instruments by noting the distortion due to refraction when looking down a railroad track or along a road past a bank or some kind of structure. Being caused by conditions that are not stable, the errors from this source are continually varying, and the time required for making a set of observations on the angle and its explement may easily account for a closing error of the horizon of a second or more. In fact, a brief examination of a very few records in the archives of the Coast and Geodetic Survey revealed closing errors of two and even more seconds per angle, where there were only two or three angles around the horizon, and which were measured in sets of six direct and six reversed. The possibility of such conditions necessitates care in preparing instructions, since the tolerance allowed between different sets on the same angle, as well as the horizon closure per angle, must take note of the abnormal conditions which may be encountered, and permit what seems unduly large discrepancies in otherwise rigid requirements.

A splendid check on the accumulation of errors of azimuth in a long traverse is obtained by occasionally observing the astronomical azimuth of a line. The frequency required in these check observations is variable, since under good conditions of clear lines of proper length the errors of observing, centering, etc., will accumulate rather slowly. On the other hand, if the lines are short and pass close to sources of lateral refraction, the same classes of error may mount up rapidly. Although the instructions call for a certain accuracy in the time keeper used, in the observation of an astronomical azimuth, that accuracy is necessary only under the most unfavorable conditions. For instance, if Polaris is observed at culmination when its change in azimuth is most rapid, amounting in middle latitudes to about two seconds of arc in five seconds of time, the time of the observation should be known with considerable accuracy. On the other hand, if the observations are made at elongation, when for a short period the motion of the star in azimuth is hardly perceptible, acceptable results may be obtained with a watch whose correction is not known to within several minutes.

One reason why astronomical azimuths are good only as checks on a long traverse line which is to be based on geodetic control is that every such determination is affected by the deflection of the vertical, an effect known as "station error", which in the mountainous parts of the United States may amount to as much as 20 seconds of arc, while values of around two seconds of arc are fairly common in regions of low relief. As a check against blunders or abnormal errors escaping undetected, astronomical azimuths distributed along a traverse are very satisfactory, but as control data to which the traverse is to be adjusted, they must be used carefully and understandingly.

In an earlier paragraph, mention was made that certain errors, as of observing and centering of instruments, would accumulate rather slowly where the lines were clear and of proper length. And this of course raises the question of length: what is a good length? Given good observing conditions and a clear line, distinctness with which the target can be observed should control the optimum length of line. In other words it is not desirable to establish an optimum length as a given linear distance. Additional control stations, if needed, can always be provided by interpolation along a tangent, and long lines are to be preferred to short lines. Very short lines are undesirable for reasons too fundamental to be discussed here. Sometimes they must be endured, but when this happens unusual care must be taken to prevent, if possible, what are ordinarily very small linear eccentricities being resolved into large angular discrepancies. One should keep constantly in mind the well-known equation "A second is a foot at forty miles", which reduces to "one second subtends three-tenths of an inch at one mile."

In length measures, the engineer will avoid much trouble if he has the tapes standardized under the same conditions that he proposes to use them, and then uses them in that way. This means tension and method of support. And if he expects to use several different methods of support, the tape should be standardized for those different methods. He may have trouble with temperature corrections, since he has no simple means of knowing the exact temperature of a tape at the time it is used. A little experimentation with tape and thermometer on carefully set monuments may give him an idea as just how the two fail to keep step, how they respond to changes in the temperature of the air, and should suggest the extent to which precautions must be taken to avoid unacceptable errors from this source.

The foregoing may be summed up in a very short paragraph. Follow the instructions for the given class of work one is doing carefully but intelligently; at every step understand why things are being done in a certain manner, and remember that results of a higher order of accuracy than the instructions indicate will surprise no one, while results of too low accuracy may mean added costs in revision surveys. And if the work be traverse, remember that a traverse of a large number of stations may be made to absorb a good-sized blunder, but when that line is later divided into sections by additional surveys, the blunder is sure to come forth to confound its author, though at the same time there may be relief on the part of those who have used the control data provided by the traverse and were embarrassed when their detail surveys failed to check acceptably with those data.

COMMENT

C. L. Garner, Hydrographic and Geodetic Engineer
Chief, Division of Geodesy, U. S. Coast and Geodetic Survey

Mr. Mitchell's article is a very timely appraisal of the results to be expected in the conduct of control surveys of specified accuracy obtained under the variable conditions usually encountered in field work.

There is an ever-increasing demand for more accurate and reliable data, particularly within the limitations required to delineate properly descriptions of real property in our metropolitan areas.

Land values in other regions, although generally lower, are also increasing, and the only means of obtaining control surveys of permanency is by the adoption of standards of accuracy which will suffice for present and future requirements.

Accurate results can be obtained most satisfactorily by using high grade instruments. The initial cost is more than for less precise instruments, but when spread over the great amount of work that is accomplished during the life of an instrument, the difference is very small indeed. To obtain high accuracy by repeating the observations with a poor instrument is sometimes expedient, but is inexcusable as regular practice.

As Mr. Mitchell has pointed out, the Coast and Geodetic Survey does not now generally engage in traverse for the reason that the use of Bilby steel triangulation towers makes it possible to obtain more satisfactory control by triangulation which is without the inherent defects common to traverse. Undoubtedly the greater part of control work carried on by non-governmental organizations, as well as the majority of work carried on by governmental organizations not charged with the functions of first- and second-order control, is accomplished by traverse surveys, generally of an accuracy below second-order. This is no doubt because such work is ordinarily for small isolated and non-recurring projects where the use of towers is not justified, and therefore, traverse is the best expedient.

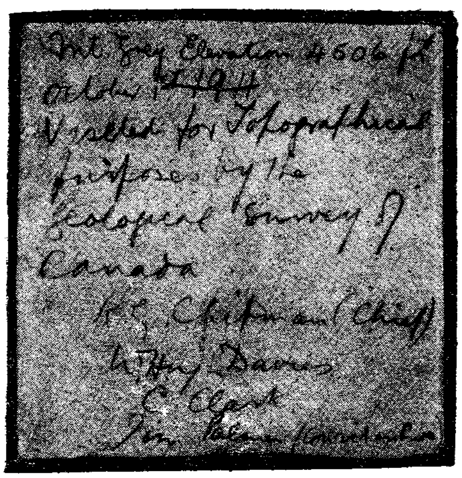
Where the control is to be obtained through traverses, it is very important that great care and high-grade instruments be used. Traverses are usually composed of short lines, subject to the accumulation of errors through eccentricity, phase, refraction, etc.; there is also a great danger of unrecorded tape lengths, transposition of set-ups or set-backs, the confusion of tape numbers, etc. While traverses performed in accordance with certain specifications may result in some nearly perfect closures, the average over a period of time will in general be according to expectancy. Mr. Mitchell's emphasis of the fact that the limit of accuracy specified is the lower limit and not the mean limit is particularly important.

One surprising thing in the execution of control surveys is the very small additional cost of first-order work over second- or of second- over third-order work. This is particularly true of triangulation. The reason is not hard to find. The cost of observing is very small as compared with the cost of transportation and building. Furthermore, the time required for first-order observations is only slightly more than for a lower order of accuracy and there is no additional expense except when stations must be occupied a second day to improve the triangle closures. With a first-class instrument first-order observations can be obtained at a station in from two to four hours and only occasionally is it necessary to occupy a station a second day for the purpose of reducing the triangle closures. Our revised specifications for second-order triangulation anticipate this condition, and do not require reoccupation except for triangle closures in excess of five seconds.

To obtain the maximum value and efficiency from his efforts in the extension of control surveys should be the desire of every engineer. To accomplish this, it is necessary to give careful consideration to: (1) the extent and required accuracy of a project; (2) the cost required to meet specific needs, and also the cost with regard to possible future usefulness; and (3) how best to reference a survey for future usefulness, consistent with the accuracy and extent of the survey.

To these matters the engineers of this country are now giving considerable attention; many now consider the survey as part of the main engineering project, and not as a matter of mere incidental expense, of no further use after the engineering project is completed. This attitude is resulting in more accurate surveys, better monumented for future use. It has also resulted in the recognition of the advantages to be gained from the use of instruments of precision, accompanied by a growing concept of the value of accuracy and permanency of surveys. This concept has in turn promoted the demand for instruments of a higher grade, and the willingness and ability of the manufacturers to meet these demands are added assurance of the future improvement of survey methods in this country.

The piece of celluloid from which this cut has "been made was sent to The Canadian Surveyor by Mr. Frank Swannell, Victoria, last December (1938). In his letter Mr. Swannell said in part, "I don't think I met Mr. Chipman when I was in Ottawa but thought he might like the enclosed bit of celluloid. I occupied Mt. Grey this year when I was extending the Vancouver Island triangulation net. The old signal was badly rotted away but we found this note inside a rusty toothpaste tin. Some of the old nails were handy in framing our own signal and strange to say, some of the 1/2" rope used in lashing the original signal was still serviceable. I doubt if anyone had ever been on the spot since 1911."



The piece of celluloid was given to Mr. Chipman as a souvenir and in speaking of the incident he said: "The record was left on Mt. Grey in 1911 by a Geological Survey party of which I was in charge. It is interesting that this bit of celluloid should turn up after having been left on a Vancouver Island mountain top more than twenty years ago. Although the celluloid is slightly stained and discoloured, the pencilled writing is as clear and legible as the day it was written. The tin container has evidently failed to protect the celluloid from the weather and one wonders if it was any real protection. The writing has not been affected by time and weather and it would seem quite probable that if there had been no container there would have been no discoloration or deterioration of the celluloid.

"The work on Vancouver Island was a plane-table intersection job and celluloid plane-table sheets were used. The advantages of celluloid are well known, but it is remarkable that a casual message written with an ordinary lead pencil should, after twenty-seven years, be as clear and sharp as if freshly written. No less remarkable is the fact that some of the 1/2" rope used in lashing the original monument was still serviceable."*

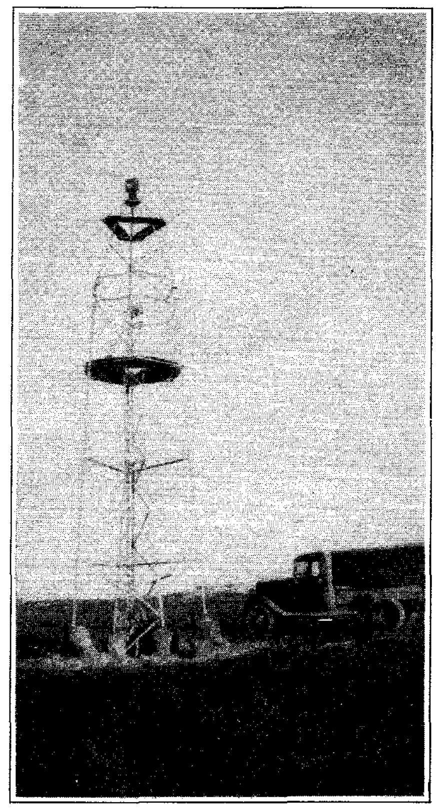
* Reprinted through the courtesy of The Canadian Surveyor.

TRUCKS AND TRIANGULATION

P. L. Bernstein, Jr. Hydrographic and. Geodetic Engineer
U. S. Coast and Geodetic Survey

Laguna Madre and Padre Island brought back ye ole hydrographic days. A former hydrographer, now a landlubber, could not easily resist the temptation to turn trucks into boats and "navigate" this area.

Laguna Madre is a shallow enclosed body of water, from five to eight miles in width, which extends southerly from Corpus Christi to Port Isabel, near the mouth of the Rio Grande. It consists mostly of mud flats surrounded by water of varying depths depending on the direction of the wind. On the east it is bounded by Padre Island and on the west by the often-heard-of but seldom-visited King Ranch. Executing a scheme of triangulation along such a flat, barren area would ordinarily be an ideal and simple problem, but with tower building and transportation the task becomes complicated.

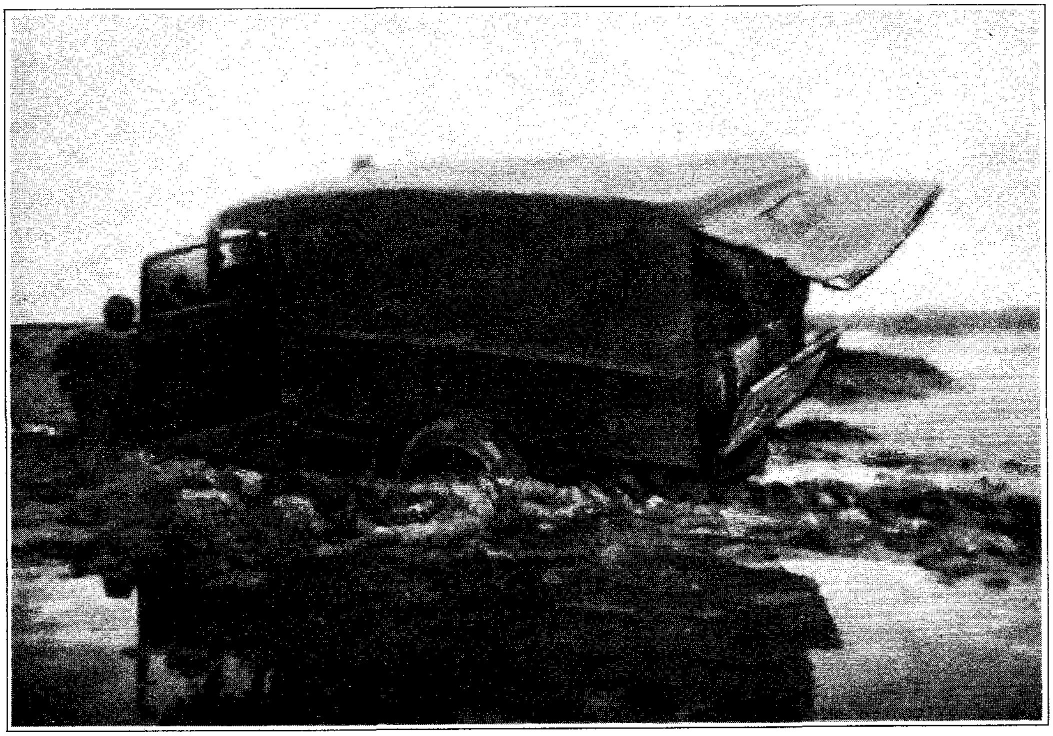


Station "Padre Island".

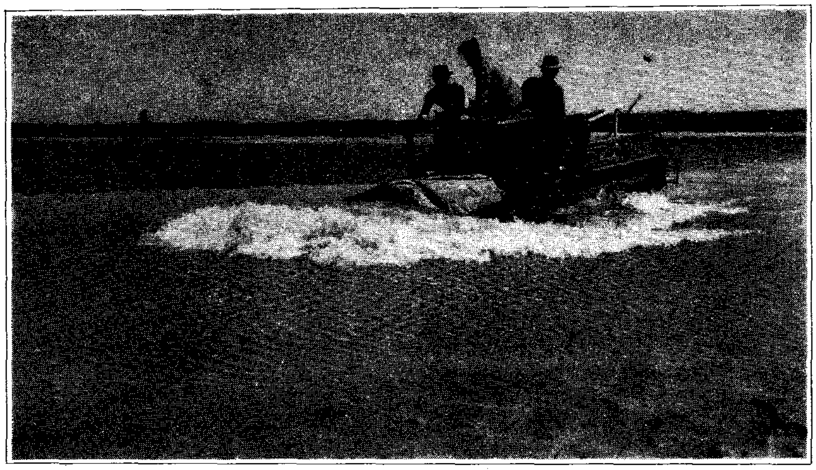
Padre Island is sandy, about 100 miles in length, and varies in width from one-half to two miles. A row of high, shifting sand dunes fringes the eastern shore, back of which are lower dunes and fairly level stretches, partly covered with grass, that extend into the marshes of Laguna Madre. Landing on the island with a truck is possible only from Port Aransas on the north and Point Isabel on the south, about 125 miles apart.

During the latter part of January, 1939, work was started at the northern end. Using four 1-1/2-ton trucks equipped with dual wheels, five steel towers were landed on the island. To leave trucks for two months exposed to the continual salt spray from the Gulf was a risk that seemed to be the least of numerous evils.

Trucks can be driven along the water's edge for the entire length of the island, provided the tide conditions are satisfactory. Unfortunately the beach was wide and flat, and since there was very little tide, frequently it was necessary to drive through the heavy sand near the dunes. With time, patience and persistence this was accomplished. It frequently became necessary to place long poles under the dual wheels when the trucks were stuck, and it is surprising how quickly a loaded truck can be freed by using poles in this manner. This often developed into a seemingly endless repetition, but even-



tually one arrived at his destination. In the "truck navigation" of the water areas, investigation on foot was made before attempting to drive the truck. Moderately firm bottom was selected and water sufficiently shoal so that the carbureter and distributor would be above the normal surface of the water. Tarpaulins, lashed over the radiator, under the motor and over the hood kept out most of the "bow-wave" and spray. The water that did get under the hood was prevented from being thrown over the motor and grounding the electrical system by disconnecting the fan belt. Short sections of relatively deeper water were crossed by "rushing", - gaining sufficient momentum to forge through the water before the vital parts of the motor would be drowned out.



In addition there were a few stretches of coral beach on top of "blue mud" which had to be crossed. Natives said that cars had been mired in such placed and had sunk out of sight within a day. These tales were taken for granted without verification. None of our trucks was lost.

No matter how thoroughly the trucks were covered it was impossible to keep out salt spray and sand. Salt would "short" distributors and electric wiring; it would "freeze" starters, clutches, brakes and everything that contained frictional parts. Many mornings fire had to be built under a truck in an effort to dry it out sufficiently to get it started. Sand was everywhere; one practically ate it and slept in it - and endured it.

The party was divided into two units, one on Padre Island and one on the mainland. Transportation on the mainland was more difficult than on the island in at least one respect. The island trucks preferred a "wet track" but the mainland trucks were left at the post in rainy weather. Numerous arroyos made it necessary to travel at least fifty miles to and from stations that actually were less than ten miles apart. And these trips were generally over gumbo mud, deep sand and shallow stretches of water. No trails or landmarks indicated the best approaches; it was simply a case of winding between dunes, across mud and water, hoping to reach your destination and trusting to find a way back.

The ranch officials gave permission to travel on their land and furnished guides when necessary. However, the Mexican guides usually claimed it was impossible to reach the selected points. No observing party has ever had to contend with so many locked gates. One man had to be always ahead of the truck getting permission to pass through them. Although these ranches rank with the largest in the country, more deer are in evidence than cattle. This is explained by the fact that these are game preserves, with deer, geese, ducks, turkeys, ground hogs and birds in great abundance.

Snakes had everyone on the lookout. Rattlesnakes over six feet long were encountered. To make matters worse, their color made them almost unnoticeable in the cactus growth and they were sluggish at that time of the year. One could almost step on them without any warning.

About the middle of March all the trucks were back in camp at San Benito, They were a sorry-looking bunch, and one wondered if they would ever traverse paved highways again. However, the prospect of going to New York made everyone optimistic, overhaul work began in earnest, and within a few weeks they were rolling along headed for the East.

One cannot forget Padre Island and the King Ranch and the difficulties encountered there but I have heard no one express a desire to return there; yet who knows but what in a comparatively short time that same Laguna Madre may be part of the endless Intracoastal Waterway of this country.

Lieutenant Commander E. V. Eickelberg, commanding the Coast and Geodetic Survey Ship GUIDE, has retained some of his office methods since returning to the field. He reports that the use of a calculating machine has simplified the computation of the astronomical triangle in celestial navigation. He believes there is less chance of error by this practice and states that the use of natural trigonometric functions instead of logarithmic functions makes the computing less laborious.

The following example is based on the equation

$$\sin h = \sin \phi \ \sin \delta + \cos \delta \ \cos \phi \ \cot t$$

Since he had no tables for natural secants he computed the azimuth by multiplying cosine δ by sine ϕ and dividing the product by cosine h.

ϕ 55°-12'-00"	sin	.82115	cos	.57071		
		X		X		
δ 17 -53 -18	sin	.30716	cos	.95165	cos	.95165
				X		X
t 81 -54 -02			cos		sin	.99002
				.14090		÷
		.25222			cos h	.94432
		+ .07652		.07652	sin α	.99770
h_c 19°-11.5'	sin h_c	.32874			α	86°-07'

PROPOSAL TO HONOR ISAAC INGALLS STEVENS

During the 1st session of the 76th Congress a joint resolution was introduced recommending that the name of the Mud Mountain Dam and Reservoir, now being constructed in the state of Washington, be changed to the "Isaac Ingalls Stevens Dam and Reservoir". The resolution has been approved by the Senate and on January 2, 1940, was pending in the House before the Committee on Flood Control. In view of Isaac Stevens' connection with the Coast Survey, Mr. Shalowitz of this Bureau has prepared the following sketch of his brief but colorful career.

(Editor)

When one peruses the early reports of the Coast Survey, he finds therein a veritable bibliography of the most advanced scientific thought and achievement of the day. The names of many men of high talent and ability adorn its pages, - men who in one field or another have helped push forward the frontiers of science and engineering. Isaac Ingalls Stevens was one of these.

Of English lineage, with an American ancestry dating back to 1640, Isaac Stevens was born in the little town of Andover, Massachusetts on the 25th of March 1818. Early in his career he exhibited qualities which portended future greatness. While at West Point he made a deep impression upon members of the faculty and his professor of mathematics remarked of him, "Though admirably adapted for a military commander and great engineer, had he selected the profession of the law he would have been prominent among the most distinguished lawyers of the age."

Cadet Stevens' rise to positions of prominence was meteoric. Upon graduation from West Point in 1839 he was awarded the highest scholastic honors, standing at the head of his class in every one of his studies. He served with the Corps of Engineers and during the war with Mexico became an adjutant of engineers. At the close of the war he was breveted captain and then major for gallant and meritorious conduct in battle.

In 1849, Professor A. D. Bache, then Superintendent of the Coast Survey, tendered Major Stevens, although only 31 years of age, the important position of "Assistant in charge of the Coast Survey Office", the second position in the Survey. (It was customary in those days to assign officers from both branches of the military service to duty in the Coast Survey). His biographer says of this appointment, "It was no light tribute to the rising reputation of Major Stevens that so wise and sagacious a man as Professor Bache, and so excellent a judge of men, should have selected him out of the whole army as his right-hand assistant and executive officer."

Major Stevens' principal contributions to the Coast Survey were in the field of administration and one of the first steps taken by him soon after his assumption of office was to organize the Bureau into a number of departments each under a responsible head, who in turn was directly responsible to the Assistant in charge of the office. It was Major Stevens who introduced the system of publishing sketches and preliminary charts in advance of the final engraved chart in order that results of the field work could be furnished the navigator without too much delay. (Changed methods of reproduction make this unnecessary today). Major Stevens was evidently the forerunner of our present inter-office dictaphone system for it is said that he caused bells to be placed in the various offices with wires running to his own room, so that he could summon his subordinates without delay when he wished to see them.

So well did Major Stevens master the technique of the Bureau's work that many of the old computers, engravers, draftsmen, topographers and others, who had spent years in the office, were astonished to find that he fully understood their technical work, and was watching, criticizing and directing it with expert skill and judgment. He quickly won the respect and admiration of such trained specialists as Professor Hilgard, who was in charge of the computing, and who afterwards rose to be Superintendent of the Coast Survey, and Lieutenant E. B. Hunt, who was in charge of engraving.

His broad vision of the scope and purpose of the Coast Survey work is exemplified in his statement that the Coast Survey maps "should be carried to every man's door having an interest in commerce, navigation, geography or science."

While Major Stevens was quick to reward ability and service in others, he was by no means unmindful of his own latent powers and when in 1853, Congress formed the new Territory of Washington, Major Stevens applied for the governorship on the ground that he was the "fittest man for the place". He received the commission in March of that year but his retirement from Coast Survey duty was deeply regretted by his associates. In the annual report for 1853, Professor Bache pays him this fine tribute:

> "The gain to the country in his appointment, and especially to that new region to which he has been called, will no doubt be great, but our loss is proportionably great. An administrative ability of a high order was joined to unceasing activity and great force of character; varied general and professional knowledge to great clearness in discerning ends, and fixedness of purpose in pursuing them; remarkable knowledge of men, and easy control of those connected in business with him, to personal qualities which rendered official intercourse agreeable to those about him."

Scarcely was the ink dry on his commission when, man of action that he was, Governor Stevens launched into a new field of activity. By a remarkable determination and zeal for the public service he succeeded in obtaining charge of the Northern Pacific exploration and in inducing three Secretaries to adopt his measures. Of this undertaking his biographer rightly says, "the bare conception of completely organizing and outfitting and starting in the field a great expedition for the survey of two thousand miles of wilderness, and all to be accomplished within two months, would have seemed not merely bold, but visionary and presumptuous, and nothing could have relieved Governor Stevens from such reproach but the fact that all this he actually accomplished."

When the Civil War broke out in 1861, Governor Stevens offered his services in the Union Army and was given the colonelcy of the

79th Regiment of New York Volunteers (The Highlanders). He was later promoted to the rank of Major General. General Stevens was killed in action at Chantilly, Virginia, September 1, 1862, while personally leading his troops in a gallant and successful charge against the enemy lines. He fell dead in the moment of victory in his 44th year.

A great executive, a faithful public servant, and a valiant soldier, it is fitting that his name be preserved for posterity.

CHARTS ON BOARD SHIP*

Lack of charts was the principal cause of the stranding of the tanker "Pass of Ballater" at the mouth of the River Loire last January, according to the Board of Trade inquiry which has just been held, and the responsibility for seeing that the proper charts were on board lay with the master, whose certificate was suspended for twelve months. *** When he left Hull he had on board only the general chart of the Bay of Biscay. He did not even have the Biscay Pilot. He hoped to buy charts at Gonfreville or Havre, but unfortunately the day he was there was a public holiday. *** He proceeded on his voyage, and did in fact make Nantes successfully. Assuming that having done so he could equally well leave the port without further navigational aids, he made no attempt to procure a chart at Nantes. At 10:20 p.m. the sea pilot was dropped somewhere near La Lambarde buoy at the entrance to the Loire, and a course was set W. 1/4 N. magnetic. Within a quarter of an hour the vessel stranded on a rocky bottom on La Lambarde shoal. *** It was suggested that the owners should have seen that the ship was adequately supplied with charts for her intended voyage, but it was shown that when the master received his appointment he was given a letter of detailed instructions, one of which was that he must at all times make sure that the ship was supplied with the necessary Admiralty charts and to purchase them personally. Even had that letter not been given, the court would still hold the master responsible in the long run for seeing that the ship had on board all necessary aids to navigation. ***

The question of liability for supplying charts to ships has aroused considerable interest among shipowners as a result of the above case. ***

(The following is from a letter to the Editor of The Nautical Magazine.)

"... I think the position respecting charts is that a ship is not considered seaworthy if she has not on board proper charts for the voyage, and to the extent that the master is responsible for seeing that his ship is seaworthy, he is responsible for charts.

"The best companies running regular lines have a list of charts carefully selected, copy of which is put on board each ship. Consequently when there is a change of route or a new port to be called at, the necessary new charts are put on board. Usually this is done through the firm's nautical optician, who is also an Admiralty chart agent; he has the firm's official list of charts and also knows what extra charts if any are on board any of the ships. All that is necessary is an order from the shipowner to the chart agent, instructing him that a certain ship is going to a certain port, and will he please send the necessary charts, out abroad if necessary."

* Reprinted through the courtesy of The Nautical Magazine.

SONO-RADIO BUOY IMPROVEMENTS

Millard F. Timm, Chief Radio Operator
U. S. Coast and Geodetic Survey Ship LYDONIA

Sono-radio buoys, developed by the Bureau to serve as floating radio acoustic ranging stations, were first used successfully in 1936. This first type was described in Field Engineers Bulletin No. 10 (1936). An article describing the use of the sono-radio buoy during the season of 1937 of the Ship LYDONIA appeared in Bulletin No, 11. In the previous issue of the Bulletin, No. 12, its further use and modification of design were described in an article titled "Sono-Radio Buoys in 1938".

Mr. Timm has been associated with the design and development of sono-radio buoys since their initial use and his rubber diaphragm dynamic hydrophone and delay circuit are described here for the first time.

Editor.

A Dynamic Type, Rubber Diaphragm Hydrophone

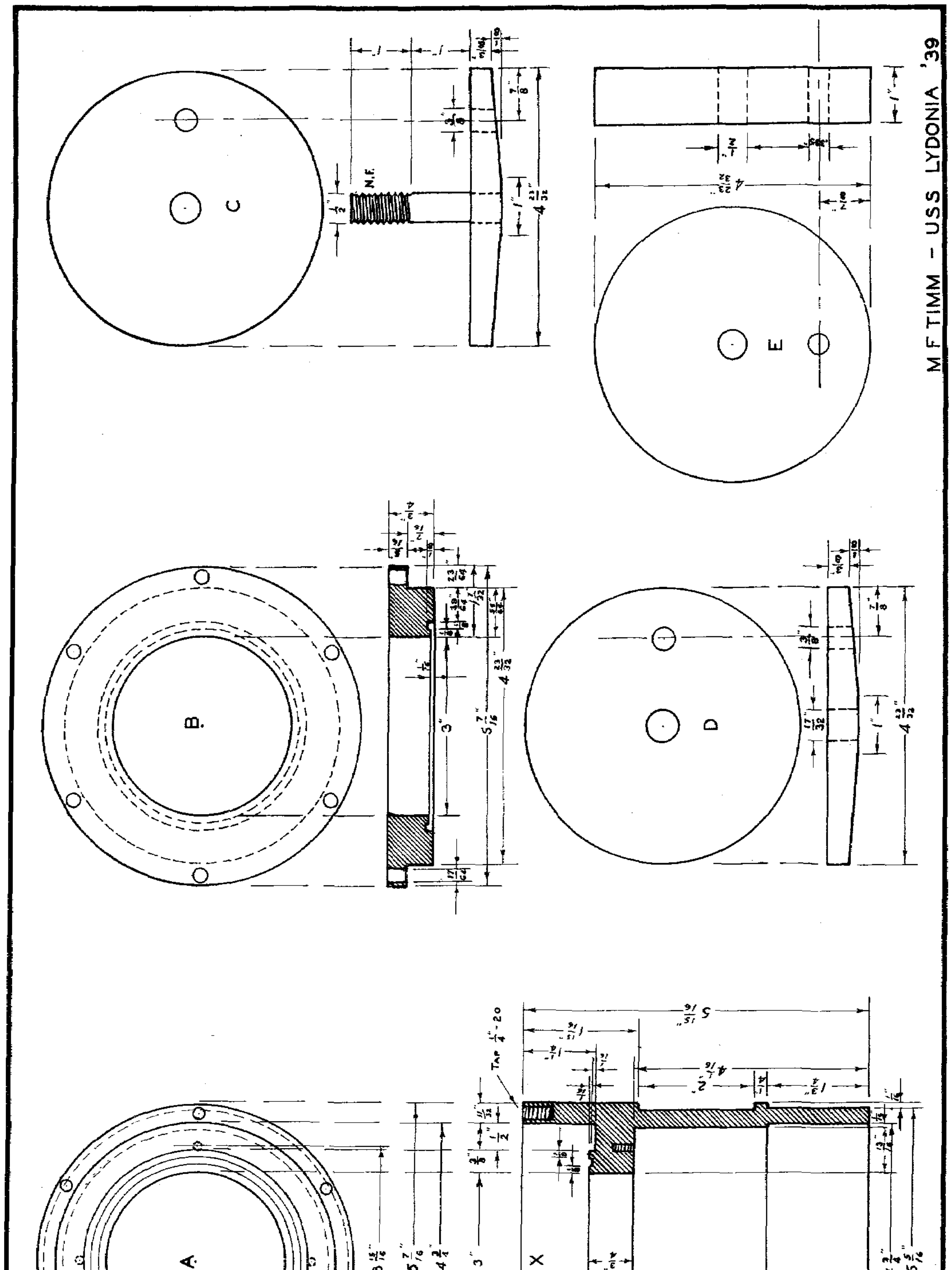
A new type of hydrophone which has its greatest response at low audio frequencies has been designed for use with sono-radio buoys on the LYDONIA. It was believed that if such a unit could be developed, the water noises, which limit the amplifier gain, would be attenuated, resulting in a greater usable sensitivity. The resulting unit, consisting of a brass casing with a tough live-rubber diaphragm and a small permanent-magnet dynamic speaker for the sound pick-up has been used for four months with excellent results.

Since this hydrophone was placed in service on one of the buoys almost immediately upon completion, adequate tests have not yet been conducted, but an idea of its frequency response may be given from one simple test. With a pair of headphones in the output of the buoy amplifier, heartbeats could be heard plainly. On the other hand, it was almost impossible to hear any loud whistling sound even when close to and directly in front of the diaphragm.

A novel construction permits opening or sealing the unit quickly and easily. One nut clamps and expands the rubber gasket to make the unit water-tight. One unit has been immersed at a depth of six or seven fathoms almost continuously since its construction, yet there has been no indication of leakage.

The casing (A), the diaphragm clamping ring (B) and the two round end clamping plates (C and D) are made of brass with a Monel-metal bolt shoulder-threaded, upset and countersunk in one of the latter plates. The tough live-rubber gasket (E) sandwiches between the plates (C and D). The rubber diaphragm has the same dimensions as the gasket (E) but has no holes.

In assembling, the diaphragm is secured in the end (X) of the casing with the clamping ring pulled metal to metal at the rim with



DYNAMIC TYPE, RUBBER DIAPHRAGM HYDROPHONE

1/4-inch brass machine screws.

The permanent-magnet speaker (Oxford 3-inch) is held in place by four 8/32-inch brass machine screws with its cone facing the rubber diaphragm.

The hydrophone is sealed by the gasket expanded between the two end plates and the two-conductor cable (American, Type SJ, No. 16, with 1/32" insulation) through the holes.

A Delay Circuit for Sono-Radio Buoys

The accompanying drawing illustrates a wiring diagram for sono-radio buoys, which embodies a time delay action that reduces interference of two or more bomb returns on the chronograph tape. The circuit, moreover, is simpler than that generally used and requires fewer parts in the assembly. It is described in detail in the following comment by Dr. Herbert Grove Dorsey.

COMMENT

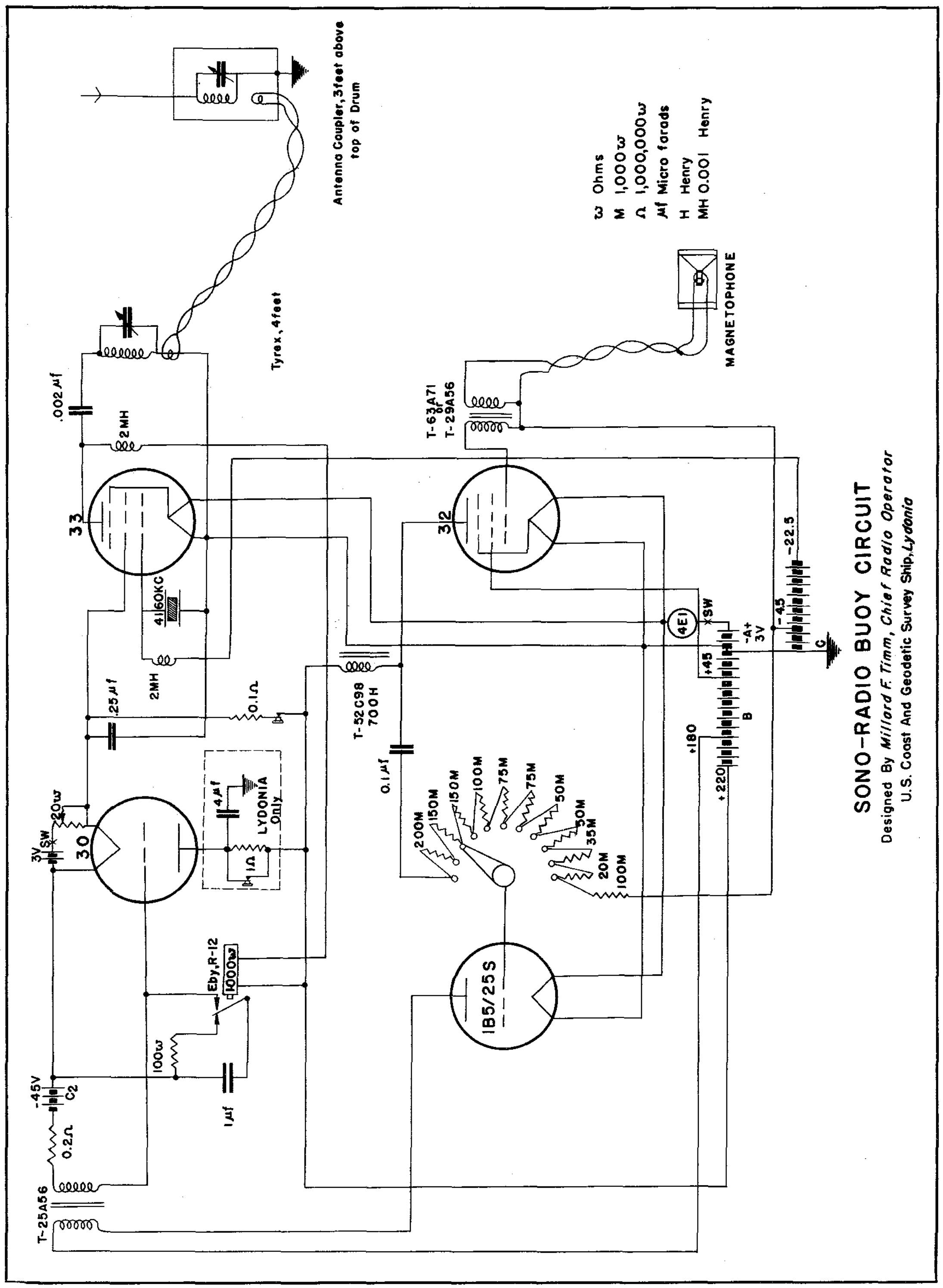
Dr. Herbert Grove Dorsey
Principal Electrical Engineer
U. S. Coast and Geodetic Survey

Chief Operator Timm's new dynamic hydrophone seems to me to be a step in the right direction. I believe that the effect of the bomb is just a push in the water and that the hydrophone which responds to the lowest frequency will be most sensitive to bomb signals and less bothered by water noises. It will be interesting to see results from more of those next season.

Concerning the delay circuit, when I first heard, early in the 1938 season, that one less tube was being used in the sono-radio buoy circuit on the LYDONIA, I was horrified. This, of course, because I feared there would be insufficient amplification of the bomb signal before it keys the transmitter tube to obtain results from maximum distances. However, this fear was gradually allayed when no alarming reports came from the LYDONIA; on the contrary, everything appeared to be working satisfactorily.

After the close of the season information was received that the operators on the OCEANOGRAPHER were building new sono-radio buoy units copying the circuits used on the LYDONIA. Since some difficulties had been encountered on the OCEANOGRAPHER during the 1938 season, I had the feeling that almost any change in the circuit might be an improvement, so I just awaited results.

Why all the unrest about circuits since they had given good results the first two seasons--at least on most of the ships? Perhaps the primary reason was the urge to try something different, hoping it would be better; the principal reason for progress throughout the ages. The ideal sono-radio buoy would respond to bomb signals only and ignore all water noises. It would continue to function for an indefinite time--perhaps for a whole season. If anything went wrong, it would remain entirely silent. Its signals would be strong enough to crash through all static and other interference, but would be so


SONO-RADIO BUOY CIRCUIT
Designed By Millard F. Timm, Chief Radio Operator
U.S. Coast And Geodetic Survey Ship, Lydonia
ω Ohms
M 1,000ω
Ω 1,000,000ω
µf Micro farads
H Henry
MH 0.001 Henry
Antenna Coupler, 3 feet above top of Drum
Tyrex, 4 feet
MAGNETOPHONE
T-63A71 or T-29A56
T-52C98 700H
T-25A56
33
32
30
1B5/25S
4160KC
2MH
2MH
.002 µf
.25 µf
0.1Ω
0.1 µf
4 µf
1Ω
LYDONIA Only
20ω
3V SW
Eby, R-12
1000ω
100ω
1 µf
-45V C2
0.2Ω
200M 150M 150M 100M 75M 75M 50M 50M 35M 20M 100M
4EI SW
-A+ 3V
+45
+180
+220
B
-45
-22.5
G

short and distinctive that signals from two separate sono-radio buoys could be identified and recorded within a tenth-second. It would be highly desirable to be able to control the sensitivity of any or all sono-radio buoys from the ship. (This is possible and has been carefully considered, but the complications are so great that at present it seems impracticable.) The whole electrical unit should be extremely simple, light in weight, rugged, and easily assembled and adjusted.

As the art advanced, it soon became evident that a shorter signal was very desirable, and, for this reason, was discussed on both coasts. Relays had been used in the plate circuit of the transmitting tube to cut off the plate current and thus shorten the radio signal. However, if the bomb sound comes in as a long rumble, as it generally does from a bomb at any considerable distance from the hydrophone, it will be emitted as two or more short signals separated by the time required for the relay to close the circuit again.

Chief Operator Timm went a step further with the relay. Keeping it in the plate circuit he did not open the B-battery current but operated on the keying tube, the inverted type-30 preceding the transmitter tube, type-33. The relay connects a 1-microfarad condenser between the grid and filament of the 30-tube, which has the equivalent effect of short-circuiting the secondary of the transformer T-25A56 and thus preventing the amplified bomb signal from causing the grid of the type-30 tube to become positive, thereby passing plate current to the screen of the 33-tube, allowing it to oscillate. This decreases the length of the radio dash to a rather definite value, since the charging of the condenser, through the 200,000-ohm resistor and the inductance of the secondary of the transformer, gradually brings the grid potential back to cutoff value. After this point is reached a second radio signal might be sent if the bomb signal is prolonged. To accomplish this, Operator Timm introduced a delay action which prevents a second signal from being sent for some appreciable time after the first signal.

This is accomplished by the condenser and resistor shown in the dashed rectangle below the type-30 keying tube. The plate current for this tube normally comes from the same plus B-battery which supplies the plate of the 33-transmitting tube. In the present case, however, a million-ohm resistor is placed in series with the plate of the 30-tube and is shunted by a 4-microfarad condenser which is charged through the million ohms.

The charged condenser acts as an independent source of plate current for the 30-tube. As soon as it is discharged, on the arrival of the bomb signal, no more radio signal can be sent until this condenser is recharged, and this requires a definite time interval, de pending upon the size of the condenser and the resistor. Hence the time delay can be made almost any desired amount up to several seconds.

As noted on the drawing, this part of the circuit is being used on the LYDONIA only. Commander Eyman's remarks explain why it is so well liked there. On the OCEANOGRAPHER, however, the general feeling is that the delay action is not so desirable since bomb signals must be received from greater distances on the OCEANOGRAPHER which, in general, is working farther off shore than the LYDONIA. For these greater distances the bomb amplifier is usually adjusted for higher gain and consequently water noises and passing ships will cause more strays than when the amplifier is set for less gain. These strays can generally be identified and so are not confused with the bomb signals. However, if the delay circuit is used and water noise should key the transmitter just a few seconds before the bomb signal reaches the sono-radio buoy, then there would be no return at all. Or worse, the delay action might recover at the latter part of a long rumbling bomb signal, in which case the radio signal might be sent a second or two after the arrival of the first part of the bomb signal.

With these arguments, pro and con, for the delay action, it seems evident that the adoption thereof may depend upon the nature of the hydrographic work to be accomplished and the opinion of the commanding officer.

The method of gain control shown in the drawing was worked out two seasons ago by Thomas J. Hickley, Senior Radio Electrician, who had so much to do with the first circuit. This gain control gives practically uniform steps of two decibels so that with a switch having numbered points it can be quickly set to any desired definite gain. The values of the resistors shown are the nearest regular sizes to the calculated correct amounts.

Chief Operator Timm arranged this multiple gang switch to control also the keys shown across the million-ohm charging resistor and the one across the screen of the 33-tube and its voltage so that the transmitting tube may be given its final tuning just before the sono-radio buoy is put overboard.

Operator Timm's improvements in the circuit part of the sono-radio buoy may be summarized as follows: one less tube, six fewer resistors, seven fewer condensers, shorter signal, and delay features. The simplified circuit is much more easily wired up and is less crowded. A smaller size B-battery may now be used, decreasing the total weight so that only one barrel, instead of two, is being used on the LYDONIA.

The circuit has worked so well on both the LYDONIA and OCEANOGRAPHER that the latter was asked to send a unit to the HYDROGRAPHER. It was received too late for use this season, but it will be given a test immediately after the ship's repairs are completed and surveying is resumed.

R. P. Eyman, Hydrographic and Geodetic Engineer
Commanding, U. S. Coast and Geodetic Survey Ship LYDONIA

A great deal of study and experiment has been given toward the improvement of our sono-radio buoys in order to permit, if possible, the identification of individual buoy returns and to eliminate some of the features that occasionally were real annoyances.

One of the chief provocations was for a buoy to emit one loud continuous wail when a bomb (even a small bottle) was fired at a moderate distance from the buoy, the wail becoming an interrupted series of returns as bombs were fired greater distances from the buoy. This long dash on the chronograph tape or the repeated returns from the same buoy often blanketed all the other returns with the consequent result that no position was obtained. Another annoying feature was the inability to obtain a fix when approaching a bisectrix between two buoys (the distance from the third sono-radio buoy would usually be not sufficient by itself to control the line); and any attempt to run a line parallel to and less than about 3/4 second from a bisectrix was a noble experiment that usually resulted in failure, unless one of the buoys was obliging enough to go dead at the proper time.

Timm's device, designed to paralyze the buoy for a short interval after each transmission has proved very effective and of great assistance in that many more buoy returns were properly recorded on the tape. We now pay very little attention to bisectrices and frequently record returns from different buoys not more than 0.2 or 0.3 second apart and in fact have recorded them as close together as 0.13 second.

Another factor that should be emphasized is that this circuit prevents a faulty buoy from keying off continuously. One such buoy can effectively stop all work until it is given attention. This season one buoy failed to function properly for some reason or other and, except for this circuit, would have been keying off continuously. The actual result, however, was extremely interesting. The buoy merely kept sending short signals at regular intervals (a number were caught on the tape and scaled, with negligible differences, in hundredths of a second, in the intervals). However, in spite of this we were able to continue work with the other buoys until a convenient time arrived to service this particular buoy.

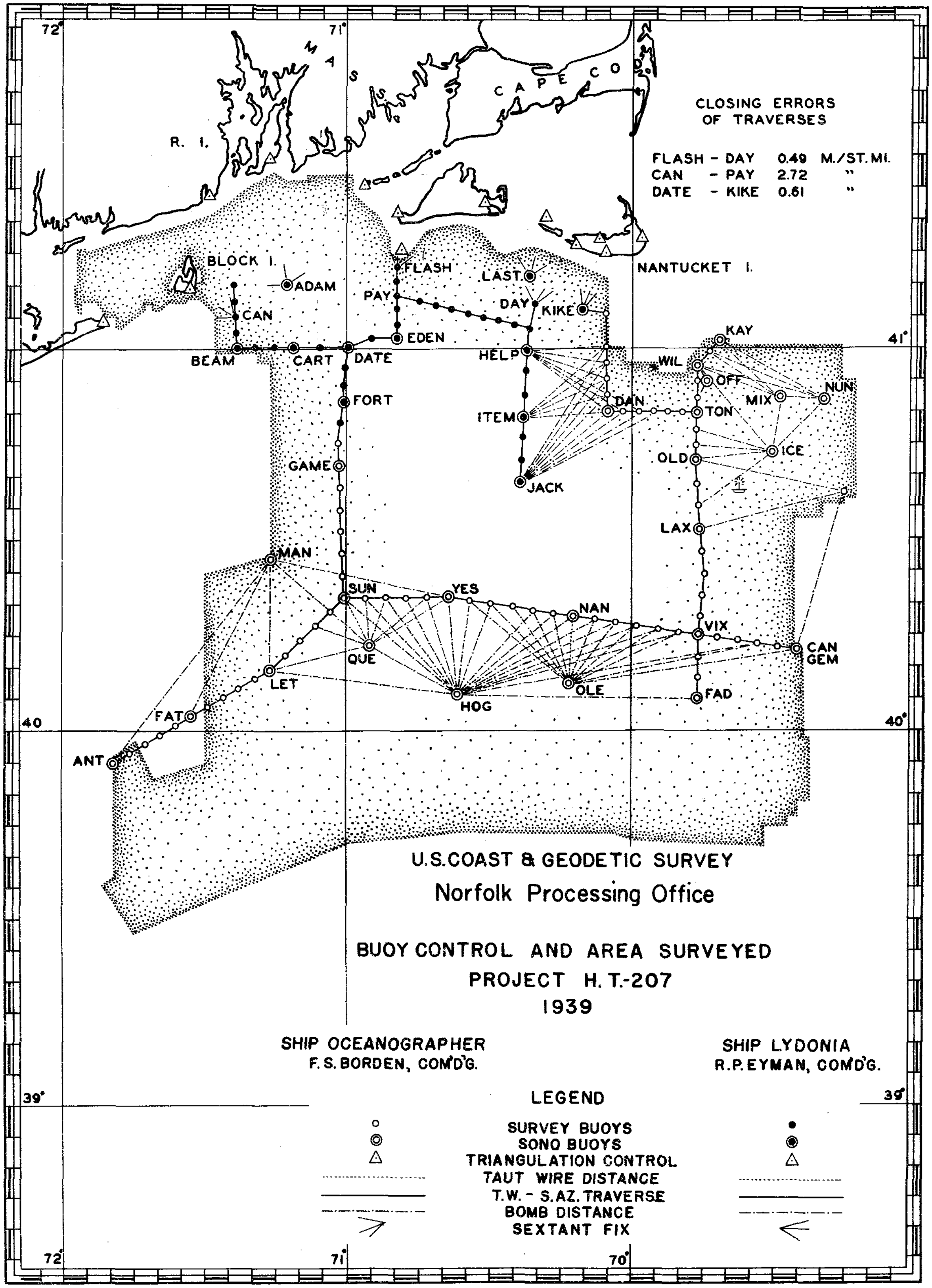
SIMPLICITY IN MAPS

Charles H. Deetz, Cartographic Engineer (retired)
U. S. Coast and Geodetic Survey

Simplicity will scarcely be denied to be the best recommendation of a map or chart,--but it should be kept in mind that simplification and abridgment are by no means convertible terms. Many maps have been published, professing to simplify the elements by reducing their exposition into a compass sufficiently generalized to dissipate the alarm which is reasonably felt where unlimited content and minute detail prevail.

The proper procedure is to bring out the essential characteristics in a clear light, without entering deeply into incidental features which have ho reference to the professed purpose of instruction. If it is true, as Aristotle says, that the mere chalk outline of a simple figure is more interesting than a multitude of brilliant colors or details thrown carelessly together, without regard to significant design, it is no less true in maps and charts, that per tinent objects should be boldly outlined for the rapid comprehension of the mind's eye, even at the exclusion of parts of minor importance.

We find too often a sort of patchwork composition without intelligent design, and the user of a chart is led to fix equal attention on all its parts, though many are superfluous, and many defective. Even where an original survey may be quite satisfactory, the final compilation of its elements, after all, is the thing where honest thought and utmost skill are of vital significance.



72°
71°
70°
41°
40°
39°
MASS
CAPE COD
R. I.
BLOCK I.
NANTUCKET I.
CLOSING ERRORS OF TRAVERSES
FLASH - DAY 0.49 M./ST. MI.
CAN - PAY 2.72 "
DATE - KIKE 0.61 "
ADAM
CAN
FLASH
PAY
EDEN
LAST
DAY
KIKE
KAY
BEAM
CART
DATE
HELP
WIL
OFF
NUN
MIX
FORT
ITEM
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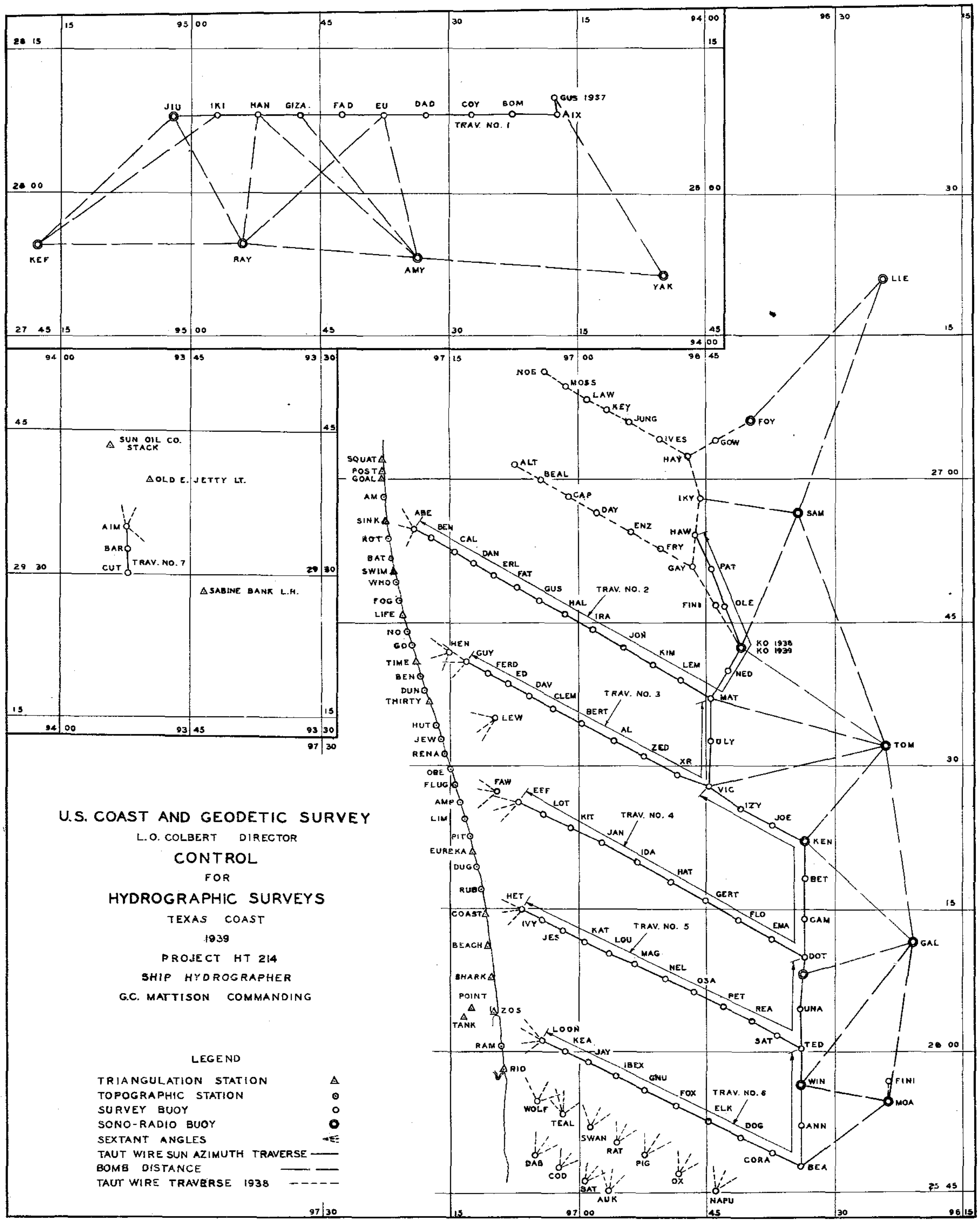
TON
ICE
OLD
GAME
JACK
LAX
MAN
SUN
YES
NAN
VIX
CAN
GEM
QUE
LET
HOG
OLE
FAD
FAT
ANT
U.S. COAST & GEODETIC SURVEY
Norfolk Processing Office
BUOY CONTROL AND AREA SURVEYED
PROJECT H. T.-207
1939
SHIP OCEANOGRAPHER
F. S. BORDEN, COM'D'G.
SHIP LYDONIA
R. P. EYMAN, COM'D'G.
LEGEND
SURVEY BUOYS
SONO BUOYS
TRIANGULATION CONTROL
TAUT WIRE DISTANCE
T.W. - S. AZ. TRAVERSE
BOMB DISTANCE
SEXTANT FIX


U.S. COAST AND GEODETIC SURVEY
L.O. COLBERT DIRECTOR
CONTROL
FOR
HYDROGRAPHIC SURVEYS
TEXAS COAST
1939
PROJECT HT 214
SHIP HYDROGRAPHER
G.C. MATTISON COMMANDING
LEGEND
TRIANGULATION STATION
TOPOGRAPHIC STATION
SURVEY BUOY
SONO-RADIO BUOY
SEXTANT ANGLES
TAUT WIRE SUN AZIMUTH TRAVERSE
BOMB DISTANCE
TAUT WIRE TRAVERSE 1938
TRAV. NO. 1
TRAV. NO. 2
TRAV. NO. 3
TRAV. NO. 4
TRAV. NO. 5
TRAV. NO. 6
TRAV. NO. 7
SUN OIL CO. STACK
OLD E. JETTY LT.
SABINE BANK L.H.

TOWARD A MORE PERFECT CHART

George F. Jordan, Assistant Cartographic Engineer
U. S. Coast and Geodetic Survey

George F. Jordan is in immediate charge of that part of the W. P. A. project at Philadelphia, which is supervised by the Division of Charts. He is supervising the work of approximately 45 employees. L. G. Simmons, Associate Geodetic Engineer is in charge of the entire Philadelphia W. P. A. office.

Editor.

The Coast and Geodetic Survey is constantly striving to provide more accurate data, and better means for securing these data each year. The general public expects and takes for granted these improvements, together with the ever-increasing service rendered by the various government bureaus, and to parallel the great strides initiated by private industries and institutions. Many of these improvements are readily apparent in inventions and improved devices, great or small. The general public takes cognizance of these things accomplished, and silently or verbally pays homage to the individual or group responsible for giving them these better things.

There are, however, many services offered to the public which, in a way, pass unnoticed, unless there is a sensational discovery or development. Very few people are fully aware of the work and services of the various government bureaus. One reads of the Departments of Agriculture, Interior, Commerce, and others, but only occasionally comes in direct contact with the actual service given by these bureaus, and the large amount of accurate material efficiently gathered to render that service.

The general public does come in contact, however, with publications of the various government agencies, and by those publications the agencies are largely judged. Among the publications of our bureau are charts, which are issued for public use and are the result of an accumulation of field data properly compiled. Does the average chart user, for example, stop to consider the amount of detail to be handled in producing the chart? What is the original basis of our horizontal and vertical control, and how has it been efficiently and accurately extended to the area covered by a certain chart? How are the offshore depths accurately obtained and located? These are problems that do not occur to the average user of our charts.

The public sees the finished product, and often takes the results for granted, with its attention inadvertently drawn to the less important but often more glamorous features. It is an old joke that the "Mrs." bought a certain automobile this year because it had a vanity case and the upholstering matched her latest ensemble. The workmanship of the product was taken for granted.

To be sure, the depths of the water, bottom characteristics, locations of shoals and dangers, buoys, lights, and so forth, are the important data that a mariner requires. However, there are a large number of our charts that are used by the operators of smaller craft in more or less local waters, with which the skippers are already familiar. They are often interested in checking the accuracy of our charts, including the location of charted depths with relation to prominent features or ranges.

In Buzzards Bay, Massachusetts, there was an interesting couple who had for their hobby the location of shoals and rocks reported by local boatmen, and also the verification of the depths and shoals on our charts. The sportswoman and her husband used two skiffs, and besides recording the intersecting ranges, kept an album of photographs of the ranges. The photographs were taken from one skiff while the second skiff was anchored over the danger. This couple willingly permitted our surveyors to examine their notes with the result that two previously uncharted rocks were found and located.

This is one unusual instance of how we are being checked by the people who are using our charts. But what of the thousands of chart users who may check on us with whom we do not come in contact? What do they think of our results, our charts? Me must be on our guard constantly, to give them accurate information, in order that the respect now enjoyed by our charts may not diminish.

There is one phase of the charts which may sometimes be slighted while concentrating on the more important data. That phase is the correct geographic names which identify the respective features on the charts. It is realized that the correct delineation of these features with relation to others is the real aim. However, a supposed trivial item like a name, if misapplied, may tend to lessen the respect of a chart user for the efforts expended to produce an accurate chart. A mariner or engineer who is not familiar with our bureau might quite justifiably feel consciously or unconsciously that, if we have been careless in applying geographic names, the other charted data may not be so reliable as at first supposed. We know that this is not the case and that our charts indicate the true conditions of land and water, as of the latest available surveys.

More accurate and more efficient methods for carrying out our surveys are constantly being developed, and the previously unknown details of this earth and the waters that surround it are steadily surrendering their secrets. Instructions have been issued pertaining to the checking of the charted names, and securing new names for our charts; but the case of questionable geographic names is considered herein.

The Geographic Name Section of the Division of Charts is constantly checking new charts for verification of named features. In the past few years the verification and correction of existing charts have been in progress. Our charts have been found to be fairly accurate in this respect, but it must be remembered that on the earlier charts less attention was given to this detail. Limited personnel has prevented a complete systematic verification of our charts in this respect. Now, the cause of the geographic name has been rallied.

Arrangements were made early in 1939 with the Works Progress Administration to establish a temporary W. P. A. office in Philadelphia supervised by the Coast and Geodetic Survey. The several Divisions of this Bureau had various work to be accomplished there, and the matter of geographic names has been undertaken in conjunction with the other work for the Division of Charts. There are a total of 150 people employed at present on work for the Divisions of

Geodesy, Terrestrial Magnetism and Seismology, Tides and Currents, and Charts. The work of this office for the Division of Charts is divided into four main subdivisions: geographic names, compilation of data for aeronautical charts, measurement of tidal high water line by states, and drafting of planimetric maps from air photographs and aeronautical charts.

The largest individual sub-division is employed, at present, on the geographic names. The work of the Washington office is augmented and supplemented by a wholesale verification of the names appearing on our nautical charts. This is accomplished by comparison with overlapping charts, planimetric maps, U. S. Geological Survey and U. S. Engineer Corps quadrangle maps, Land Office, Soil, Forestry and Post Route maps, and Rand McNally Atlas, besides the initial checking against the Geographic Name Standard charts on file in the Washington office.

Any disagreements found are investigated by local inquiries by mail to the area concerned. These inquiries are usually sent to postmasters, Coast Guard stations, District Engineer offices, and so forth. Some of the field parties may have been asked about these inquiries by the local people, for many inquiries have been sent out. Cooperation has been excellent, and the way in which the replies have been made is greatly appreciated. The results of these inquiries are referred to the Section of Geographic Names in the Washington office, and the Name Standards are verified or corrected. In case the correct geographic name is still in doubt, it is submitted for a decision to the U. S. Board on Geographical Names.

Lists of the accepted names for every geographic feature on each chart are compiled and typed. These lists are later grouped by states, and also by regions, and include a short description in addition to the geographic position of each feature.

Generally, a discussion on any subject is more appreciated if examples are cited. It is to be emphasized, however, before concluding, that the percentage of mischarted names is very small, and does indicate the prevalence of general accuracy. Even so, the following list of examples will indicate that the importance of names should not be slighted. The added respect of the local mariner or engineer will be assured if names are reported and charted correctly, as these chart users know them.

Correct Name	Incorrect Name
SEVERN CEDAR POINT	SEVEN CEDAR POINT
MAYCOX POINT	MAYCOCKS POINT
REPAUPO CREEK	REPARTO CREEK
RANCOCAS CREEK	RANCOCAS RIVER
MONIE CREEK	BIG MONIE CREEK

Moreover, the names of adjacent features have been found to be reversed, occasionally.

It is impractical for a topographer to consume the time necessary for a complete research into the name of each feature. (One reply to an inquiry on a single name covered a full page, going back to a grant of King George III in 1752, for verification.) But a ge ographic name, its spelling or location, should not be accepted too readily. It should be verified locally, and if there is any discrepancy it should be verified by several sources. The time will be well spent and the result will be a more perfect chart.

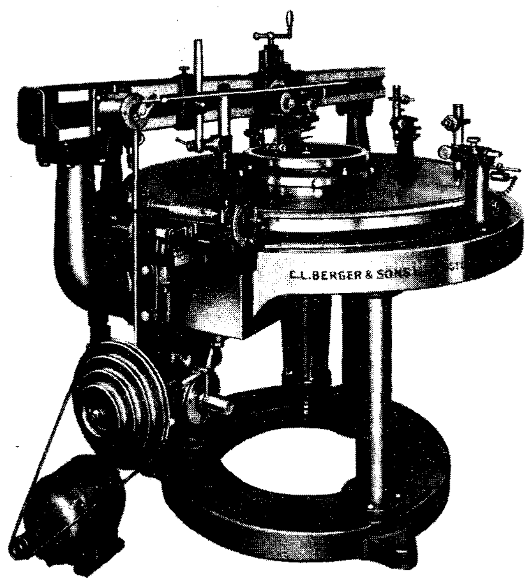
THE CARE OF SURVEYING INSTRUMENTS*

L. H. Berger, President,
C. L. Berger and Sons, Inc., Boston, Mass.

Like all instruments of precision, surveying instruments require the greatest care in handling. However, unlike other delicate devices, they not only are subjected to climatic conditions of the severest nature, but are accorded various kinds of especially rough treatment. Because of this, it is essential that the user should be instructed as to the proper care of whatever instrument he is required to use, and the precautions he must take to avoid serious trouble.

* * *

Every user should be sufficiently acquainted with his instrument to make at least adequate makeshift repairs when an emergency occurs. He should also learn to discriminate carefully between the adjustments and repairs which he can and ought to make himself and



An Automatic Dividing Engine

This machine, used for dividing circles of all diameters from 4 to 40 inches, has an accuracy of 1 second of arc.

those which he should not attempt. Harm may be done both by neglecting to make repairs and by trying to perform in the field a delicate operation which only the maker, with the proper equipment, should attempt.

Common sense is a safe guide in the handling of instruments. One of its dictums, for instance, is that a transit or a level should be lifted by the leveling base or foot plate--the structural supports designed to serve as its foundation. To lift an instrument by the

* Reprinted through the courtesy of Civil Engineering for July, 1939.

telescope or under the horizontal circle is to take unwarranted liberties with what is really its heart, which should certainly not be subjected to needless strains. If it is necessary to lift an instrument by its superstructure, it is advisable to grasp the base of the standards near the horizontal plate, being careful during the lifting not to exert any lateral pressure.

Sensitive and careful treatment of a surveying instrument is necessary even in its leveling. It is possible through binding one of the screws of a four-screw leveling base to apply a pressure of several hundred pounds. It is easy to imagine the distortion which continual application of this pressure can produce on the socket of the leveling head. What is even more injurious is that this pressure is transmitted as a direct thrust on to the vertical spindles of the instrument.

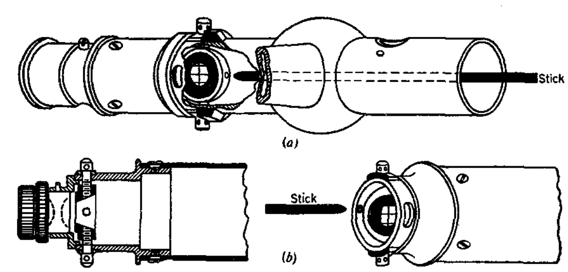
Protection should be afforded instruments when used in bright sunlight. Sensitive spirit levels of transits and levels ought to be protected from the direct rays of the sun whenever possible. A cloth hood should be provided to cover the instrument when it is not in actual use.

Telescopes as now constructed with interior focusing require very little care and adjustment. It is better to put up with such annoyances as a small amount of dust on the cross-hairs or on the inside surface of the lenses until the instrument can be sent to the maker. The exposed lenses should be dusted with a scrupulously clean piece of linen, free from lint, applied with a light circular motion.

. . . Lack of proper ventilation in the telescope tube causes the condensation known as "dew-drops" to gather on the cross-hairs and on the surfaces of the various lenses. This condensation will gradually disappear when temperatures have been equalized.

Removing the Diaphragm

Unless experienced, one should not attempt to adjust or clean the cross and stadia wires. Actually they seldom need adjusting or cleaning, and an inexperienced person attempting it may change the telescope's line of collimation. If an engineer is going into remote sections it is better for him to take along with his instrument an extra diaphragm. However, should it be found necessary to clean the diaphragm wires the following procedure is advised:



Method for removing diaphragm from (a) erecting and (b) inverting transit telescope.

With an erecting telescope (whether of the exterior or interior focusing type): (1) Unscrew the object glass by turning it to the left. (Before doing so, observe whether there are any marks to show how far the cell is to be turned to place it in the correct position. If there are none, a small mark should be made parallel to the line of collimation which will extend from the edge of the cell to the collar. When the cell is put back, it must be turned until these marks coincide exactly.) (2) Remove the focusing pinion, and carefully draw out the focusing slide. (3) Remove the telescope spirit level. (4) Remove the two capstan-head screws and their washers at the right and left of the cross ring. (5) Loosen the remaining screws to such an extent that the ring may be turned 90 degrees. (6) Insert a long, sharp-pointed stick into the hole nearest the objective end of the telescope, so as to hold the diaphragm. (7) Remove the two remaining screws, and take the diaphragm out on the stick.

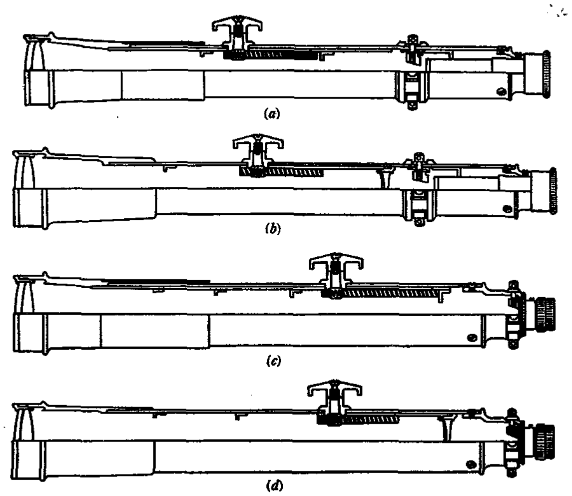
With an inverting eyepiece, the diaphragm is more easily taken out through the eyepiece end of the tube. It is not necessary to detach the telescope level or to remove the object glass, the focusing pinion, or the slide. First remove the two opposite screws having slots which hold the eyepiece in its mounting in the outer barrel of the telescope. Then slightly release all four diaphragm adjusting screws. Remove the entire eyepiece mounting. Then, by taking out two opposite diaphragm screws and inserting a sharp-pointed stick, the diaphragm can be removed as in the case of the erecting telescope.

The cross-wires may be cleaned by using a small wedge-shaped piece of fine-texture tissue paper, moving it gently forward and back along the wires. This operation requires a very steady hand and the use of a reading glass to prevent cross-wire breakage.

* * *

Focusing Slide Needs No Lubrication

When the manufacturer has selected the correct metals for a focusing slide and the barrel in which it travels, and the slide has



Focusing Systems for Transit Telescopes

(a) Erecting, with exterior focusing slide--five lenses; (b) erecting, with internal focusing--six lenses; (c) inverting, with exterior focusing slide--three lenses; (d) inverting, with interior focusing--four lenses.

been painstakingly fitted, the slide or barrel never requires lubrication of any kind. This is also true of the objective lens slide, found on the older types of instruments. If these parts are oiled, the lubrication will harden in cold weather, so that the slide will move only under undue force; in warmer weather the oil will thin, causing a dust-bearing and fogging medium to be freed within the telescope barrel, which will be deposited on the cross-hairs and on the surfaces of the lenses.

If the focusing slide frets, a little fine watch oil may be applied as an emergency practice, but the instrument should not be used more than necessary before being repaired, in order to prevent this fretting condition from becoming worse.

* * *

Trunnions should be oiled frequently, with the best grade of oil, to preserve their true form.

* * *

Suggestions on Cleaning and Oiling

It is of course necessary for a surveyor to be able to disassemble his instrument for cleaning and oiling, as well as to make the proper field adjustments. As a practical precaution, frequent cleanings seem to be the best preventive of instrument trouble. Of course an instrument should never be cleaned where dust or dirt is present; a clean bench and a dust-free room are prime requisites. An orderly arrangement of the disassembled parts is also necessary to insure their uninterrupted and proper reassembly. Particular care should be taken to place the graduated circle in such a position that no dirt will possibly get on its surface.

When the parts needing attention have been disassembled, the first operation is to remove all traces of the old oil. The instrument should be thoroughly cleaned before any re-oiling is attempted. An absolutely clean chemical solvent that leaves no residue, such as naphtha or benzine that has not previously been used, should be employed. This should be applied with a piece of good-grade linen, which has been thoroughly washed and is absolutely free from lint. It is important to clean both the spindles and the sockets, or the purpose of the cleaning is defeated. The flanges of the spindles and their upper rests should be cleaned with another clean rag to remove all traces of film left by the solvent.

The proper way to oil the instrument centers is to apply a few drops to the spindles and their sockets, and their respective flanges. No harm is done if the oil is applied liberally, but there is no point in wasting it. The vernier plate clamp, the horizontal circle clamp, and the telescope clamp should also be thoroughly cleaned and oiled.

Leveling screws should be cleaned with naphtha or benzine, applied with a stiff clean typewriter brush. No heavy lubricants or greases should be applied, as dust will readily adhere to such substances and settle on the screws. Vaseline should not be put on screw threads, as it is likely to harden, especially in winter, causing the screws to move very stiffly.

When the instrument is apart, the graduated circle may be lightly dusted with a fine camel's-hair brush. But no attempt should ever be made to clean the graduations--even with abrasives as fine as optical rouge--and silver polish, even of the highest grade, should never be used. Another "don't" is this: The graduations of the horizontal circle, after cleaning, should never be coated with a film of oil or vaseline, however thin, as any film is likely to overflow across the graduated lines and cause erroneous angular readings. For the same reason, in servicing an instrument, when it becomes necessary to remove the tarnish from an accurately cut graduation on sterling silver, a coat of transparent lacquer should not be applied.

Use of the best oils and lubricants on the market is a prime factor in lowering the maintenance cost of surveying instruments. Only the finest grades of watch or clock oils should be applied. Light machine oils, however purified they may be, are not suitable, and oils of the penetrating or cutting type should not be allowed even on the same bench as the instrument. It is worth noting that oils and greases formerly recommended by instrument manufacturers have in many instances been discontinued because superior products are now available. Certain excellent watch and clock oils made by various companies work well at even 20 degrees below zero.

Tools such as screwdrivers, spanner wrenches, and adjusting pins should be of reasonable fit to prevent the burring of screws. These tools are a part of the equipment furnished with every transit, so there is rarely need for substitute devices. Such makeshift implements as brads, wire nails, and surveyors' tacks are very poor substitutes.

Care should be exercised if long adjusting pins are used, because there is likelihood of applying too strong pressure and thus stripping the threads of screws or nuts.

* * *

COMMENT

Robert H. Griffin,*
Assistant Engineer, U. S. Forest Service

The article on "The Care of Surveying Instruments" by L. H. Berger, contains considerable information that should be of value to all engineers using surveying instruments, especially those who must of necessity use instruments in remote and inaccessible locations. The writer's experience with the telescopic alidade used in most plane-table work has been rather extensive and thoroughly bears out Mr. Berger's statement that "frequent cleanings seem to be the best preventive of instrument trouble." Inexperienced men frequently hesitate to undertake this cleaning and its attendant oiling and as a result, especially when the instrument is used in a dusty location, the trunnions and their bearing surfaces on the standards become coated with a dust and oil cake that completely destroys the quality of the bearing and makes use of the instrument very unsatisfactory. Usually in such a case the instrument is blamed for troubles that are the fault of the instrumentman and that could easily be prevented or corrected if the instrument were cleaned and oiled.

It is doubtful if instrument-makers realize the amount of rough

* Reprinted through the courtesy of Civil Engineering for September, 1939.

use that the average telescopic alidade receives. The alidade is usually carried on the outside of the plane-table case on the topographer's back. This does not subject the alidade to any particular rough use unless the topographer fails or unless he is going through heavy brush or undergrowth. In the latter case it is practically impossible to prevent the alidade from receiving occasional blows from small twigs or, sometimes, from limbs of considerable size. A few days or even a few hours spent in following a topographer through a heavy brush field would be very instructive to an instrument designer and might lead to a change in design. The desirable changes appear to be in a strengthening of the standards and of the springs which limit the vertical motion of the alidade. On one well-known make of alidade, which the writer used, these springs were almost continually so bent as to be useless, though every effort was made to treat the instrument with the care which it undoubtedly deserved.

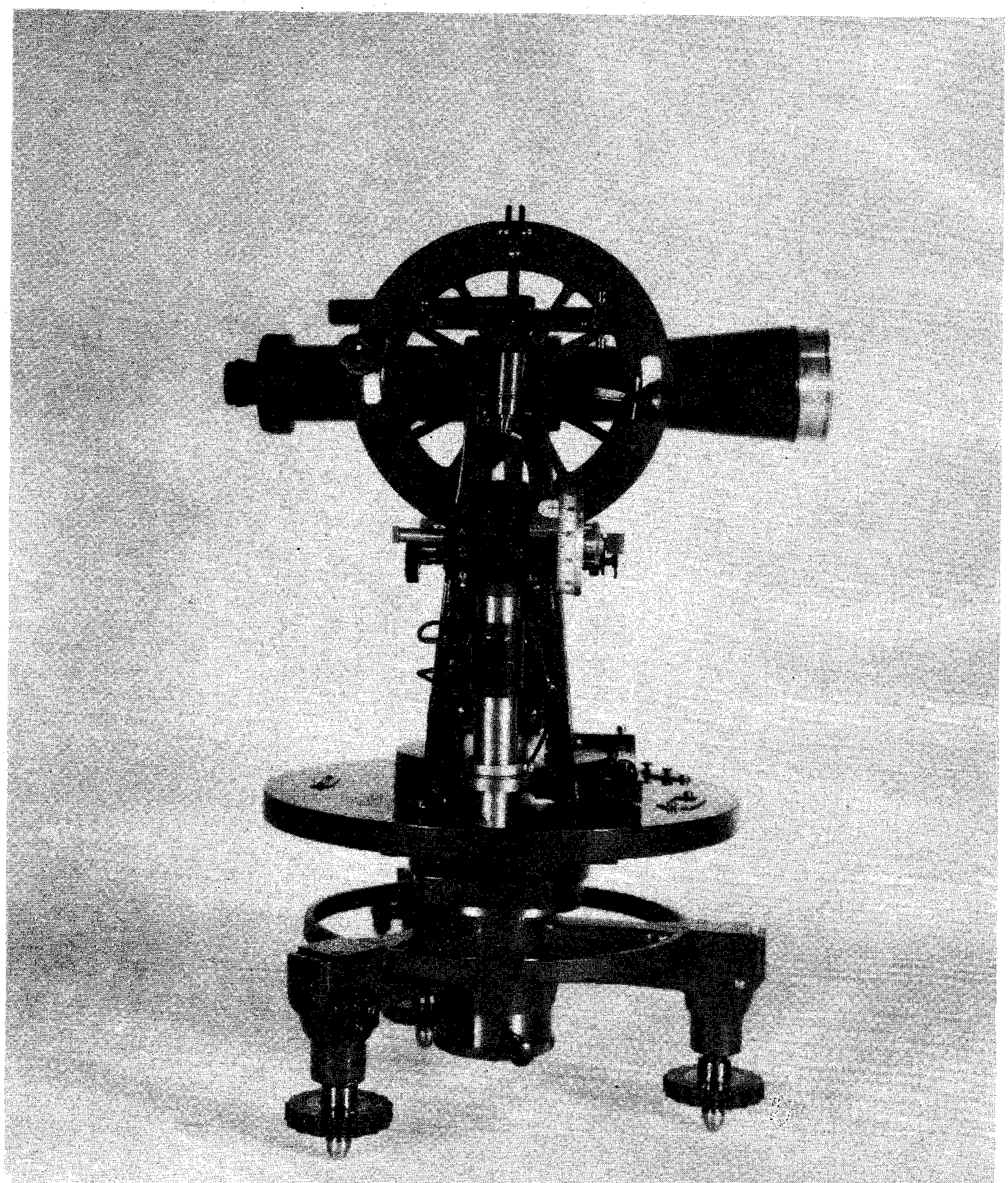
The Johnson head tripod is an important part of the plane-table outfit and is frequently the source of considerable trouble to the inexperienced man. As in the case of other instruments the best preventive is frequent and regular cleaning, though oil should never be used. The surfaces of the tripod, both interior and exterior, become coated with dust, causing the tripod to have a jumpy irregular motion and making satisfactory orientation and leveling of the board very difficult. If the head is not cleaned when this condition develops the tripod may freeze and become seriously damaged. However, this can easily be prevented by cleaning the tripod surfaces. Mere wiping of these surfaces with a cloth does not seem to be sufficient, and rubbing with fine steel wool or, in an emergency, with fine sand paper is necessary to bring the tripod head to proper condition. The writer would be glad to know of some less drastic method which will accomplish the same result.

As an example of what an inexperienced man may do the writer recalls one case in which a topographer broke a level vial and, not knowing that he had a replacement in his instrument box, made a trip of several hundred miles by automobile to obtain a new vial. Whenever an inexperienced man is required to use and care for an instrument he should be taught the principles of instrument care.

H. W. Hemple, Hydrographic and Geodetic Engineer
Assistant Chief, Division of Geodesy
U. S. Coast and Geodetic Survey

Mr. Berger's article, particularly the suggestions as to cleaning and oiling, is well worth the attentive consideration of every officer. The proper care of surveying instruments is an important part of field operations and cleaning and oiling where necessary should be done as a matter of routine at frequent intervals. It cannot be too strongly emphasized that our precise instruments should be kept clean and that the moving parts should move freely and not bind. We all appreciate the ease of manipulation of a high grade instrument which has been kept in excellent condition. Conversely, we deprecate working with an instrument intended for precise observations which is in poor shape and which, because of this, may give questionable results.

Every officer should be familiar with the working parts of a theodolite. He should be capable of taking the instrument apart for



Nine-Inch Parkhurst Theodolite,
designed by D. L. Parkhurst, Chief, Instrument Division,
U. S. Coast and Geodetic Survey, used in first-order triangulation.
The circle can be read directly to one second of arc.

cleaning purposes. He should know what can be done safely in the field, and what is primarily an instrument-shop operation and should not be attempted unless such facilities are at hand and an experienced instrument-shop man available.

The parts of a theodolite which should be cleaned in the field are the telescope lenses, axis centers, tangent screws, micrometer screws, standard supports, clamp collars, and foot screws. No other parts should be tampered with except in an emergency.

While it is necessary that the user of an instrument be familiar with its construction for purposes of cleaning, he should bear in mind that he must be ever on the alert to guard against the unexpected. There are numerous instances in which instruments have been accidentally damaged in curious manners, such as the injuring of a theodolite circle by the winding knob of a loosely attached wrist watch, while the spindle was being cleaned.

There was an instance where an officer left his theodolite on the stand of an 80-foot signal while he descended to tighten a guy wire. The strain of tightening snapped the guy and the sudden release of tension hurled the instrument from the stand and it fell the 80 feet to the ground. An instrument fell from a tower by being caught by a loose rope, and a level rod was broken by becoming wedged between a road bank and a moving truck. One theodolite was considerably damaged when it was carefully placed on a shelf in a launch to guard it against injury, only to be damaged by water coming in through an opened seam.

Of course there are some accidents which are unavoidable, such as the number of occasions in which boats containing observing parties have capsized in the surf while landing. Hydrographic observers have been thrown from a launch by heavy seas, usually at the time when both hands were being used to read the sextant. One such incident failed to disturb the observer's equanimity, and as he came spluttering to the surface of the water, he called out his angle to the plotting officer before attempting to get aboard.

Instruments have been damaged by fire, lightning, wind, wild animals, have tumbled over cliffs, been run over by trains, dropped into the sea, in fact, in almost every conceivable manner, to say nothing of a ship, on which one was being returned to Europe for repairs, catching fire at sea.

It is surprising to find, sometimes, where material in the Field Engineers Bulletin eventually lands. In a contribution to the January, 1940 issue of "The Auk", the organ of The American Ornithologists' Union, Mr. Henry S. Shaw, of Exeter, New Hampshire, reproduces the figure of the two birds which was used to illustrate the article "The First Thousand Years of Finding New York", in Field Engineers Bulletin No. 12. Mr. Shaw, long a friend of the Bureau, states that in reading the article his attention was at once attracted to the picture of these odd-looking birds. On reading the descriptive matter in "The English Pilot", edition of 1742, in which the illustration originally appeared, he was convinced that the birds were not "Pengwins" as stated, but were Great Auks (Plautus impennis). The Great Auk, which was flightless, became extinct nearly a hundred years ago, the last record of one being a bird which was killed near Iceland in 1844. The Great Auk is now a rare museum specimen.

SONO-RADIO BUOY "GULF" IN 400 FATHOMS

L. P. Raynor, Hydrographic and Geodetic Engineer
Executive Officer, U. S. Coast and Geodetic Survey
Ship HYDROGRAPHER

Sono-radio buoy "GULF", anchored in 400 fathoms of water, 150 miles from shore and some 30 miles beyond the 100-fathom curve, has been an important aid in controlling the lines of soundings to the extreme limits of offshore hydrographic survey No. H-6501, just completed by the HYDROGRAPHER in the western part of the Gulf of Mexico. The system of sono-radio buoys ordinarily furnishing the control is just inside the 100-fathom curve. A brief description of the method of anchoring the offshore buoy may be of interest.

A few soundings of 370 fathoms in an area of a general depth of 450 to 600 fathoms on one of the sounding lines on H-6501 indicated a desirable location for a sono-radio buoy that should furnish control for the southern and eastern unsurveyed portion of this survey. With the location determined, the problem arose as to the best method of placing the buoy there.

It was decided that 500 fathoms of anchor wire would give sufficient scope in a depth of 400 fathoms, even if the shoalest spot were not found at first. The weight of 500 fathoms of the 3/8-inch wire which was to be used is about 600 pounds net in the water. Although it was probable that not more than 450 fathoms of wire would ever be actually in suspension, it was simple to make allowance for the total length by using two spherical floats in tandem, about 10 feet apart, instead of the one float regularly used for all depths under 100 fathoms. These spheres, incidently, are apparently discarded mines (either Army or Navy), which were bought from a junk dealer in Mobile, Alabama. They are made of 1/4-inch galvanized iron, 2.5 feet outside diameter, and capable of supporting about 375 pounds each in addition to their own weight. It was anticipated that two of them would support the wire satisfactorily, as was subsequently proved when the buoy was placed in the water.

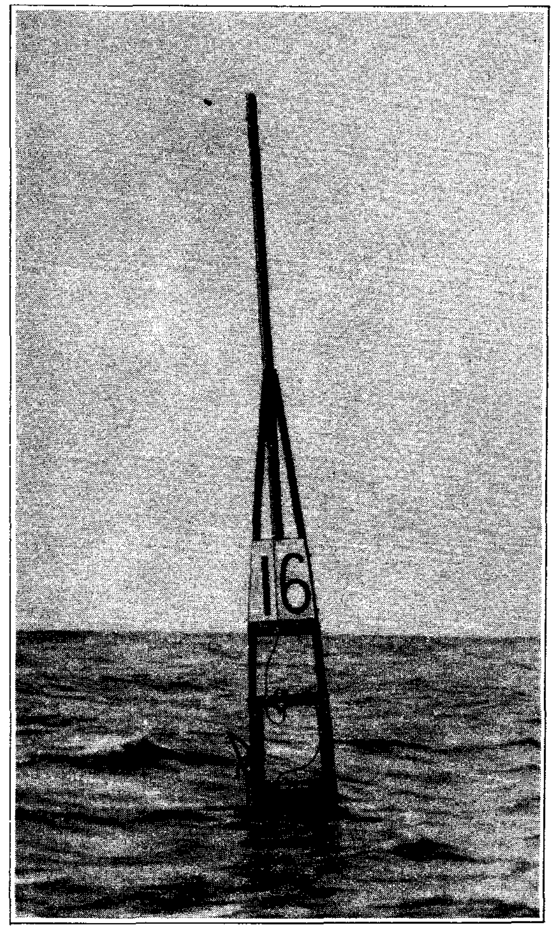
Several methods were proposed for dropping the anchor without fouling the wire or other gear. The method used when buoys are located in less than 100 fathoms is to lower the buoy and the "lead-off-sphere" into the water, then back the ship away from them, paying out the anchor cable by hand from a small diameter coil on deck, taking care that no kinks in the wire occur. When the cable is well stretched out, the 800- to 900-pound anchor, consisting of three railroad car couplers (drawheads), is let go from the rail, where it has been suspended by a trip rope. This procedure could have been followed in the present instance by taking a turn or two around the bitts so that the added weight of the extra 400 fathoms of wire could be handled. However, the area selected for the location of the buoy had not been completely surveyed, and if the shoal were small, the ship might easily drift into deeper water before the wire could be completely payed out. Another method suggested was to fake the wire in large figure-of-eight coils on the forward deck and then to let the anchor go with a run, hoping that nothing would foul. The risk of possible injury to personnel should anything go wrong was considered too great an objection to this method.

Fortunately, Captain G. T. Rude, Chief of the Division of

Hydrography and Topography, was aboard on an inspection trip, and he suggested the method which was eventually used so successfully. Four hundred fathoms of the anchor wire were stretched, in fleets, along the starboard side of the hull, from the forward to the after bitts on the main deck rail, a distance of about 90 feet. Each fleet was drawn taut and secured at the loop end by a light marlin lashing, and approximately every two fathoms between the ends the wire was supported by lashings of doubled sailtwine. The upper fleet was secured about two inches below the rail, and each successive fleet was secured approximately two inches lower. The forward end of the lowest fleet was made fast to the anchor, and the upper end was connected to the other 100 fathoms of wire in the coil which led to the spheres and buoy in the usual manner.

When the "shoal" was reached, the buoy and two lead-off-spheres were dropped and first 100 fathoms of wire paid out as usual. As soon as this was taut, the buoy anchor was dropped and as it sank the lashings on the wire, faked against the ship's side, broke one by one and allowed the wire to pay out gradually until the anchor reached bottom. The slightly heavier lashing at the end of the 100-fathom piece was then cut and buoy "GULF" was in place, with no more trouble and only a little more work than is needed to place a buoy in lesser depths.

The operation of faking the wire alongside the ship's hull took about two hours, due to the unfamiliarity of the personnel with this method. The after half of the starboard alleyway was filled with buoy frames over which the men had to climb to place the lashings, which slowed the operation. More lashings were undoubtedly used than were necessary, and it is believed that one in the middle or, at the most, two at the quarter points, with the ends drawn taut, would be sufficient. With this number of lashings and a clear alleyway, the preparation can undoubtedly be done in 30 to 45 minutes.



Sono-Radio Buoy

In addition to furnishing control for the regular sounding lines, "GULF" was also used to control the complete development of the surrounding shoal by means of bearings and bomb distances, and with the same accuracy as would have been obtained in shoaler water. It also furnished a fixed point for the observation of surface currents at the beginning and end of each line.

IT'S A SMALL WORLD AFTER ALL

One never knows what historical surprise may be disclosed following a talk on some routine phase of Coast Survey work. At a recent meeting of the American Society of Civil Engineers, in San Diego, California, Lieutenant F. G. Johnson discussed the "Use of Plane Coordinates". At the conclusion of the lecture, the speaker was approached by an elderly gentleman, who introduced himself as John S. Siebert, an architect and a Councilman of San Diego. Mr. Siebert said he was formerly an Aid in the Survey, and produced a picture of himself in the party of Assistant Mossman at work on the measurement of the Holton Base in Indiana in 1892. (The writer of this article, A. L. Shalowitz, now a cartographer in the Washington office, was likewise a shipmate of Mr. Siebert in 1916 engaged in a survey of San Diego Bay.--Ed.)

But as if that recollection of early Coast Survey history were not enough, Councilman Siebert proceeded to delve into a little family history by informing Lieutenant Johnson, who had with him a print of the chart of San Diego Entrance, published in 1853, that it was Siebert, Senior, who engraved the chart. A little research into the Survey's records disclosed the interesting fact that it was the Councilman's father who also assisted in the engraving of the first chart of New York Harbor (published in 1845), and it might be said, in passing, but with no reflection on our present-day standards, that chart engraving in those days was a real art. The limited commercial needs of the country permitted the full exploitation of the engraver's skill in artistic expression. The delicate shadings and fineness of detail attained in the copper engraving are unmatched by any other method of chart reproduction, and some of the finest specimens of land topography came from the early engravers in the Coast Survey.

But topographic engraving was new in this country when the time came to publish the first chart and the records show that, in 1841, Professor Hassler, the first Superintendent of the Coast Survey, imported (but not without opposition) two engravers from Europe -- one of these was Siebert père. These engravers constituted what Hassler termed "the seed from abroad". What an interesting sidelight on the uncompromising nature of the great Swiss engineer! Just as he tenaciously insisted from the very beginning that the survey of our coasts be grounded on sound scientific principles, so did he refuse to authorize the publication of charts until they had been engraved in the best style possible.

Had the scientific genius of Hassler been accompanied by the administrative foresight of an Isaac Ingalls Stevens, and had he promptly published preliminary charts of the harbors*, even if in somewhat inferior style, he might have saved himself much of the groundless and unwarranted criticism heaped upon him during his turbulent career in the Coast Survey. But a compromise with expediency was entirely foreign to the man who with full confidence and assurance of his own worth could tell a President of the United States (when informed that the salary he demanded was as much as that of his Secretary of the Treasury) that, "Any President can make a Secretary of the Treasury, but only God Almighty can make a Hassler".

* See "Proposal to Honor Isaac Ingalls Stevens" in this issue.

SPECIAL SURVEY, SITKA, ALASKA.

L. C. Wilder, Hydrographic and Geodetic Engineer
Executive Officer, U. S. Coast and Geodetic Survey
Ship EXPLORER

In 1938, one of the projects to which the Ship EXPLORER was assigned, was the complete resurvey of Sitka Harbor, during which a 1:1,000 scale hydrographic survey was accomplished in the narrow channel off the docks. As large-scale surveys of this type are infrequently made in the Coast and Geodetic Survey and as methods differing from the conventional ones were necessary to obtain the desired accuracy, a description of those used may be of value.

The necessary topography was surveyed by Ensign H. C. Applequist, with particular accuracy and methods evolved for the purpose. The following is quoted from his Descriptive Report:

> "Due to the large scale of this survey it was necessary to modify somewhat the regular topographic methods. However, plane table positions were generally obtained by traverse or by three-point fixes. A good deal of care was used in plumbing over the plane table stations.
>
> "A level rod was used as a stadia rod. The rod was standardized by measuring the intercept obtained at the following distances, measured with a tape: 10, 15, 20, 30, 40, 50, 60, 70 and 100 meters. Three readings were taken at each distance and from the mean of these readings a table was made up showing the intercept for each meter from 10 to 100.
>
> "No stadia shots over 60 meters were used in carrying the traverse, and they were checked frequently with a tape. Traverse distances over 60 meters were all measured by tape. In the location of detail, no stadia shots over 100 meters were taken. Much of the detail, such as buildings and walks, was measured with the tape.
>
> "The alidade was used as a level in carrying the H. I. (height of instrument) on the shore line traverses and the high and low water lines were leveled in. Vertical angles were used in carrying the H. I. on the traverses back from the shore line. The H. I. was carried to tenths of a foot and elevations for contouring taken to the nearest foot."

First Hydrographic Method

The methods used for control of the hydrography were very simple. An ordinary traverse was run between control points with a 4-inch theodolite (the control points were triangulation and topographic stations), along which stakes were driven at the interval required for the desired spacing of the sounding lines. After the stakes were established, the sounding was accomplished from a skiff rowed along a sounding line at right angles, or at any predetermined angle, to the lines of stakes and held on line by an officer on shore at the traverse stake used as an origin for that particular sounding line. The officer kept the skiff on line by using a sextant, set at the proper angle, using a distant backsight for his sextant angle initial rather than the line of stakes. The traverse line of stakes can be placed where desired as long as the traverse is started and ended at control stations.

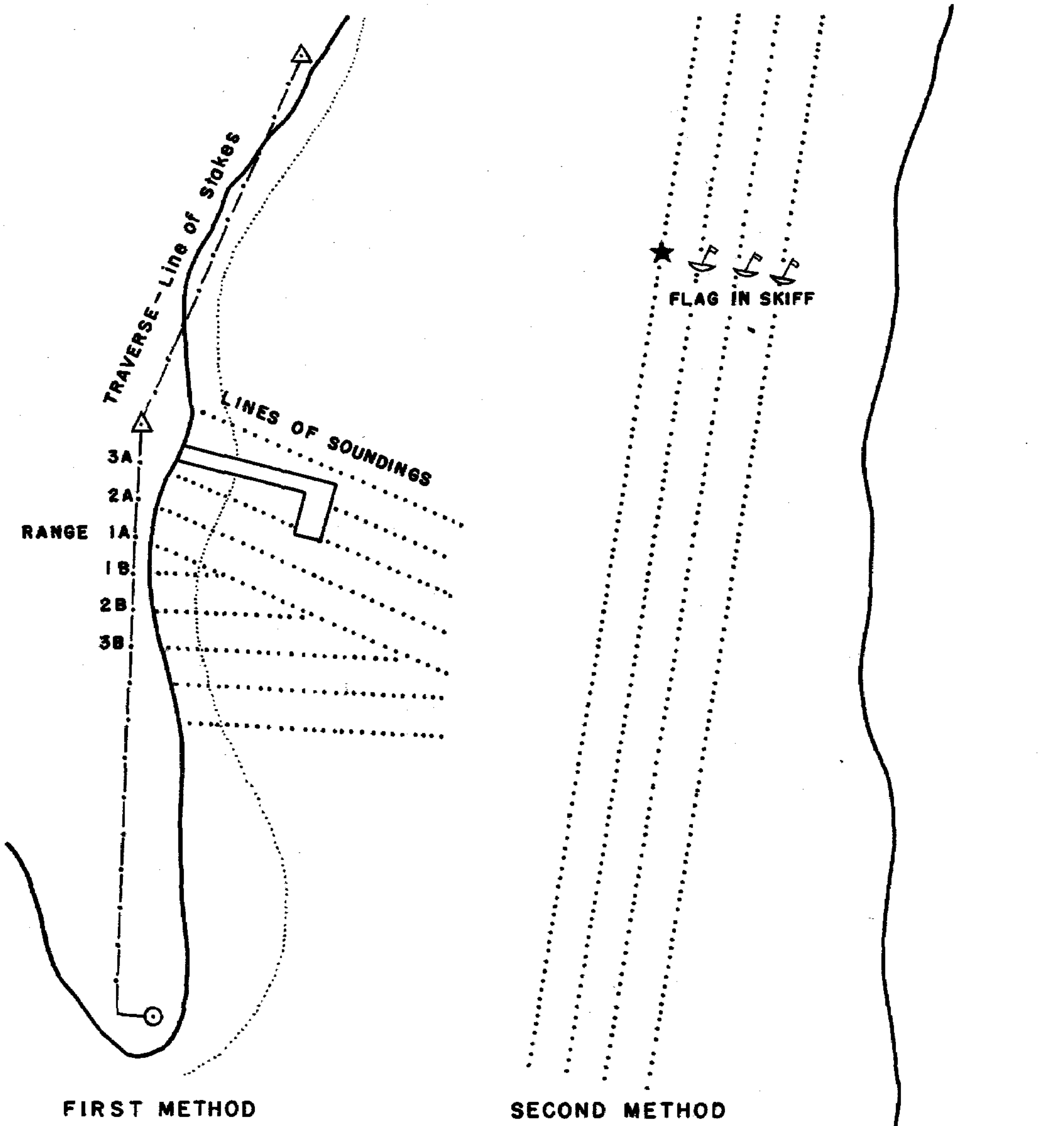
A small wooden reel with crank was made up by the carpenter, of suitable dimensions and characteristics for reeling in and out the required amount of stranded sounding wire, in this case about 100 fathoms. The reel was secured to a thwart in the skiff so that it would not hinder the oarsmen. In the stern sheets of the skiff a calibrated swivel-type sounding sheave with short legs, mounted on a board at a height of about two feet, was secured to the seat with the fairlead of the sheave leading fair to the wire reel.

This affair was used only for measuring horizontal distances and not for sounding. The wire was led from the reel twice around the sheave and an eye was placed in the outboard end. In measuring distances along the traverse for the locations of the stakes, this arrangement was used in lieu of a tape. The skiff, containing two men, was beached solidly enough so that it would not move, and the end of the wire was taken to a hub and the dial set at zero; then stakes were set by readings on the sheave at such distances as were required. This method was found to be very accurate when a calibrated sheave was used and I should judge could be used for distances up to one-fourth mile on a survey of this scale. It is also somewhat faster than the use of a tape. When used in lieu of a tape, a reasonably constant tension should be maintained on the wire when reeling out or in.

As previously stated, when sounding by hand lead, the skiff was kept on line by means of a sextant angle. When a sounding line was started from the beach, the skiff was beached on line and the dial of the sheave set at zero with the end of the wire at the stern sheets where the leadsman stood. The officer with the sextant carried the end of the wire from the position of the boat to the stake and dropped the eye over the stake. The boat was then rowed to the first dial reading where on the "mark" the man at the reel applied the brakes, stopping the skiff's progress, and a sounding was taken. The dial reading gave the correct distance this sounding was distant from the stake or origin. In this case the boat was stopped for soundings by the brakes on the reel at 4-fathom intervals. This same method was tried coming inshore on the next line by reeling in, but few of these sheaves will record accurately when reeling in.

A method of recording was used which termed each stake a "range" and they were numbered "Range 1a", "Range 2a", etc., the latter denoting the day as in other methods of hydrography. Under each range down the record page, followed the soundings with the respective distances out from the origin as "4 fms. out", "8 fms. out", and so forth, and the time and the kind of bottom. A level rod was used for soundings in very shoal water where more detail was wanted.

This method is flexible and variations in it can be made to meet special requirements or conditions. It is readily adaptable about docks where detail is required provided the topographer has



METHOD FOR DETAILED SOUNDING
SITKA 1938

rodded in a suitable number of recoverable points. Lines can be run fan-shaped from corners of wharves with the end of the wire fixed.

Second Method

Along the middle of the channel a variation of the standard method of small boat hydrography was used on the same scale which, although not as accurate as the above method, is much faster. A catamaran (two skiffs secured together) with outboard motor and containing two leadsmen was used for sounding. To space the lines as closely as 24 feet apart, a good coxswain is necessary and ranges must be used. As a movable range, a man was placed in a skiff which had an upright flag nailed to one of the thwarts and this man was furnished a long length of leadline marked at 24-foot intervals.

There happened to be a navigational light near one end of the area to be sounded and at approximately the center of the channel. (A fixed point on one side of the channel would have served almost as well.) This man secured the zero end of his line to the light and pulled his boat away at right angles to the direction of the sounding lines and with an occasional stroke of his oars, depending upon the amount of current, held the boat with the small flag at a distance of 24 feet from the light. This flag was used as a front range by the catamaran coxswain, and a reasonably distant back range was selected which had to be changed very little when a new line was begun. At the end of one line the man in the skiff was signaled to move out another 24 feet and by this means an even spacing of 24 feet between the lines was readily obtained. The speed of the catamaran was held as constant as possible and the recording was standard.

In the very detailed survey of the lower Hudson River, accomplished by the Motor Vessel GILBERT during the early months of 1939, Lieutenant Charles M. Thomas, Chief of Party, was forced to depart from customary hydrographic practice.

Position fixes were taken every minute and echo soundings were recorded at 5-second intervals. As can be imagined, the recording of these proved quite a problem. Time was entered in the sounding records during the previous night and the record begun on the succeeding day at the particular 5-second interval that hydrography was started. Two writers were employed, one for position recording and the other for sounding. Even so, each recorder was taxed to his utmost. One recorder was ambidextrous and he would shift his pencil from one hand to the other to relieve writer's cramp. Both recorders taped their fingers to keep from wearing off the skin.

A very interesting example of the accuracy and value of the Dorsey Precision Fathometer arose during the course of the survey. While sounding in depths of about 47 feet, two soundings of 51 feet were obtained. A search with the hand lead revealed no shoal. Lieutenant Thomas developed the area by sounding with the Fathometer on a number of different courses and decided that the shoal was the remains of a wreck. He estimated the wreck to be 120 feet long and 30 feet beam, lying with its keel parallel to the axis of the river. The wreck was reported and, when subsequently removed, was found to be lying in the position as stated by Lieutenant Thomas, and the measured dimensions were 110 feet long and 35 feet beam.

PLOTTING THREE POINT FIXES WITHOUT THE USE OF A PROTRACTOR

Charles Fierce, Hydrographic and Geodetic Engineer
Executive Officer, U. S. Coast and Geodetic Survey
Ship PATHFINDER

This subject has been covered by five separate reports in the Field Engineers Bulletins.* No claim is made for anything new in the following discussion of the methods used on the PATHFINDER for hydrographic surveys off the west coast of Palawan I., P. I. The area covered by these surveys lies northwest of Ulugan Bay, Palawan, distant seven to 32 miles from the shore line, and with depths from a few fathoms to 60 fathoms.

The 1:80,000 scale survey sheet in use, prior to adoption of the circle sheets, necessitated extension arms on the protractor and the close development required on the numerous shoals was difficult to analyze on this scale. The results of the field surveys were being plotted in the Manila office by transferring all plotted positions from the 1:80,000 scale sheet to a 1:20,000 scale smooth sheet, which process entailed a great amount of labor.

In our case the lines of centers of the arcs of equal angles were entirely off the sheets and as only a brief discussion covering this phase of the subject could be found in any of the articles in the Bulletins a detailed description of our methods is given here. The maximum radius required for the extreme arc was 57,404 meters. The distance between adjacent triangulation stations for one of the angles of the fix was 45,000 meters. In the construction of one of the lines of centers on one of the boat sheets, this line was distant from the nearest edge of the sheet the length of the boat sheet.

The first procedure is to make an accurate layout on a chart outlining the various sheets. It is emphasized here that extreme care must be taken in the selection of the three shore objects for the fix. It may be necessary to steam along the perimeter of the boat sheet with the ship to select the best fix available. More than three sets of circles on a sheet cause confusion in plotting. The triangulation stations selected for the fix are plotted accurately on the chart layout and lines between the stations are drawn. The perpendicular (the line of centers for the curves) is erected to the line between adjacent stations. With a short beam compass draw four arcs on the layout sheet as follows: one arc close to the top of the sheet, one near the bottom, and two arcs approximately equidistant between the top and bottom arcs. On the accompanying sketch these are arcs for angles of 17°, 19°, 22° and 25°. With a protractor, scale off for each of these arcs the angle (to nearest degree) subtended between the adjacent triangulation stations. On each of the four arcs select three points, one close to either edge of the boat sheet and one close to the center of the sheet. These

* "Plotting Three Point Fixes Without the Use of a Protractor."
A. M. Sobieralski, Vol. 3, p. 52.
"Drawing RAR Distance Circles of Long Radii."
F. B. T. Siems, Vol. 3, p. 99.
"Plotting Arcs of Circle with Large Radius and Comparatively Small Angle at the Center."
W. H. Burger, Vol. 4, p. 63.
"Plotting Three Point Fixes Without the Use of a Protractor."
L. D. Graham, Vol. 7, p. 91.
"Plotting Circular Arcs on Offshore Hydrographic Sheets Without Use of Beam Compass."
G. C. Hattison, Vol. 9, p. 43.

points are designated A, B, and C for each arc and their geodetic positions are computed as explained later. Place a protractor on the center for each of these four selected circles and read off to nearest 1/2° the geodetic azimuth from the center to the points A, B, and C selected on the respective curves. These values are the assumed azimuths used in computing the positions of points A, B, and C on the four circles. Scale off with a protractor the maximum range of angles subtended by the adjacent triangulation stations for the boat sheet, which will be the circles necessary to be drawn. The last data which should be taken from the layout sheet are the approximate limits of the centers along the line of centers, so that when construction of the curves is started it will require simply an inspection of the layout sheet to place the boat sheet on the drafting table so that the line of centers will not fall outside the limits of the drafting table. When the above listed data have been taken from the layout sheet the computations are made as follows:

1. The distances and azimuths between the adjacent triangulation stations to be used are necessary and if not available an inverse computation must be made. On the inverse form, compute the values log a/2 and log a/4 ("a" is the distance between adjacent triangulation stations) which values are used later in computing "c", "d" and the geodetic positions of centers.

2. Compute the values of "c" and "d" for the entire range of curves to be drawn on the boat sheet. Curves should be drawn to the limits of the sheet as a fix if often desired beyond the limits of the hydrography. "c" is the radius of the curve and "d" is the distance measured along the center line from the mid-point ("D") between adjacent triangulation stations to the center of the curve. The formulas for these values, as given by Lieutenant Commander L. D. Graham in his article in Volume 7, Field Engineers Bulletin, are:

$$x \text{ (scale factor)} = \frac{10{,}000}{\text{scale used}}$$

$$c = x\ a/2 \csc \alpha$$

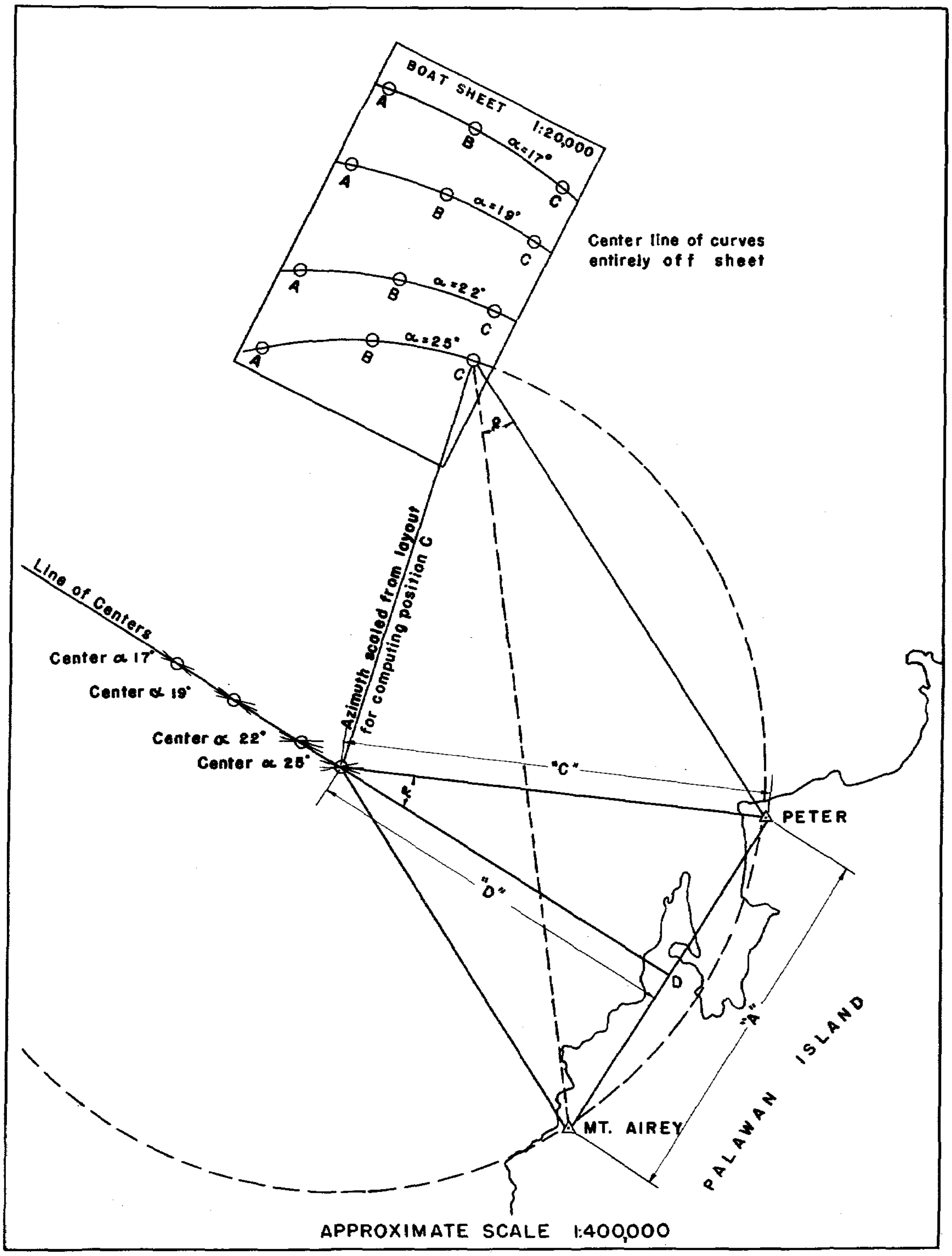
$$d = x\ a/2 \cot \alpha$$

Since sheets on a scale of 1:20,000 were used for our work, "x" becomes 1/2 and, in the example cited below, the first term is a/4. The adoption of this scale permitted us to measure all distances directly by a 1:10,000 meter scale.

Computations for "c" and "d" for Stations Mt. Airey - Peter:

Log a/4 3.870 9177 — All values on scale of 1:10,000

α	CSC.	"c" meters	α	COT.	"d" meters
25°	0.374 0517		25°	0.331 3275	
	3.870 9177			3.870 9177	
	4.244 9694 ---	17,578.0		4.202 2452 ---	15,931.1



BOAT SHEET 1:20,000
A
B
C
α=17°
α=19°
α=22°
α=25°
Center line of curves entirely off sheet
Azimuth scaled from layout for computing position C
Line of Centers
Center α 17°
Center α 19°
Center α 22°
Center α 25°
"C"
"D"
D
"A"
PETER
MT. AIREY
PALAWAN ISLAND
APPROXIMATE SCALE 1:400,000

3. Compute the geodetic positions of point "D" midway between adjacent triangulation stations. This was found necessary where such lengths exceeded 25,000 meters because the azimuths from the mid-point "D" to either triangulation station differed appreciably from the azimuth between stations.

4. Compute the geodetic positions of the four centers for the arcs selected on the layout sheet. (See accompanying sketch.)

5. Compute the geodetic positions of the points A, B, and C on all four arcs selected on the layout sheet. This is readily done using the line, center to one triangulation station, as the known side (this is the radius of the arc) and the assumed azimuth previously scaled from layout sheet.

Thus for each set of curves drawn the following computations are made:

1. An inverse computation, if necessary, between adjacent stations.

2. Values of "c" and "d" for entire range of curves.

3. Computation of position of point "D" midway between stations.

4. Four position computations for centers of four arcs selected.

5. Twelve position computations of points A, B, and C on the selected curves.

Construction of Curves

The ship carpenter built two beams for the beam compass, each of a "T" cross section, from some well-seasoned pine. These beams were each six feet long and so constructed that the web of the "T" fitted snugly into a groove cut in the top of the "T". A brass strip screwed over the top of the "T" provided for splicing the two beam compasses together, giving an effective length of 12 feet for swinging arcs. It is recommended that a single beam, eight feet long, be made to eliminate the whip in the center which was found troublesome with two six-foot beams spliced together. On our longest arcs with the spliced beam it was necessary to support the beam at its center to eliminate sag.

A large drafting table is necessary for drawing the circles. The drafting table used for constructing these curves in the Manila Office was satisfactory and was approximately five feet wide by 14 feet long.

The boat sheet is placed on the drafting table in such a position that the line of centers will not fall beyond the limits of the table. This is easily planned from an inspection of the chart layout and determining the direction of the center line and its approximate distance from one of the edges of the boat sheet. The boat sheet is then thumbtacked in position. Plain boat sheet paper is then laid down on the drafting table in the approximate position as determined above for the center line. The width of the boat sheet paper allows a sufficient factor of safety for the approximation made above for its probable position. The center line paper is then tacked in position.

A narrow strip of boat sheet paper is cut of a length slightly-greater than the length of the longest arc to be swung. This is secured to the table for use in measuring the distances. Distances of 10,000, 20,000 and 30,000 meters are laid off on a straight line laid down on this measuring strip of paper. Over the initial zero point a small piece of celluloid is tacked down to prevent excessive wear from the repeated measurements necessary from the same point.

In laying off all distance arcs on the beam compass we found it a great aid to lay off an increment from the 10,000, 20,000 or 30,000 meter point previously fixed on the measuring strip. One man laid off these increments and two additional men were required to set the various distances on the beam compass. The radii were then struck off from the respective A, B, and C points computed on the four curves, the intersections defining the respective centers for the curves. A straight line drawn between these intersections defined the line of centers. As an additional check on the accuracy of the construction work the distances between the four centers graphically determined above were checked against the computed distances. Any discrepancy found was adjusted in relation to all four points established by the construction work.

The centers for all curves required on the sheet were then laid down along the center line or its extension, using for an initial the closest of the respective centers laid down in the construction. It is an advantage to lay off an initial point of some even thousand meters, close to one of the centers laid down by construction, to facilitate subtracting between adjacent distances between centers. These are the "d" values found in the computations (see sample computation).

The last step of drawing the curves from these center points offers no difficulties and 12 distinct checks are secured when the curves are drawn through the 12 computed geodetic positions.

For the four sheets for which this method has been used to date, the mechanical construction of the curves proceeded very smoothly and the errors did not exceed the width of the curves drawn. It required about one day to complete the drawing of two sets of curves, approximately 40 curves to each set. Where part of the line of centers falls on the boat sheet the computations are much simpler and the method described by Lieutenant Commander Graham in his article in the Field Engineers Bulletin, Volume No. 7, was used effectively.

Emphasis cannot be placed too strongly on the importance of selection of the fix. Objects with the greatest probability of visibility under all conditions will eliminate the necessity of more than two sets of curves, one fix. On the west coast of Palawan the highest peaks are not suitable due to prevailing clouds covering them most of the year. Lower peaks must be selected with care so that they will not be invisible against a background from some areas of the survey. The previous articles on this subject have covered the advantages of this method and our experience with it confirms their statements.

IT HAPPENED IN A FIELD STATION

Marie H. Smithson, Scientific Aid
U. S. Coast and Geodetic Survey

The life of an employee in the San Francisco Field Station is anything but monotonous. Even though computing 14 tides and 16 suns a month may lose its charm after the first few years, there are always questions from the public which either force one to do a little research work, and thus add to his fund of knowledge, or else bring forth a chuckle. Many people seem to think the Coast and Geodetic Survey knows everything, for the questions range from "How long will it take a body to sink?" to "Do you think there is life on Mars?". And the handsome officers, young and old, who pass through the station on their way to and from Manila or nearer points, add interest and good fellowship. During the last five years one of the clerks has kept a log of officers passing through. Of the 170 on the roster, about 60 have been through San Francisco. They are catalogued according to complexion, dress, democratic or aristocratic manner (these latter mostly lieutenants, junior grade), and in other ways. So far there have been 30 brunettes, 19 common blonds, two Titian blonds and nine in various stages of baldness.

When time begins to hang heavy and we have a taste of ennui, the phone is sure to ring and someone will ask a question that will cause us to show signs of life and make us realize that, after all, this is an interesting bureau. Of course, most of the questions are intelligent and concern navigation or surveying. But--. We answer them all cheerfully and as conscientiously as possible, and always with due regard for the seriousness of the questioner, even though we have a good laugh sometimes when it's over.

There was the time when Minnie, the whale, was purported to be at large in the bay. She led the Coast Guard a merry chase, and when she got to the southern part of the bay, one woman called us to ascertain the depth of water there. She was worried, fearing it was not deep enough for Minnie to swim around comfortably.

At times we have a run on astrologers. Not knowing what their interests are, we go to a great deal of trouble to compute meridian passages for certain points, and we show them much deference because they know the meanings of such astronomical terms as "perigee" and "declination". After computing about six such points though, it dawns on us that all these places are dog race tracks! The astrologer probably never knows why we suddenly become cool and disinterested.

Then there was the woman who phoned to ascertain the Pacific time when it was noon in Sydney, Australia. After checking it carefully and having the Inspector approve the time, we called her to give her the information. She was very grateful and added rather shyly, "You know, I have a daughter over there, and I became a grandmother yesterday." We didn't have the heart to tell the Inspector the wonderful news for he had been interrupted while engaged on some important computations, and we thought the shock might be too great for him.

One day the Post Office Department asked us to help deliver a letter which was addressed merely to Bill and Grace at a certain latitude and longitude, given in minutes and seconds. We located the street, and the postman on that route was contacted. He said, "Oh, sure, I know Bill and Grace; they live just around the corner." The letter was delivered.

We often have phone calls asking for exact distances or elevations, and when we inquire why the information is desired, it is often, "Oh, just to settle a little argument." The laughing and clinking of glasses at the other end of the line make us realize how thirsty these poor souls are for knowledge, and we go to no end of trouble to help them.

Although all information given the 70 newspapers and airports each month is checked and rechecked, one or two errors have occurred. One caused a great deal of amusement because the editor of that particular newspaper happened to have a sense of humor. We received a letter saying that, while he knew the Coast Survey couldn't be wrong, his subscribers had been complaining that the sunrise figures were all "wet". Bathers going to the beach for the sunrise found old Sol an hour high when, according to our figures, he should have been on the horizon. On referring to our files, we discovered that the minutes of sunrise had been checked so carefully that the hour had been missed and had been typed and checked as six instead of five. We immediately wired the editor, and life at Long Beach became normal again.

Then there was Zorima, Queen of the Nudists at Treasure Island, who called at the office one afternoon to see if the Inspector would help her decide when was the best time to swim the bay. It must have been difficult to figure the currents, for Zorima stayed quite a while.

Ho, hum, life at the San Francisco Field Station is perplexing in some ways, but it has its compensations.

HONORS TO DR. BOWIE

The many friends and colleagues of Dr. William Bowie, Hydrographic and Geodetic Engineer (retired), will be pleased to know that, during 1939, several honors were added to his already imposing list. Dr. Bowie was the first recipient of the Bowie Medal, newly established in his honor by the American Geophysical Union, and he was decorated with the Cross of Grand Officer of the Order of St. Sava by the Government of Yugoslavia in recognition of his outstanding achievements in international science and geodesy.

By happy coincidence, the Division of Geodesy of the Coast and Geodetic Survey contributed to Dr. Bowie's honors in assigning the name "Bowie" to Gravity Station No. 1000. It was mere chance that this number coincided with the name, since numbers are assigned in the Washington Office in the order of establishment of the stations and the names are given in the field, a station usually being named for the nearest town. The Chief of Party stated that had a mountain blizzard not caused a sudden change in the planned schedule, "Bowie" would actually have occurred some 10 or 20 stations later. As it was, the gravity party after slipping out over a high pass, headed for the station having the lowest altitude of those on the schedule, which happened to be near the town of Bowie, southern Arizona.

MOTOR VESSEL E. LESTER JONES

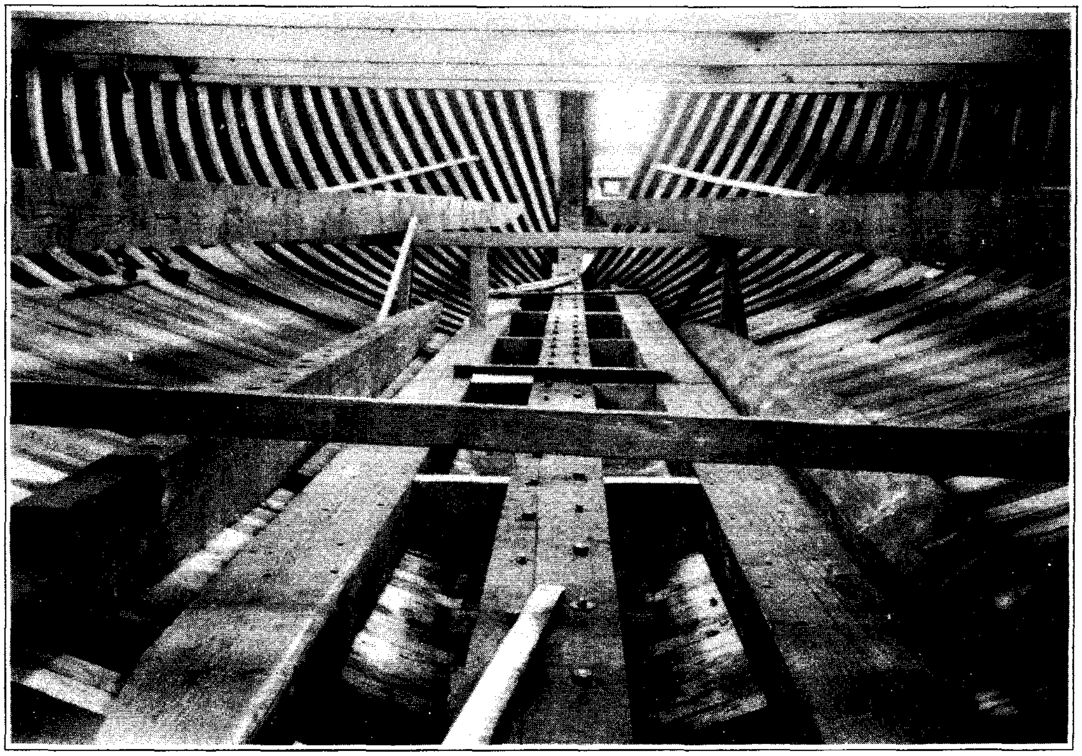
L. C. Wilder, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

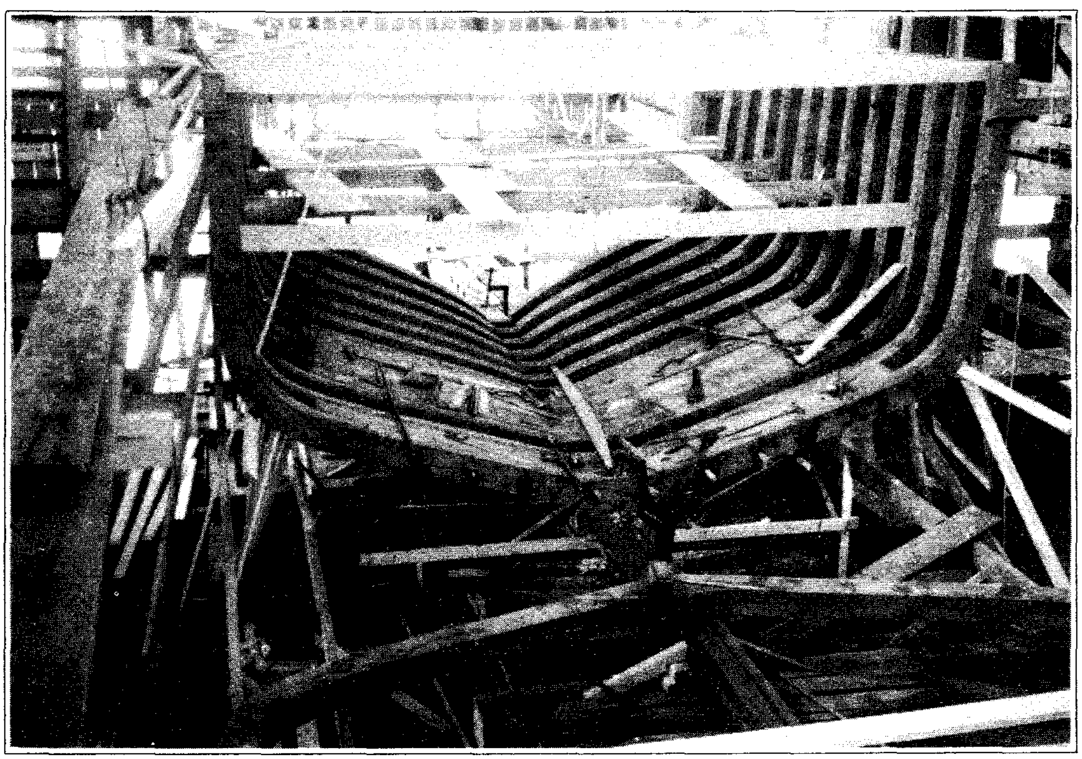
The Motor Vessel E. LESTER JOKES, now building, is to be an 88-foot, twin screw, diesel, wooden tender with a beam of 21 feet, a minimum freeboard of five feet, a displacement of 150 long tons and a probable speed of nine or ten knots with accommodations for three officers and twelve men. Bids were opened on August 20, 1938, and the award was made to the Astoria Marine Construction Company for the sum of $99,500 (Cooper-Bessemer engines of 150 HP each). The contract called for a redesign of the vessel along the lines of the design submitted for the purpose of bids and also for the submission of complete rewritten specifications by the builder. To December 1, additional items have been awarded the builder to the approximate amount of #27,600, which includes $4,800 for Wolmanizing all fir lumber and $2,135 for a larger electric windlass and anchoring gear.

Other features of her construction and equipment are: construction to the highest class with the American Bureau of Shipping and to the requirements of the Bureau of Marine Inspection and Navigation for ocean vessels, twin 150-HP Cooper-Bessemer diesel engines and twin auxiliaries, very sturdy construction, Monel fastenings from keel to maindeck and Everdur fastenings on deck, four sub-dividing water-tight steel bulkheads, Markey Electric windlass with 7/8" cast steel chain on the starboard wildcat and one-inch wire on the port side, Photo Electric Automatic Steerer, radio compass, Dorsey III Fathometer, Rotary Clear View Screen, CO_2 fire extinguishing system in the engine-room, Carrier refrigeration in the storage and day box, 110-volt lighting and auxiliary power circuits and 32-volt emergency circuit, two 16-foot dinghies and two 16-foot powered dory-skiffs.

Actual construction following the redesign started in February, 1939, with the fabrication of the stem and sternpost and all members adjacent thereto, which were shaped and temporarily fastened together for fairing, preparatory to the Wolmanizing process, in order to avoid the removal of wood by dubbing and fairing after Wolmanizing. For other parts of the hull, careful shaping from molds from the loft floor, where the vessel's lines were laid down to full size, served the purpose and it was not necessary to assemble for fairing prior to Wolmanizing. This Wolmanizing process was applied to all fir lumber at Wauna, Ore., 30 miles from the building site. The process consists of subjecting the lumber, placed in a retort, to live steam, first under pressure, and then under a vacuum, to pre-season the material. The salts consisting of sodium-fluoride, dinitro-phenol, chromates and arsenates in solution, are then applied to the wood under pressure to maximum absorption after which the retort is opened and the lumber allowed to drain. After the treatment the lumber is kiln dried to about 20 per cent moisture content. The process discolors the wood to a brown shade but has no effect on subsequent painting. To all places where the wood is dubbed or bored for fastenings during building, the salts are applied in liquid form.

Particularly sturdy and lasting features of structural members are the outstanding points of this building. The keel is 9-1/2" x 11-1/2"; the keelsons (five in number), 9-1/2" x 11-1/2"; the sawed frames are double flitch of 3-3/4" each spaced on 18" centers; bilge clamps (seven in number) are 5-1/2" x 7-1/2"; planking, 2-1/2" and

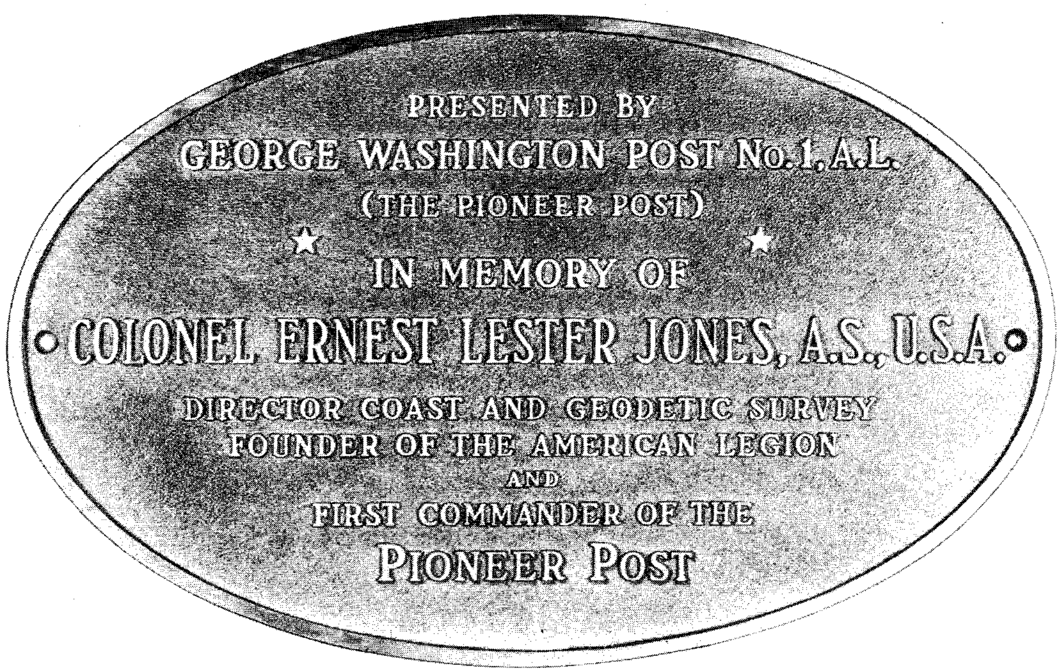


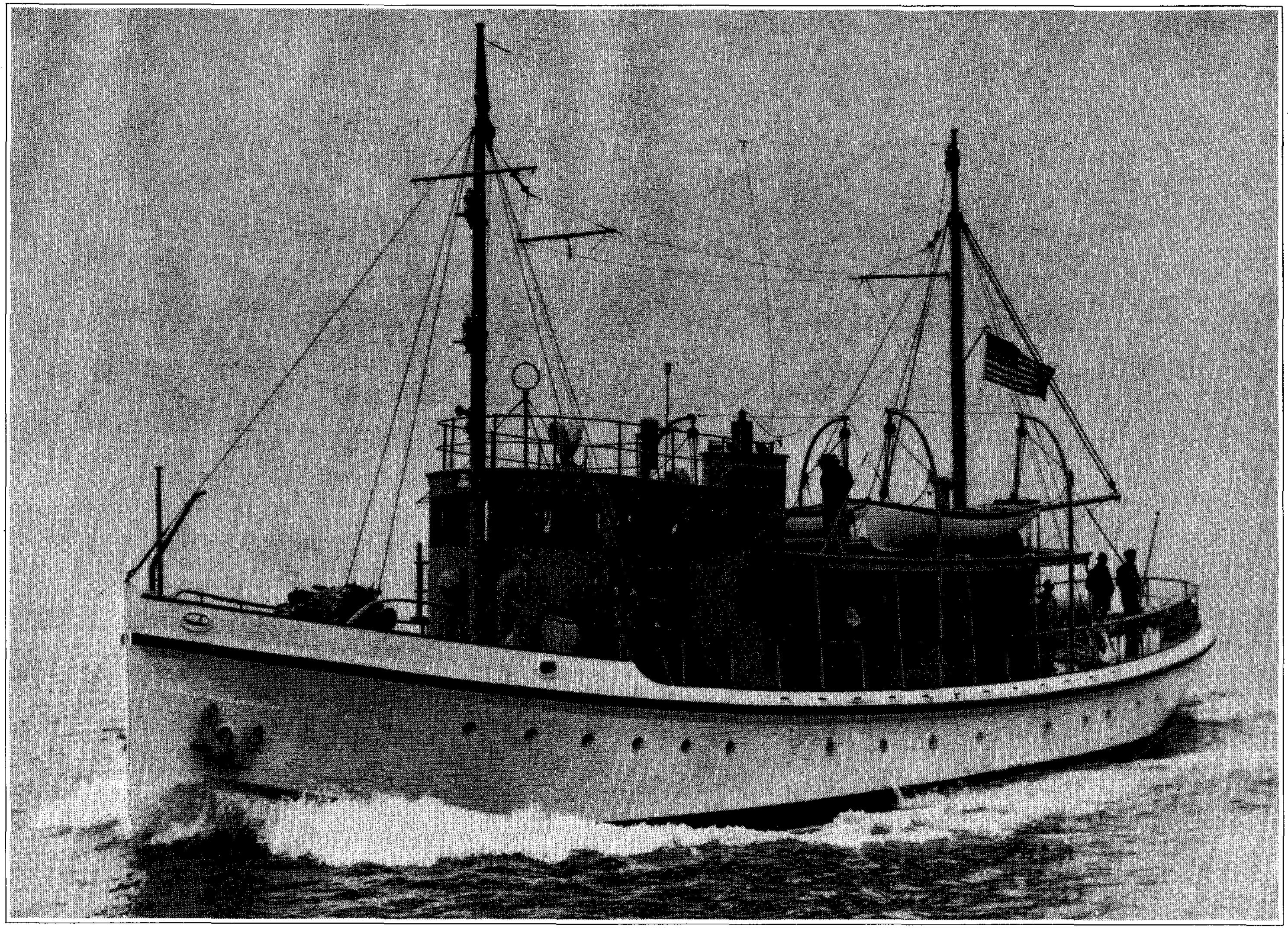


other members are correspondingly heavy. All the ceiling is edge fastened. With the Wolmanized lumber, Monel and Everdur fastenings for the most part and no black iron, the useful service life of this vessel should be considerably lengthened. Wolmanizing should more than double the life of the wood in her hull.

January 29, 1940, is the date set for the launching and since the vessel is being completely equipped on land it will be ready for delivery almost immediately after launching. Miss Mary Lawrence McArthur, great-granddaughter of Lieutenant Commander William Pope McArthur, who was in command of the Schooner EWING in 1849, during the execution of the Bureau's first hydrographic work on the Pacific Coast, has been named as sponsor for the new vessel. Miss McArthur is a daughter of Mr. Lewis A. McArthur, Secretary of the Oregon Geographic Board, who has collaborated with the Bureau in the advancement of geodetic surveys in the State of Oregon.

As mentioned in Field Engineers Bulletin No. 12, 1938, the vessel is named for Col. E. Lester Jones, who was Director of the Coast and Geodetic Survey from April 15, 1915, until the time of his death on April 9, 1929, and who was responsible in a large measure for the initiation of a long range plan of extensive survey operations which are still in progress in Alaska waters where the new ship will be placed in service. Col. Jones was furloughed from the Bureau for military duty in France during the World War. The American Legion has expressed its appreciation of his services in the presentation of a plaque, illustrated below, which will be mounted on the new vessel.





The Motor Vessel *E. LESTER JONES*
February 16, 1940

GEOGRAPHIC NAMES OF INTEREST

In Field Engineers Bulletin No. 10 for December, 1936, there were listed certain geographic names which perpetuate the names of men who served in the Coast and Geodetic Survey, together with descriptions of the circumstances relative to their adoption. On this page and the several pages following are listed additional names of the same nature. Neither the prominence of the geographic feature named nor the importance of the individual after whom named were considered in the selections presented in these lists. Field Engineers Bulletin No. 11, for December, 1937, contained a list of geographic names which perpetuate the names of ships of the Bureau.

Editor.

BAKER ISLAND

Alaska

A large island, about 12 miles long and averaging 4-1/2 miles in width, located on the west side of the south end of Bucareli Bay, southeastern Alaska. Professor Davidson identified this island as the landfall of Chirikof in 1741.

Named in 1879 after Marcus Baker (1849-1903) who accompanied Dr. Dall on three of his trips to Alaska — 1873, 1874, and 1880 -- and who also assisted in the compilation of the Alaska Coast Pilot of 1883.

In 1886 Marcus Baker joined the U. S. Geological Survey, and later compiled and published in 1902 the "Geographic Dictionary of Alaska". He was one of the founders of the National Geographic Society, and a short time before his death was assistant secretary of the Carnegie Institution of Washington. He was also a member of the U. S. Geographic Board from its foundation until 1903.

MOUNT MARCUS BAKER*, a peak towering 13,250 feet in the Chugach Mountains, ten miles north of the head of College Fiord, Prince William Sound, is also named for him, as well as BAKER POINT, south shore of Kasaan Bay, Prince of Wales Island, and presumably BAKER GLACIER*, on the north side of Harriman Fiord, on an arm of Port Wells in the region of Prince William Sound.

His work in Alaska provides an interesting instance of how names were applied in early days. ELDRED ROCK at the north end of Lynn Canal, marked by a lighthouse, and ELDRED PASSAGE, south shore of Kachemak Bay, Cook Inlet, were both named by Dr. Dall or by Baker himself after the latter's wife, Sarah Eldred; and SADIE COVE, on the south shore of Kachemak Bay was also named after her by Dr. Dall in 1880.

DALL ISLAND

Alaska

One of the larger islands of southeastern Alaska, nearly 50

* Decision of the U. S. Geographic Board.

miles long, on the north side of Dixon Entrance off the southwest coast of Prince of Wales Island. Early charts called the southern part "Dall" and the northern part "Quadra", there being only a narrow connection between the two parts.

Named in 1879 after William. Healey Dall (1844-1927).

Dr. Dall was first appointed to the Coast Survey in 1871 as acting Assistant, and during that year and in 1872 was in charge of a party on the schooner HUMBOLDT, doing reconnaissance in Alaskan waters, including the Aleutian and Shumagin Islands; in 1873-74 he used the schooner YUKON. A final trip was made in 1880 when he went from Sitka to Unalaska and almost as far as Pt. Barrow. In 1874-80 and 1881-84 he was in the Washington office, his work being largely the compilation of the Alaska Coast Pilot of 1883. He resigned in 1884 and thereafter was with the U. S. Geological Survey until his retirement in 1923.

Dr. Dall's earliest trips to Alaska (1865-68) were in the em ploy of the Western Union Telegraph Company. His book "Alaska and Its Resources" was published in 1870. Dr. Dall was one of the outstanding figures in the early American history of Alaska.

Many features in Alaska were named for him, including DALL BAY, south shore of Gravina Island; DALL POINT*, near Cape Romanzof, in 1869; DALL ISLAND, Koyukuk River; DALL LAKE, between the Yukon and Kuskokwim Rivers; DALL RIDGE, Gravina Island; and MOUNT DALL (9,000 feet), 45 miles southwest of Mt. McKinley. ANNETTE ISLAND, the largest of the Gravina group, and ANNETTE BAY, on its north side, were named by him after his wife, Annette Whitney Dall.

MOUNT DAVIDSON*

California

The highest peak (938 feet) in the San Miguel Hills, San Francisco, California.

Named in 1911 in honor of Professor George Davidson (1825-1911), for 50 years an outstanding figure in the work of the Coast Survey, particularly on the Pacific Coast and in Alaska.

Born in Nottingham, England, George Davidson as a child of seven came to the United States with his family, who settled in Philadelphia. Later as a student in Central High School he came into contact with Alexander Dallas Bache, who had become president of Girard College in 1836. As soon as he completed his high school course he joined a field party of the Survey, of which Professor Bache had in the meantime been named Superintendent. He first went to the Pacific Coast in 1850 to join the hydrographic party under Lieut. W. P. McArthur, being one of the four young men who pledged themselves, for one year, to do any duty, however difficult, incident to the work of the Survey. He remained there until 1857, when he returned to Washington for a period of ten years, during which time he prepared his "Directory of the Pacific Coast".

In 1867, after completing a survey of the "Isthmus of Darien", he made his first trip to Alaska on the U. S. Revenue Cutter LINCOLN. His report to Secretary of State Seward is said to have influenced greatly the consummation of the purchase of Alaska from Russia. From

* Decision of the U. S. Geographic Board.

1868 until his retirement in 1895 he was engaged in surveying on the Pacific Coast. The first Alaska Coast Pilot of 1869 was prepared by him. One of his greatest achievements was the measurement of base lines upon which the extensive triangulation of the State of California depends (1880 and 1888-89). He devoted considerable attention to irrigation problems in California, making a trip around the world in 1874 for a special study of irrigation methods in India, Egypt, Italy, Holland and other countries.

Professor Davidson's inventive genius suggested many improvements in the instruments employed in the work of the Survey, the annual report for 1867 containing a description of the Davidson meridian instrument for determining time, longitude and latitude. He was the author of 260 publications, books, pamphlets and papers. He is credited with having been the decisive factor in determining the establishment of the Lick Observatory.

Among the many features named for George Davidson are DAVIDSON GLACIER, Lynn Canal, by the Superintendent of the Survey in 1867; MOUNT DAVIDSON on Nagai Island, Alaska, by Dall in 1872; DAVIDSON INLET, south of Kosciusko Island, Alaska, by Dall, 1879; DAVIDSON BANK, south of Unimak Island, by the U. S. Fish Commission, 1888; DAVIDSON RANGE, on the Arctic Coast west of the boundary, by John Turner, Assistant, Coast and Geodetic Survey, 1890; and DAVIDSON'S POINT, located on Royal Geographic Society Island, Victoria Strait, Queen Maud's Sea, by Captain Roald Amundsen. In 1854 Davidson discovered a submerged rock in Rosario Strait, off the southeast extremity of Lopez Island, which he named Entrance Rock, but the British Admiralty Chart 2689, 1858-9, called it DAVIDSON'S ROCK, thus recognizing its discoverer.

It is of interest to note that a younger brother, Thomas Davidson, Jr., became a naval constructor in the U. S. Navy and designed the TUSCARORA, used by Admiral Belknap in his Pacific deep-sea soundings in 1873.

FARIS PEAK

Alaska

A peak in the southwest part of Unimak Island, three miles south of Pogromni Volcano, Aleutian Islands, Alaska.

Named in 1902 by Superintendent O. H. Tittmann for Assistant Robert Lee Faris (1868-1932), who was in the party of Ferdinand Westdahl on the McARTHUR, and who determined the peak's position in 1901. The annual report for 1902, page 147, contains the following tribute by Assistant Westdahl:

> "I desire especially to commend Assistant R. L. Faris, for to him is largely due the success the party attained in carrying out the instructions of the Superintendent. His knowledge of all branches of the work, his untiring zeal and good judgment, and his hearty cooperation with me in taking advantage of every hour of suitable weather to push the work are worthy of all praise."

In a sketch opposite page 147 of the 1902 annual report this peak was called "No Name".

Captain Faris entered the Coast and Geodetic Survey in 1891 and for 41 years served in many capacities until his retirement January 31, 1932. From 1906 to 1914 he was Chief of the Division of Terrestrial Magnetism and 1915-32 was Assistant Director. His intimate knowledge of the Mississippi Valley led to his appointment as a member of the Mississippi River Commission in 1919, which post he held until his death October 5, 1932,

MOUNT FREMONT MORSE*

Alaska

A peak 6,732 feet high, on the international boundary, marking an angle approximately 30 nautical miles northwest by north of Juneau, southeastern Alaska.

Named in 1927 after Lieutenant Commander Fremont Morse (1857-1936), a Hydrographic and Geodetic Engineer of the Coast and Geodetic Survey.

Fremont Morse first entered the Survey in 1879, and practically all of his service was on the Pacific Coast, an outstanding accomplishment being his triangulation and topographic work in connection with the Alaska-British Columbia Boundary Survey. He was retired in 1924 and died April 5, 1936.

Various other features in Alaska have been named for him, including MORSE COVE, in Ray Anchorage, east shore of Duke Island, and MORSE ROCK in Port Chester, Annette Island, southeastern Alaska.

MOUNT HILGARD

Alaska

The highest peak, 1390 feet, on the promontory dividing East Bight, on the eastern shore of Nagai Island, Shumagin Islands, into two arms.

Named in 1872 after Julius Erasmus Hilgard (1825-1891), Assistant and later Superintendent of the Coast and Geodetic Survey (1881-85). The name was assigned by Dr. Dall in his lengthy and detailed report on the Shumagin Islands, published in the annual report of the Survey for 1872.

Mr. Hilgard was born in Bavaria and came to the United States in 1836, when his family settled in Belleville, Illinois, the birthplace of another Superintendent of the Survey, Dr. O. H. Tittmann. He was influenced to enter the Survey by Dr. A. D. Bache, and served forty years. After being Assistant in charge of the Washington office for many years, he became Superintendent in 1881, resigning in 1885. His death occurred in Washington, D. C, May 8, 1891.

LAWSON REEF

Washington

A rocky reef, submerged 17 feet at mean lower low water, in the

* Decision of the U. S. Geographic Board.

southern part of Rosario Strait, approximately seven miles northwest of Smith Island.

Named after James S. Lawson (1828-1893), Assistant, Coast and Geodetic Survey, who discovered it in 1870, while engaged in triangulation work. On November 6-7, 1871, he made a detailed survey of this reef in the launch LIVELY.

James S. Lawson entered the Survey January 1, 1848, and in May, 1850, was assigned to duty on the Pacific Coast. He was one of the four young officers (Davidson was another) who pledged themselves, for one year, to any duty, however difficult, incident to the survey of that coast. Thenceforth, for about 40 years, he was in active field service, always on the West Coast and particularly in the State of Washington, then a territory.

MOUNT LESTER JONES

Canada

A mountain, 8,000 feet high, five miles southeast of the Taku River on the Canadian side of the international boundary, in British Columbia.

Named by the Geographic Board of Canada in its 19th Report (1924-1927) "after Col. E. Lester Jones, United States Commissioner, International Boundary Commission".

Colonel Ernest Lester Jones (1876-1929) became Superintendent of the Coast and Geodetic Survey in 1915, the title being changed to Director in 1919 during his incumbency. He had previously been Deputy Commissioner of Fisheries and was deeply interested in Alaska and its development. He remained at the head of the Survey until his death, except for a furlough in 1918-19 during which he served with the Army in France (Signal Corps and Military Aeronautics). He was a Commissioner of the International Boundaries between Alaska-Canada and Canada-United States.

MENDENHALL GLACIER

Alaska

A large glacier on the mainland, east of the south end of Lynn Canal and about ten miles northwest of Juneau, southeastern Alaska.

Named in 1892 after Thomas Corwin Mendenhall, (1841-1924) Superintendent of the Coast and Geodetic Survey 1889-1894.

Professor Mendenhall had a long scholastic career both prior to and after his incumbency as Superintendent. He was professor of physics at Ohio University and the Imperial University in Tokyo, Japan, president of Rose Polytechnic Institute and Worcester Polytechnic Institute, and for a short time (1884-86) was connected with the U. S. Signal Service in Washington, D. C.

Numerous other features in Alaska have been named for him, including MENDENHALL PENINSULA*, on the east side of Auke Bay, south of Mendenhall Glacier; MENDENHALL RIVER, draining Mendenhall Glacier; MENDENHALL RIVER, tributary to Takhini River; and CAPE MENDENHALL*,

* Decision of the U. S. Geographic Board.

the southernmost extremity of Nunivak Island.

OGDEN PASSAGE*

Alaska

A passage along the southeast shore of Herbert Graves Island separating it from Chichagof Island, and connecting Khaz Bay with Surveyor Passage, about 45 miles north-northwest of Sitka, southeastern Alaska.

Named in 1906 after Herbert Gouverneur Ogden (1846-1906), Assistant, Coast and Geodetic Survey.

This passage was first surveyed in 1906 by E. F. Dickens, in command of the GEDNEY, and it was he who named the passage for Assistant Ogden, who had died that year.

Mr. Ogden was appointed to the Coast Survey in 1863. In 1870 he was a member of the naval exploring expedition to the "Isthmus of Darien". In 1880 he was placed in charge of the Engraving Division and in 1898 became Inspector of Hydrography and Topography. He was one of the original members of the U. S, Geographic Board, and remained a member until his sudden death, February 25, 1906. He collaborated with Marcus Baker in the preparation of the well-known "Geographic Dictionary of Alaska".

MOUNT OGDEN*, situated at a point where the international boundary makes a right angle turn south of the Taku River, is also named after him.

PATTERSON GLACIER

Alaska

A glacier on the mainland, just east of Frederick Sound, draining into the southeast arm of Thomas Bay, southeastern Alaska.

First named in 1882 after Carlile P. Patterson (1816-1881), Superintendent of the Coast Survey from 1874 to 1881. The names Patterson Glacier and Carlile Bay, (a bay supposed to exist in front of the glacier,) were suggested in honor of the late Superintendent by Captain E. P. Lull, U. S. N., while serving as Hydrographic Inspector of the Survey. Subsequent surveys in 1887 proved that there was no such bay and the name Carlile Bay passed out of existence.

This glacier appears to have been the only feature specifically named for Superintendent Patterson, altho indirectly the Ship PATTERSON, named after him, transmitted his name to many features in Alaska.

Carlile P. Patterson was born at Shieldsborough, Miss., in 1816, and immediately upon entering the U. S. Navy was ordered to duty in the Coast Survey under Superintendent Hassler. During the 1850's he spent some years in commercial shipping and became Hydrographic Inspector of the Survey in 1861, serving thereafter in various capacities until his appointment as Superintendent in 1874. It was during his incumbency that the name of the Survey was changed (1878). He died in office, August 5, 1881.

* Decision of the U. S. Geographic Board.

PATTON BAY*

Alaska

A large bay about 4-1/2 miles wide indenting the southeast coast of Montague Island, between Box Point and Wooded Islands, south of Prince William Sound, Alaska. This bay, which has not yet been surveyed, is entered by a comparatively large river.

Named in 1938 in honor of Rear Admiral Raymond Stanton Patton (1882-1937), Director of the Coast and Geodetic Survey from 1929 until his death November 25, 1937.

Rear Admiral Patton entered the Survey in 1904 immediately after graduating from Western Reserve University. His field service included work oh both coasts of the United States, in Alaska and the Philippine Islands. From 1912 to 1915 he was in command of the EXPLORER in charge of surveys in western Alaska, principally near the Kuskokwim River, Cook Inlet and Prince William Sound; and it was during his final season in Alaska that he made surveys near Montague Island. In 1915-17 he was in charge of the Coast Pilot Section. From 1917 to 1919 he served in the World War, and from his return in 1919 to regular service until being appointed Director in 1929 he was Chief of the Division of Charts. For eight years (1926-34) he was a member of the U. S. Geographic Board.

CAPE PEIRCE*

Alaska

A cape on the north shore of Bristol Bay, Alaska, 14 miles east of Cape Newenham. It may be identical with Calm Point or Cape, so named by Cook on July 13, 1778.

Named in 1869 after Professor Benjamin Peirce (1809-1880), Superintendent of the Coast Survey from 1867 to 1874.

Benjamin Peirce was the foremost mathematician in the United States for many years prior to his death. He was director of longitude determinations of the Survey from 1852 to 1867, and during that period and while Superintendent he was professor of mathematics at Harvard University. He was unusually successful in securing larger appropriations from Congress for the expansion of the work of the Survey, and it was during his incumbency that the geodetic survey from coast to coast was really started, leading to the change in name a few years later (1878).

MOUNT PEIRCE, about 1775 feet high, in the northern part of Nagai Island, Shumagin Islands, Alaska, was named in 1872 by Dr. Dall after Professor Peirce, then Superintendent.

TITTMANN GLACIER*

Alaska

A glacier west of Mount Anderson about 60 miles north of Mount St. Elias, joining Anderson Glacier about four miles west of the international boundary between Alaska and Canada.

Named in 1917 after Otto Hilgard Tittmann (1850-1938), Super-

* Decision of the U. S. Geographic Board.

intendent of the Coast and Geodetic Survey from 1901 to 1915.

Dr. Tittmann entered the Coast Survey as an Aid in 1867, and served continuously in various capacities until 1895 when he was put in charge of the Washington office, first with rank of Assistant and later as Assistant Superintendent, He was assistant astronomer with the expedition to Japan in 1874 to observe the transit of Venus. In 1890 while in charge of weights and measures he made a trip to Europe to study the organization of the offices of weights and measures in London, Paris and Berlin, From 1903 to 1915 he was active in the work of the Alaska-Canada and Canada-United States Boundary Commissions.

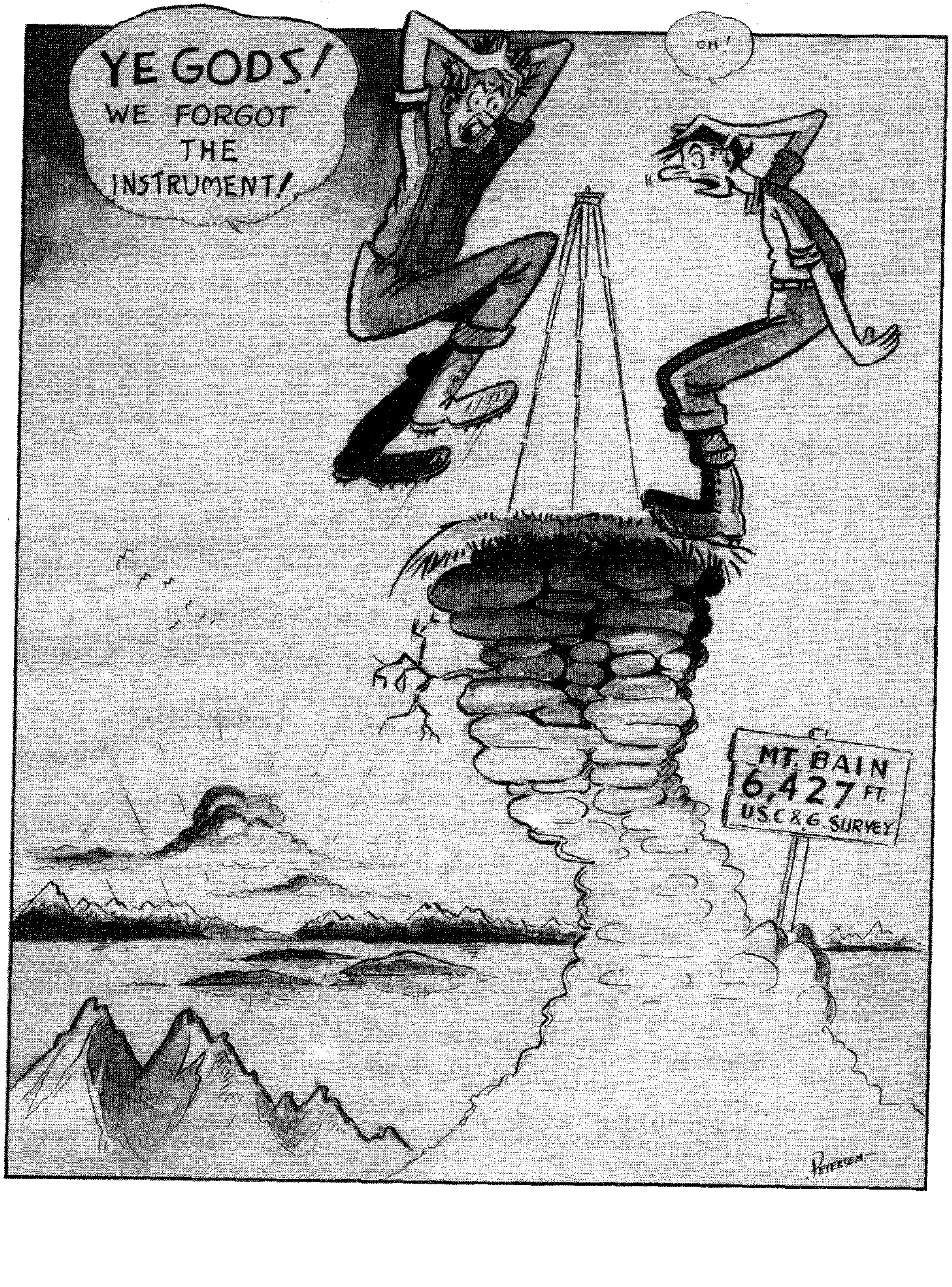
Dr. Tittmann's long service in the Survey would appear to have been influenced at the outset by his family connection with an earlier Superintendent, Julius Erasmus Hilgard (1825-1891), Superintendent from 1881 to 1885, who had been influenced to enter the Survey by Professor A. D. Bache, Superintendent from 1843 to 1867.

TITTMANN MOUNTAIN*, at the head of Tittmann Glacier, about five miles west of the junction of Tittmann and Anderson glaciers, is also named for Dr. Tittmann.

The year 1939 marked several anniversaries worth noting. The United States Lighthouse Service, now incorporated in the Coast Guard, celebrated its 150th anniversary on August 7. Our colleagues in the Netherlands-East-Indies completed 75 years of the Topographic Service on February 25, and are to be complimented on the excellence of the anniversary number of their publication which was titled "75 Jaren Topografie in Nederlandsch-Indië".

Appropriate exercises at Georgetown University marked the 100th anniversary of the use of the word "cartography" by the Portuguese. In this connection, Mr. Charles H. Deetz, Cartographic Engineer (retired), U. S. Coast and Geodetic Survey and author of the Bureau's manual "Cartography", feels that the word had a much earlier use by other nations since it is a simple and logical construction from two Greek terms, the first meaning a leaf of paper or papyrus and the second, representation by means of lines. In a communication to the Federal Board of Surveys and Maps he called attention to the work "Abrege de Geographie, 1833, à Paris" by Adrien Balbi in which on Page IV of the "Introduction à la Geographie" the word "Cartographie" appears along with the other sciences, and on pages XVIII and XIX there is a critique on the subject, beginning, "La cartographie est sans nul doute une partie principale de geographie; nous dirons plus, etc." Mr. Deetz also cites a quotation from Sir Richard Burton, celebrated English explorer and linguist, in 1859, which reads: "The circlets in cartography denote cities or towns." It appears that between the French use in 1833 and the use by Burton in 1859, the English form was "Chartography". However, the "ch" was pronounced like "k" and the spelling as we have it today prevails not only in English but in the Romance languages as well.

* Decision of the U. S. Geographic Board.


YE GODS!
WE FORGOT THE INSTRUMENT!
OH!
MT. BAIN
6,427 FT.
U.S.C.&G. SURVEY
PETERSEN

Extracts from the Bulletins of the Bureau of Marine Inspection and Navigation

SEA MANNERS

A passenger vessel recently crossed through a large force of the United States Fleet, from the port to starboard side. All vessels apparently had the right-of-way and, as this occurred at night, all were showing their running lights. As a result, one of the large battleships had to change course sharply and take extreme measures to avoid collision.

Regardless of the relative positions of a single vessel and of a fleet, as would affect the question of right-of-way, it is pointed out with emphasis that for reasons obvious to any seaman, it is imprudent for a single ship to hold its course and pass through a fleet formation when by an early change of course such single ship could pass astern or otherwise well clear of the fleet formation. A large number of naval vessels, proceeding in company, forms a compact set of units operating close to each other. The orderliness and safety of these units is hazarded when one or more of them is forced individually to change its course or speed. For a single ship of any character, or for a tow, to cut through or pass critically close to such a formation constitutes culpable neglect of caution and, to say the least, very bad sea manners.

The Bureau realizes that such incidents have been very rare in the American Merchant Marine, and brings attention to this case in order that the younger and less experienced watch officers may profit therefrom.

WHAT NOT TO PAINT

1. Do not paint rubber gaskets on watertight doors.
2. Do not paint rubber gaskets on portholes and deadlights.
3. Do not paint threads on bolts and nuts.
4. Do not paint builders plates on lifeboats.
5. Do not paint manufacturers plates on boat davits.
6. Do not paint fire extinguishers or lifebuoy lights.
7. Do not paint valve tags on fire extinguishing system.
8. Do not paint gear clutch shaft on anchor windlass.
9. Do not paint over electric wiring and switches.
10. Do not paint Detector Heads of Sprinkler Heads.

MAGNETIC OBSERVATIONS IN ALASKA

July - August, 1939

The following extracts are reprinted from E. H. Bramhall's 1939 season's report as information of general interest.

Transportation

A necessary preliminary step in making plans for occupying the widely separated stations scheduled for the Alaskan magnetic survey, which is made about every ten years, was a decision on the most economical mode of transportation, with respect to both time and money. Obviously, points along the highways and the railroad could best be reached by automobile and train.

To reach river points, the choice lay between motor launches and airplanes equipped with either pontoons or wheels.

After some investigation, the airplane was decided upon as the most advantageous, provided that landing fields were available not too far from the magnetic stations. The following factors justify the reasons for choosing plane travel:

The cost of a motorboat capable of 20 miles per hour downstream, (perhaps ten miles per hour upstream), was $5.00 per operating hour, compared with the cost of a plane capable of 100 to 130 miles per hour, (on a basis of two flying hours per day), of about $30.00 per operating hour. Assuming comparable distances by river and by air, to reach by boat a point 100 miles distant would cost between $25.00 and $50.00 compared with $30.00 by plane, but the distance by river is usually twice, and often three times that by air. In boat travel, retracing one's route is inevitable, and there is less flexibility of the itinerary. Many points, too, are accessible by boat only under certain favorable conditions.

The difference in the time factor of plane and boat travel is illustrated by the trip from Holy Cross to Iditarod, several days of difficult navigation up the Innoko and Iditarod Rivers being necessary by boat in contrast with 40 minutes flying time by plane. A second example is the Porcupine River trip to Rampart House; by boat approximately six days up and three days down river; and by plane, 80 minutes up from Fort Yukon, then directly to Eagle without retracing any distance.

Choice between Pontoon or Wheel Plane

The type of plane to be used is an important phase of the transportation question. The choice for this season's work between a plane equipped with floats and one with wheels was not difficult because the only pontoon ship available for charter, in Fairbanks, commanded a prohibitively high rate, so a wheel plane was chartered. In the observer's opinion, however, a pontoon plane would have had distinct advantages over one equipped with wheels because every station on the second and third parts of the itinerary is accessible to pontoons during the entire summer season, while at times the river bars used for landing fields and the small, unkempt airports are not in condition for the landing of wheel planes. In spite of all this, the feasibility of using a land plane was discussed with a number of pilots and aviation officials, and the observer was convinced that the survey could be expeditiously made by using a land plane. Where landing fields are overgrown badly with grass and shrubs, pilots prefer to land on river bars, if available. Pontoon ships could, in most cases, land nearer to stations than wheel planes. However, for the work this season, some sort of transportation for the gear from plane to station was secured in every instance, although at times with some delay and difficulty.

Itinerary

Mr. Bramhall's itinerary was divided into three principal trips:

1. By automobile along the Richardson Highway and Edgarton Cut-off to Fairbanks, Big Delta, Meiers, Chitina, and Fort Liscum; by steamship from Valdez to Cordova and Seward; by the Alaska Railroad from Seward to Anchorage, Matanuska Junction, and College; and by automobile along the Steese Highway to Circle City.

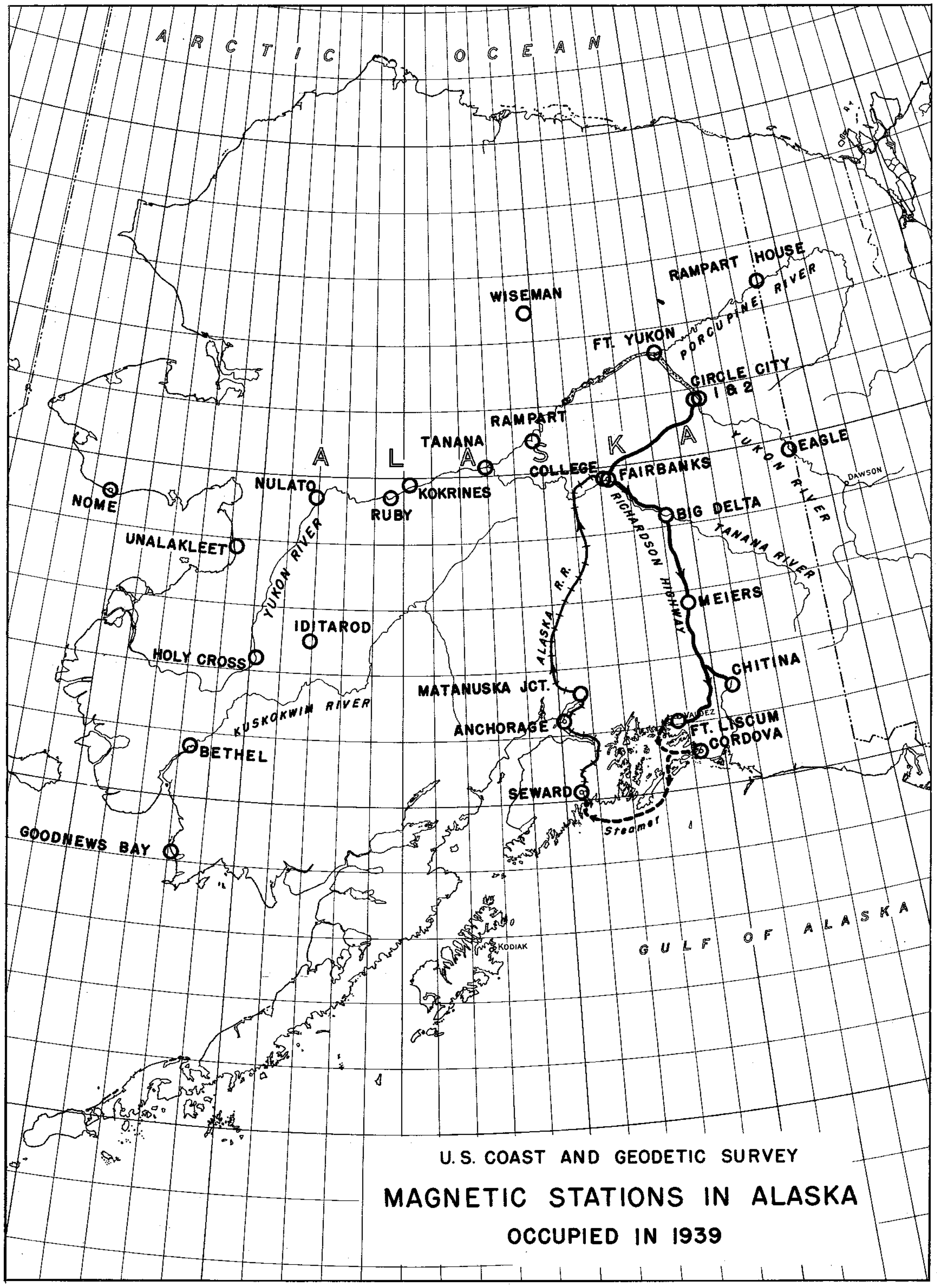
2. By chartered airplane to Rampart, Wiseman, Fort Yukon, Rampart House, and Eagle.

3. By chartered airplane to Tanana, Iditarod, Holy Cross, Bethel, Goodnews Bay, Unalakleet, Nome, Nulato, Ruby and Kokrines.

In the first trip McCarthy could have been included because travel to that point is still possible by speeder from Chitina over the abandoned Copper River Railroad, but no description of the station was available. Inclusion of the stations on Kodiak Island might have been made on this trip also, either by regular boat from Seward, which would have required ten days, or by chartered plane from Anchorage, which would have required one day if flying conditions were favorable. (They were not, when the observer was in Anchorage.) Consequently these stations were omitted from the observer's itinerary, since none of them had been given priority in the instructions.

The omission of Bettles and Hughes had been authorized, and new stations at Chandalar or Wiseman recommended. Information available at the time the second trip Was made led the observer to omit Bettles from the itinerary and proceed to Wiseman. Later it was determined that a landing on wheels was possible on a bar across the Koyukuk River from Bettles (now nearly abandoned), and that a few natives with boat's live nearby so that transportation of gear could have been arranged. There is no reason why this station cannot be reoccupied, although the mark is probably submerged under a foot or two of silt from a recent flood, and its proximity to the station at Wiseman makes it scarcely necessary. The new station at Wiseman appears to be a satisfactory substitute because that village is likely to survive for some years and a new landing field is under construction there.

On the third trip a new station was established, and the old one reoccupied at Goodnews Bay. Initial plans included St. Michael on this trip, but after carefully examining the region from the air


ARCTIC OCEAN
RAMPART HOUSE
PORCUPINE RIVER
WISEMAN
FT. YUKON
CIRCLE CITY 1 & 2
RAMPART
TANANA
A L A S K A
EAGLE
YUKON RIVER
DAWSON
COLLEGE
FAIRBANKS
NULATO
KOKRINES
RUBY
NOME
BIG DELTA
TANANA RIVER
UNALAKLEET
RICHARDSON HIGHWAY
YUKON RIVER
ALASKA R.R.
MEIERS
IDITAROD
HOLY CROSS
CHITINA
MATANUSKA JCT.
KUSKOKWIM RIVER
ANCHORAGE
VALDEZ
FT. LISCUM
CORDOVA
BETHEL
SEWARD
Steamer
GOODNEWS BAY
KODIAK
GULF OF ALASKA
U. S. COAST AND GEODETIC SURVEY
MAGNETIC STATIONS IN ALASKA
OCCUPIED IN 1939

for a radius of ten miles, the pilot decided that no landing was possible. Therefore, Unalakleet, a village with a reasonably good airport and accessible by boat, was substituted. Since much trade for the Lower Yukon is handled from this point, it will probably remain a permanent settlement. A new station was established at Ruby, which is in a better and a more easily accessible location than that at Kokrines, and should serve as a suitable alternate for that station. There is no landing field at Kokrines, and the bar across the river is available only at low water; in addition, the location of the station at this point is no longer very suitable because of the absence of reference marks and its inaccessibility.

* * *

(There follow a few excerpts from the reports on the stations occupied.)

FAIRBANKS: The station is located near the middle of the runway of the airport, so that it was necessary to work at times when air traffic was light. Permission was secured to occupy this station very early in the morning.

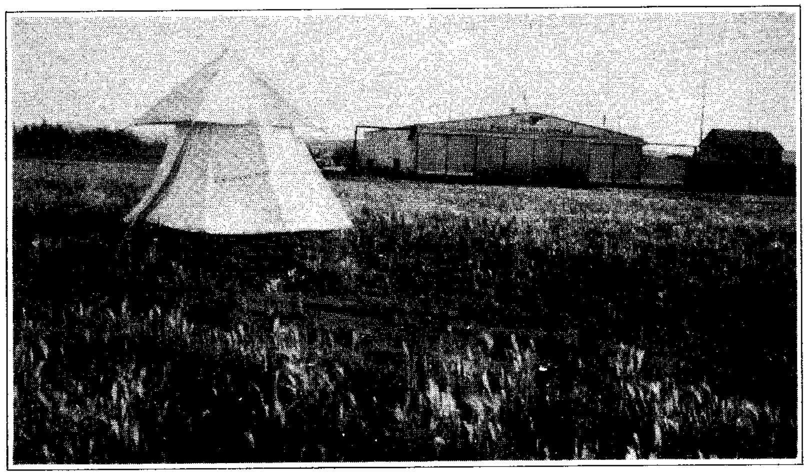
BIG DELTA: The site of the old station was found, but the top of the monument containing the copper spike had been knocked off and was lying on the ground. Heavy road-repair equipment of the Alaska Road Commission was sitting only a few feet away, and a log fence six feet north and south of the station had been repaired with long iron spikes and strung with iron wire. Consequently, the station was considered temporarily unsuitable for magnetic measurements, and a new one set up 163 feet southwest of it. If the fence is removed and the cooperation of the Alaska Road Commission is secured, the old station would again be satisfactory.

FORT LISCUM: Great difficulty was experienced in locating the old station. The hospital referred to in the description of the station has been removed (about 1923) and only sketchy outlines of the foundation were visible. The station is located in what was formerly a garden, but what is now a morass thickly overgrown with ferns six feet and more in height, intertwined with rank weeds. Additional inconveniences were gnats and more or less continuous rain which drenched everything not already soaked by the swampy wetness. From a magnetic point of view -- but only from that point of view -- this site was considered suitable for a station. - - - - - -

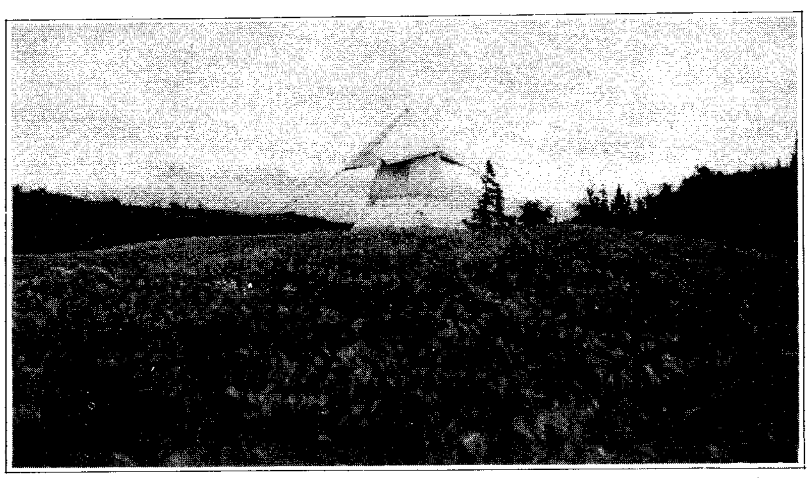
CORDOVA: The old station back of buildings belonging to the U. S. Forestry Service was obliterated by a landslide seven years ago. Moreover, new buildings have been erected very near the old site. Consequently, a new station was established farther up the hillside about 120 feet from the old one. - - - - - -

SEWARD: The old station here was found to be uncomfortably (from an olfactory viewpoint) near a well-used dog kennel. The stone marking the station was not firmly anchored, but had apparently been unmolested. From a magnetic standpoint a pile of rubbish, composed of bedsprings and other discarded metallic objects, some 15 feet away should be mentioned, as well as the tin roof on the dog kennel. The natural characteristics of the location are ideal for a station, and it is easily found.

ANCHORAGE: The station was found in good condition in the City Ball Park. - - - - - -



FAIRBANKS
On Airplane Landing Field



MATANUSKA JUNCTION
New Station on Knoll Near Experimental Farm.

MATANUSKA JUNCTION: The old station was located on what is now the driveway to a residence on the experimental farm, and was too near this residence to be magnetically suitable. Accordingly, a new station was established in a pasture several hundred feet from the old site. - - - - - -

WISEMAN: A new station was established on a ridge near the new airport.

RAMPART HOUSE: Some delay was experienced in reaching the station after a landing was effected on a bar in the Porcupine River, because the gear had to be taken to the shore in a canvas boat and then carried up the cliff. The village was occupied by only two old Indian women at the time, and no help was available. The wooden post marking the station had become the home of a colony of ants and had to be replaced by a concrete pier.

IDITAROD: No landing field existed at Iditarod, so the gear was flown to Flat and transported by truck over eight miles of road. The town is now abandoned and is no longer on the river, which has taken a new course at that point. The wireless tower referred to in the description is no longer there, but the station was located from measurements made to the former site of the tower.

KOKRINES: The old station was located without trouble, although there was a delay of several hours in securing transportation across the river from the sand bar which served as the landing field. The former cleared space (around the mark) was overgrown with grass three to four feet high - - - - - - .

* * *

Weather

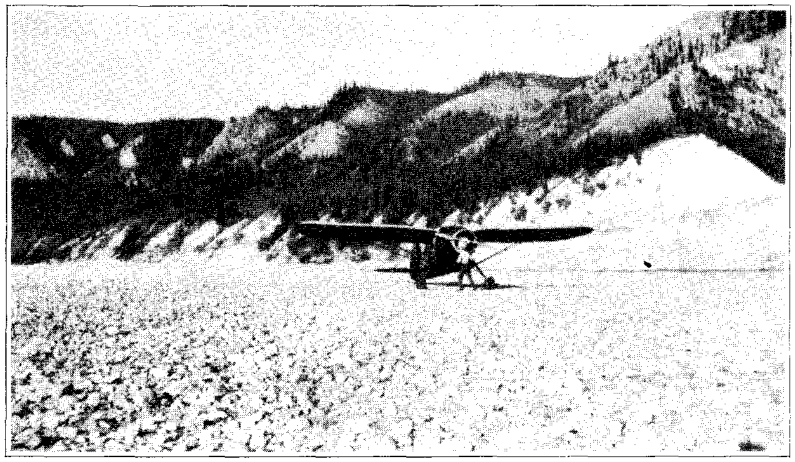
In general, the observer was favored by breaks in the weather, and sights of the sun were obtained when necessary without undue delay. There were two exceptions to this: the stations at Fort Liscum and at Kokrines were occupied without sight of the sun. In both cases, none of the marks given in the description could be seen because of fog and low clouds, so that, until the true bearings of certain objects used as marks are determined, no value of declination for these stations can be computed. At several stations, i.e., Meiers, Bethel, and Goodnews Bay, sun sights were very fortunately obtained on days which were almost 100% overcast.

Weather records indicate that better conditions are usually encountered in the interior of Alaska and westward in the early summer, May and June, than in July and August. The longer period of daylight would also expedite the work since there would be sufficient light for observations at any hour.

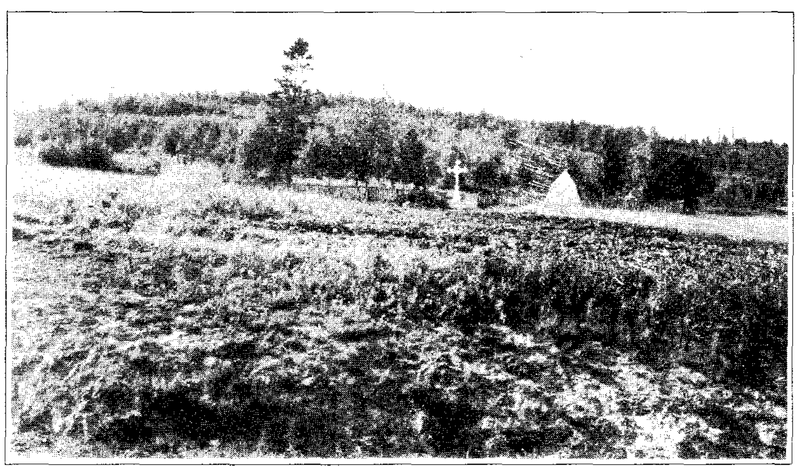
* * *

Other Conditions Affecting Observations

Insect life, as was to be expected, proved annoying during occupation of the stations. Only during a cold spell or a stiff wind is an observer free from attacks of gnats, mosquitoes or sand flies, so that he must provide some protection against them in order to work efficiently. A large amount of Buhach was used and proved to be quite effective in clearing the air in the tent, provided it



RAMPART HOUSE
Gravel Bar Used As Landing Field.



HOLY CROSS
Station On Hill Near Cemetery.

was closed rather securely. At Chitina, for example, handfuls of gnats were removed from the fold of mosquito netting sewed around the bottom of the tent after Buhach had been burned preceding the observations in the morning. The netting sewed on the tent was an aid in keeping it clear of insects after it was once cleared. In an enclosed tent, after these precautions, an observer can work without gloves, head-net, or other hampering paraphernalia. A grass smudge can be used successfully against mosquitoes but is useless against gnats, and the smoke affects an observer's eyes inconveniently. Buhach is better. In any case, for satisfactory working conditions, adequate protection is essential.

Station Monuments

Some of the monuments marking magnetic stations along the highways and the railroad are unsatisfactory, and in the observer's opinion, should be replaced by concrete piers with standard discs. - - - - . Even a concrete pier is not proof against shifting unless there is good drainage. If this is not the case, the freezing of the underlying soil may cause breaking or tilting of the pier. This was probably the cause of the poor condition of the stations at Meiers and at Nome, both of which had been located on poorly drained land.

* * *

Accessibility of Stations

It is believed that some information on the accessibility of the stations visited by boat, plane, or other means of travel, as well as additional data on points where stations exist, might be of some value for future reference. The following summary is from information on hand:

BIG DELTA -- car, over Richardson Highway, or by plane equipped with wheels or floats.

MEIERS -- car, over Richardson Highway.

CHITINA -- car, over Richardson Highway and Edgarton Cut-off, or by plane with either wheels or on floats. Former route to Cordova over Copper River R. R. now closed.

FORT LISCUM -- plane with floats or wheels, landing in Valdez, thence by car over Richardson Highway, and motorboat from Valdez.

CORDOVA -- by boat, or plane with either wheels or floats.

SEWARD -- by boat, or plane with either wheels or floats.

ANCHORAGE -- by train, or plane with either wheels or floats.

MATANUSKA JUNCTION -- by train or car from Anchorage.

CIRCLE CITY -- by car over Steese Highway; or Yukon River by boat, or by plane with either wheels or floats. Wheel landing is on a bar, across the river.

RAMPART -- by boat (Yukon River), plane with floats or wheels. Wheel landing is on a bar a mile upstream when water is low.

BETTLES -- by boat sometimes (Koyukuk River), plane with floats or wheels. Wheel landing is on bar across river from village except at very high water,

WISEMAN -- by small boat (Koyukuk River), plane with wheels or floats. New landing field under construction.

FORT YUKON -- by Yukon River boat, plane with wheels or floats. Landing field is badly overgrown and pilots usually prefer bar in river.

RAMPART HOUSE -- by small boat (Porcupine River), plane with wheels landed on gravel bar across river from village, but this is

NULATO
Showing Some of Mission Buildings.

RUBY
Showing Station with Relation to Landing Field and Road.

available only at low water, and is very rough. Plane with floats could land only with some difficulty due to swift current. Wheel or float plane can usually land at Old Crow, 40 miles upstream, in Yukon Territory (must have clearance papers for customs) and then by motorboat down to Rampart House.

DEMARCATION POINT -- no reliable data secured on landing conditions there. Probably could land on one of the islands and take a boat for remainder of trip.

EAGLE -- Yukon River boat, or plane with wheels or floats. Landing field in fair condition.

TANANA -- Yukon River boat, plane with wheels or floats. Landing field is small, in poor condition, and is about a mile and a half from station. Only one small cart, hand-drawn, available for transportation of gear.

NULATO -- Yukon River boat, plane with floats, or at low water, plane with wheels can land on bar across river. A landing field is under construction here.

IDITAROD -- by small boat (Innoko River and Iditarod River), by plane with floats. Wheel landing at Flat, eight miles of fair road to Iditarod.

HOLY CROSS -- Yukon River boat, or plane with wheels or floats. The landing field is small but is maintained in fairly good condition.

BETHEL -- Kuskokwim River boat, or plane with wheels or floats. Good landing field.

G00DNEWS BAY -- by steamer, or plane with wheels or floats. Fair landing field at Platinum, and three and a half miles of rough going by car to end of spit where station is located.

LAKE ILIAMNA -- Plane with floats, only.

CLARK POINT -- by steamer, or plane with floats.

ST. MICHAEL -- by steamer, or plane with floats.

UNALAKLEET -- by steamer, or plane with wheels or floats. Landing field in fair condition.

NOME -- by steamer, plane with floats or wheels. Good landing field.

RUBY -- Yukon River boat, plane with wheels or floats. Good landing field.

KOKRINES -- Yukon River boat, plane with floats. Wheel landing was made on bar across river during low water.

POINT HOPE -- by steamer, plane with wheels or floats.

POINT BARROW --by steamer, plane with wheels or floats.

As a rule, the site of the magnetic station could be approached more closely by a plane equipped with floats than with wheels, with a consequent saving of time in preparing for observations. At Tanana, for example, several hours were spent in carting the gear from the airfield to the station since a small handcart was the only means of conveyance. At Iditarod, time was required to secure a truck to transport the equipment from the landing field at Flat to the station eight miles distant. And at Nulato and Kokrines it was necessary to obtain a motorboat for transport across the river after landing on a bar. The observer was very fortunate to be able to land at all near the station at Kokrines. On August 14th the sand bar was not visible above the water, but by August 25th the river had fallen about four feet and the sand bar afforded a good landing place. Had this not been the case, a motorboat would have been required to move the equipment from Ruby to Kokrines and return, a distance of about 60 miles.

It seems more likely that, provided it could be secured at a reasonable figure, a plane equipped with floats would provide the best transportation for the purpose of making any future magnetic survey of interior Alaska. In any case, after examining from the air the Porcupine, Yukon, Innoko, Kuskokwim, and Koyukuk rivers with their many oxbows and 180° bends, one is convinced that a plane has the advantage over a boat as a means of transport, from any point of view.

Equipment

While economy in weight of equipment is not particularly important when transport is by motorboat or car, it becomes very desirable to cut down weight to as low a figure as possible if a plane is used. This is especially important because of the uncertain conditions for landing and take-off. With the equipment supplied for this survey, the weight could not be reduced to less than 260 lbs.----- This weight was not excessive for the plane which was chartered, but certain items could have been considerably lighter in weight.

* * *

Operation of Equipment

In general, no trouble was experienced with the instruments. However, a theodolite entirely separate from the magnetometer is preferable (to the observer) over a combination instrument.

* * *

No source of artificial light was used on the trip, although such a provision would, in several instances, have meant an important saving of time. If the survey were conducted earlier in the season, little would be gained by having artificial light available because there would be sufficient natural light for purposes of observation at all times. A small but good camera should be furnished as an aid in fixing the station locations. The excellent chronometer was very dependable, but it would be advantageous to have two reliable time pieces, in case of damage to one.

Radio Time Signals

Using an SW3, regenerative-type receiver, the observer had no difficulty in picking up NAA (Arlington) practically every day. On frequencies of 9250 or 9425 kilocycles, the signals were usually very clear at any hour from 17:00 to 23:00, 150th meridian standard time, and early in the morning. A 75-foot antenna of stranded copper wire elevated two or three feet above the ground proved very satisfactory. At Rampart House, NAA came in strongly with 30 feet of antenna lying directly on the gravel. At Anchorage and Cordova a good signal was obtained using a few feet of wire on the floor of the hotel room, the ground lead being connected to the radiator. In the opinion of the observer, this receiver could not be improved for the reception of code signals, the only disadvantage being the weight of 135 volts of "B" batteries. Midget batteries capable of supplying the current needed for short periods could certainly be substituted.

* * *

Acknowledgments

The observer was very fortunate in securing the services of Messrs. John E. Lynn and Richard C. Ragle, both very able pilots, for the trips in chartered planes. They also helped materially in transporting and setting up the equipment on station location.

* * *

Mr. Bramhill was treated with the usual Alaskan courtesy and hospitality and found the residents most helpful and accommodating to him at his various stations. (Editor)

OUTSIDERS' IMPRESSIONS

From Maritime Commission Cadet Officers

For the last two years the U. S. Coast and Geodetic Survey has been providing an opportunity for the training of a limited number of Maritime Commission Cadet Officers during the regular season's field work. This extra training, offered us by the Government, is to familiarize the future Merchant Marine Officers with the accuracy and completeness of the nautical charts and other publications of the Coast and Geodetic Survey and the Hydrographic Office.

When we three cadets were assigned to the LYDONIA, we had no idea how surveys for charts were made. As we watched members of the Coast Survey at work, we were impressed by the number of things which those in the Survey, through long familiarity, took for granted. What impressed us most was the accuracy and painstaking attention to detail that characterized all work done by the Survey officers. Everything was checked and rechecked before being accepted.

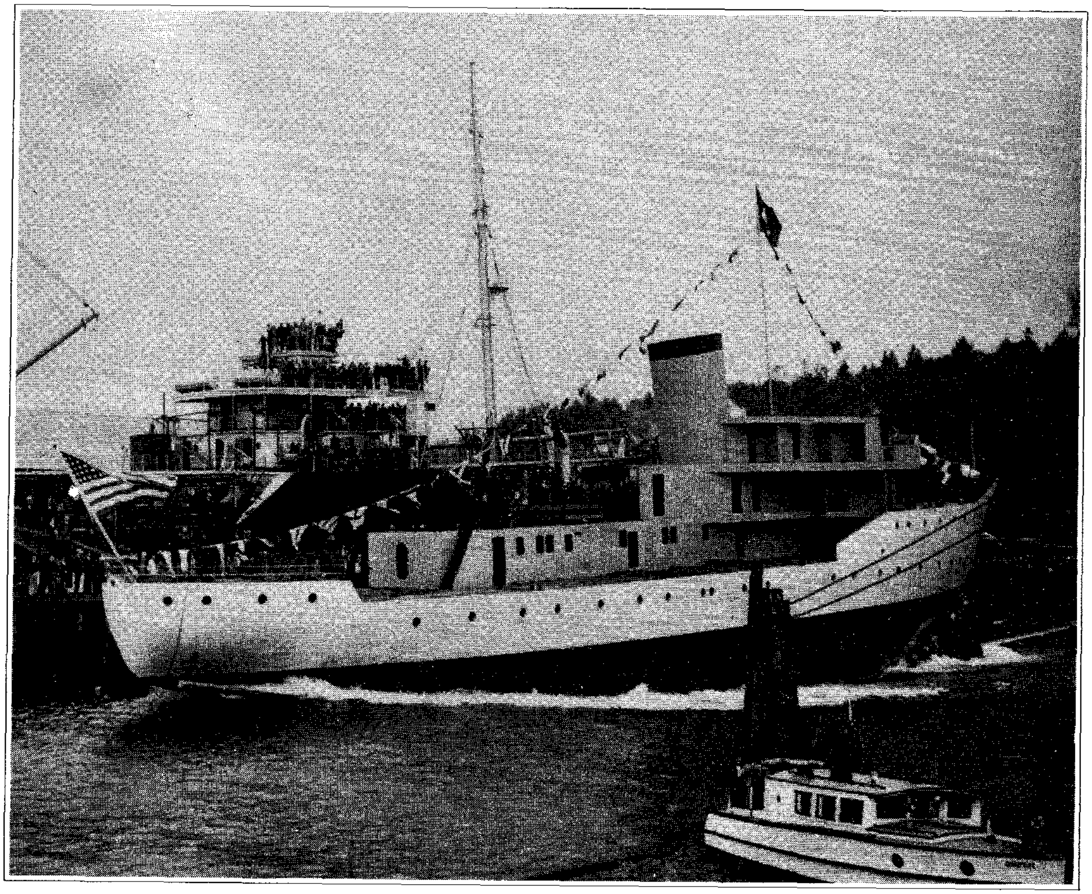
The scientific precision of radio acoustic ranging was an attribute to the Radio Engineers of the Coast Survey. This method of obtaining a fix was one of the biggest surprises of our cruise.

Another thing that impressed us was the contour chart* of a part of the waters of the West Coast. These newer type charts, we believe, are a valuable asset, and indicate the large amount of progress that characterizes all the work of the Coast Survey.

Our confidence in the accuracy and reliability of the Coast Survey charts and other publications has been increased tremendously; and the knowledge that we have gained of methods of survey, the finer points of navigation, and the use of the chart, is certain to be valuable to us in our future assignments; and we believe that this period of time has been well spent.

(Signed) Harold F. Millar
William W. Perkins
William E. Judge
Maritime Commission Cadet Officers.

* Chart 5101A. See "A New Type of Nautical Chart" by C. K. Green, page 7, Field Engineers Bulletin No. 12, and "On Soundings" by K. T. Adams, page 1131, August, 1939, issue of U. S. Naval Institute Proceedings.



THE LAUNCHING OF THE NEW SHIP EXPLORER

The new EXPLORER was successfully launched on October 14, 1939, on the waters of Lake Washington by the contractor at Houghton, Washington. Amid colorful ceremonies, Mrs. Leo Otis Colbert, wife of the Director of the Bureau, christened the new vessel in the presence of over 3,000 spectators, and the EXPLORER slid gracefully into the water amid the cheers of the spectators and the whistles from surrounding vessels, especially the SURVEYOR. The launching was of particular interest locally for the EXPLORER is the largest ship built on Puget Sound since the boom of wartime construction.

The new vessel is scheduled for completion in the early spring, and at a cost of $1,250,000, she will be the largest and most modern of the survey vessels of the Bureau. Her complement will be 90 officers and men, and after a shake-down cruise along the California coast she will proceed to her first assignment of surveys off the Aleutian Islands in western Alaska.

On the day of the launching, the SURVEYOR, just returned a few days previously from a long and arduous season in Alaska, transported the sponsor and the launching party from Seattle to the shipyard. It was particularly fitting that Mrs. Colbert was designated sponsor by the Secretary of Commerce, since it was only through the Director's unceasing efforts that an appropriation for the construction of the vessel was secured.

The launching took place without incident and because of her fine lines at the stern the vessel entered the water so smoothly that there was practically no splash such as is often seen at a launching. Neither was there a splash when the bow struck the water, as might have been expected from the rather steep slope of the ways. She remained on an even keel with practically no rolling as is so often the case. The rudder had been set about ten degrees to starboard and she swung slowly into the wind. After the peak tank, filled for the launching, had been emptied, she drew about 6'-6" forward and 10'-6" aft which agreed exactly with the naval architect's figures.

At the time of the launching, the vessel was about 70% completed. The boilers, condensers, and much of the auxiliary machinery, including the generators, had been installed, but the main turbines were not yet installed. The stack was in place but the masts had not yet been placed. The propellor had been installed just a few days before the launching. Before delivery the propeller was tested by representatives of the U. S. Naval Inspector of Materials, American Bureau of Shipping and Bureau of Marine Inspection and Navigation. The dynamic balancing of the propeller was an innovation for a private shipyard in the Puget Sound area and excited considerable interest.

The new vessel will have a cruising radius of 7,000 miles at a normal speed of about 14 knots. She is of steel construction throughout, 1,500 tons displacement, and an over-all length of 220 feet. She will be completely fireproof and of the two-compartment construction.

Her surveying equipment will include a Dorsey Fathometer, a Hughes depth recorder and several of her launches will be equipped with the newly developed Submarine Signal Company portable depth recorders. A taut-wire apparatus will be included.

The quarters for officers and crew are particularly designed for the comfort of men required to live on board continuously for long periods in remote localities. The most sanitary installation possible has been made in the galley, the storerooms and the refrigeration rooms, where large quantities of food must be preserved for long periods. Provision is also made for the storage of frozen vegetables.

Incident to the launching, Director Leo Otis Colbert was principal speaker at the Seattle Chamber of Commerce meeting in Seattle. He told how the varied activities of the U. S. Coast and Geodetic Survey had been intimately connected with the development of Puget Sound ports for nearly a century. Men like James Alden, George Davidson, John Jacob Gilbert, James S. Lawson, William P. McArthur, John Francis Pratt, John Rodgers, Isaac Ingalls Stevens*, and others, were early pioneers in the development of the Pacific Northwest. He also spoke of the work yet to be done in the way of modern surveys of the 750,000 square miles of the Bering Sea between the international date line and the mainland north of the Aleutian Islands, an area over ten times that of the State of Washington.

The old Ship EXPLORER, whose name has been perpetuated in the vessel just launched, was transferred to the National Youth Administration on October 16, 1939, one of the conditions being that she will be renamed.

PROPOSED ASSIGNMENT OF OFFICERS FOR FIELD SEASON, 1940
DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

OCEANOGRAPHER

Peacock, F.L., Comdg.
Meaney, C.D., Exec.
Finnegan, H.E.
Sanders, I.T.
Kirsch, E.H.
Lushene, J.P.
Gossett, F.R.
Mathisson, J.C.
Russell, W.C.
Bull, J.C.
Wardwell, A.L.
Okeson, F.E.
Jones, Don
Gile, K.R., Eng.Off.

HYDROGRAPHER

Mattison, G.C., Comdg.
Scaife, W.M., Exec.
McCarthy, E.R.
Baum, E.C.
Lewey, E.B.
Tribble, J.C., Jr.
Tison, J.C., Jr.
Weber, P.A.
Clark, C.W.
Stirni, J.W.
Sawyer, E.M., Eng.Off.

GILBERT

Warwick, H.C., Comdg.
Marshall, R.A., Exec.
Waugh, J.E., Jr.

LYDONIA

Cotton, H.A., Comdg.
Karo, H.A., Exec.
Fortin, Henry
George, C.A.
Garber, H.F.
Bryant, F.J.
Overton, R.C.
Whipp, D.M.
Jones, C.R., Eng.Off.

OGDEN and MITCHELL

Gallen, F.L., in charge
Schanck, C.A.
Ricketts, M.C.
Gilmore, R.A.

SURVEYOR

Schoppe, R.L., Comdg.
Knox, R.W., Exec.
Hubbard, L.S.
Thorson, A.C.
Partington, J.C.
Nelson, G.A.
Gibbens, V.M.
Reed, C.R.
Leary, W.J., Med. Off.
Healy, R.W.
Smith, H.H.
Zimmerman, E.G., Eng.Off.

GUIDE

Eickelberg, E.W., Comdg.
Thomas, C.M., Exec.
Johnson, F.G.
Chovan, W.J.
Hecht, M.A.
Applequist, H.C.
Schoene, C.A.
Jackson, W.R.
Wetzel, J.W., Med.Off.
Popper, F.X.
Seymour, F., Eng.Off.

EXPLORER

Peters, J.H., Comdg.
Bean, G.L., Exec.
Bernstein, E.H.
Roberts, E.B.
Doran, P.C.
Paton, H.A.
Latham, E.B.
Bowie, John, Jr.
Burmister, C.A.
Wagner, C.J.
Brown, E.B., Jr.
Tryon, R.H.
Public Health Med. Off.
Greer, W.E., Eng.Off.

DISCOVERER

Graham, L.D., Comdg.
Durgin, C.M., Exec.
Boothe, G.E.
Deily, E.A.
Johnson, L.C.
Thurmond, J.D.
Jarman, J.T.
Hicks, E.F., Jr.
Chenworth, C.F.
Tucker, W.R.
Moore, G.W.
Soule, F.J., Med. Off.
Weidlich, W.
Lariviere, E.W., Eng.Off.

PIONEER

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Rittenburg, I.E., Exec.
Grenell, S.B.
Gibson, W.M.
Pfau, R.L.
Fish, G.R.
Laskowski, John
Stohsner, E.E.
Conerly, H.G.
Reed, H.D.
Davis, S.N., Eng.Off.

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Bose, J.C., Exec.
Deane, W.F.

ELSIE

Riddell, F.A., Comdg.
Sturmer, D.E., Exec.

E. LESTER JONES

Wilder, L.C., Comdg.
Bolstad, R.C., Exec.
Ellerbe, J.C.

PATHFINDER

Egner, C.A., Comdg.
Porter, W.R., Exec.
Morris, G.E.
Public Health Med. Off.

FATHOMER

Shaw, C., Comdg.
LeFever, C.

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San Francisco: Smook, J.M.
In charge
Oliver, H.J.
Norfolk: Brittain, J.H.

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Maher, T.J.

Manila

Lukens, R.R.

Boston

Moore, R.R.

New Orleans

Raynor, L.P.

Seattle

Hardy, F.H.
Rubottom, I.R.

San Francisco

Smook, J.M.

Honolulu

Heaton, E.O.

COAST PILOT

Anderson, G.L.

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Crosby, K.G.
Jones, E.L.

Baltimore

Swanson, L.W.
Jones, J.N.

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Unassigned

Siems, F.B.T.
Adams, K.T.
Pierce, Charles
Healy, H.J.

Washington Office

Rude, G.T.
Cowie, G.D.
Campbell, H.B.
Senior, Jack
Eyman, R.P.
Reading, O.S.
Bond, J.A.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY (cont.)

The field parties of the Division of Hydrography and Topography will operate during the 1940 summer field season in the following localities:

The HYDROGRAPHER in the central and eastern part of the Gulf of Mexico.

The OCEANOGRAPHER in the Gulf of Maine.

The LYDONIA on Nantucket Shoals and in the approaches to Boston Harbor.

The GILBERT on Nantucket Shoals and in Nantucket Sound.

The WESTDAHL in Glacier Bay, Alaska.

The SURVEYOR on the coast of Alaska between Cape Fairweather and Cape St. Elias.

The EXPLORER and PIONEER in the Aleutian Islands westward from Umnak Island.

The GUIDE will continue surveys in the Bering Sea eastward from Unimak Pass along the north coast of Unimak Island and the Alaska Peninsula.

The DISCOVERER will continue operations along the south coast of the Alaska Peninsula eastward from the Sanak Islands.

The E. LESTER JONES in the outer southern approaches to Sitka, Alaska, and in the Aleutian Islands.

The Launches MITCHELL and OGDEN in the Chester River and Eastern Bay, Maryland.

The Launch ELSIE in the Intracoastal Waterways.

The PATHFINDER and FATHOMER off the west coast of Palawan and in the South Sulu Sea area.

The Air Photographic Survey Party at Baltimore, Maryland, will continue work on air photographic surveys of the eastern shore of Chesapeake Bay, and of Boston Harbor and Cape Cod.

The Air Photographic Survey Party at Tampa, Florida, will be engaged on air photographic surveys on the west coast of Florida and the Okeechobee Cross-Florida Waterway.

A party at Boston, Massachusetts, will make revision hydrographic surveys and wire drag surveys of Boston Harbor and immediate approaches.

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WASHINGTON OFFICE	NEW YORK COMPUTING OFFICE	PHILADELPHIA OFFICE
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Hemple, H.W.	Quinn, F.B.	Taylor, Paul
Bainbridge, W.H.	Earle, R.A.	
Aslakson, C.I.		

FIELD	FIELD	FIELD	FIELD
Woodworth, R.W.	Bernstein, P.L.	Morton, J.S.	Seaborg, H.J.
Hoskinson, A.J.	Lovesee, G.W.	Sheridan, E.H.	Mussetter, W.
Sammons, J.C.	Stewart, A.N.	Beyma, C.J.	Braden, M.Z.
Rowse, R.C.	Jeffers, K.B.	Konichek, D.H.	Risvold, O.S.
Sipe, R.J.	Mast, G.C.	Martin, W.N.	Packer, E.B.
Shelton, G.R.	Natella, F.		

DIVISION OF CHARTS	DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY	DIVISION OF TIDES AND CURRENTS	DIVISION OF PERSONNEL AND ACCOUNTS
Borden, F.S.	Heck, N.H.	Whitney, P.C.	Luce, R.F.
Green, C.K.	Swainson, O.W.	Malnate, W.F.	
Smith, P.A.	Jones, G.C.	Wennermark, M.E.	
Studds, R.F.A.	Patterson, W.D.		
Reed, T.B.			

STATISTICS AND DISTRIBUTION OF FIELD PARTIES
U. S. COAST AND GEODETIC SURVEY - DIVISION OF HYDROGRAPHY AND TOPOGRAPHY
July 1, 1938 - June 30, 1939

				Hydrography			Topography		Triangulation			Tides and Currents			
Locality	Project H.T. No.	Ship or Party No.	Chief of Party	Sounding Lines Mi.	Area sq. mi.	Soundings No.	Shore Line Mi.	Area sq. mi.	Length of scheme mi.	Area sq. mi.	Geo. Pos. No.	Ti. Sta.	Cu. Sta.	BMs Est.	Mag. Sta. No.
Nantucket Sound	217	GI.	C. K. Thomas	1,399	62	39,429	15					6		6	
Nantucket Sound	217	MI.	F. L. Gallen	343	10	15,938						2		5	
Nantucket Sound	227	A.P. "A"	L. W. Swanson				186	40							
North coast of Long Id.	225	Spec.	F. R. Gossett						25	64	74				
Hudson R.	228	GI.	C. K. Thomas	980	11	95,255						4	1	9	
Atlantic coast east of Fire Island	207	LY.	R. P. Eyman	6,567	3,045	70,807	14				8	6		7	1
Atlantic coast east of Fire Island	207	OC.	F. S. Borden	8,700	8,380	83,299									
N.J. coast	207	OC.	F. S. Borden	2,793	1,082	27,605									
Chesapeake Bay	215	MI.	F. L. Gallen	3,575	143	131,290	2					7		20	
Chesapeake Bay	215	A.P. "A"	L. W. Swanson				215	150							
Chesapeake Bay	224	A.P. "A"	L. W. Swanson						25	57	62				
James R., Virginia	226		H. E. Finnegan						50	150	156				
St. Johns R., Florida	168	A.P. "B"	R. J. Sipe				545	290							
St. Johns R., Florida	212	MI.	F. L. Gallen	778	35	42,065						10		16	
Fla. Keys	158	S.P. 1	E. R. McCarthy	1,552	145	56,382					4	19		4	3
Choctawhatchee Bay, Fla.	234	S.P. 1	G. L. Anderson	123	5	3,838	5					1		3	
Texas coast	214	HY.	G. C. Mattison	18,115	18,074	204,222	107	30	6	6	9	4		3	18
Coast of Northern Cal.	W.D.		I. E. Rittenburg		57										
Coast of Northern Cal.			R. R. Lukens						12	15	11				
Coast of Northern Cal.	206	GU.	E. W. Eickelberg	1,899	1,026	11,788						2		2	
Columbia R. and coast of Washington	201	S.P. 3	W. M. Scaife	692	20	34,790	104					16		25	
Columbia R. and coast of Washington	222	S.P. 3	W. M. Scaife						54	380	256				10
Columbia R. and coast of Washington	223	S.P. 3	W. M. Scaife						90	642	373				
Willapa Bay, Washington	232	S.P. 3	W. M. Scaife				70			11	13				
Northern Puget Sound	233	EX.	R. W. Knox	245	14	8,027	41	23	10	15	29	4	2	11	6
Southeastern Alaska	211,220	EX.	G. C. Jones	1,212	36	37,511	72	19	3	4	2	2	1	4	3
Southeastern Alaska	221	WE.	B. H. Rigg	916	50	31,082	72	50	88	258	124	2	1	7	23
Gulf of Alaska	Deep Sea	DI. GU. PI. SU.		6,890		11,110									
Alaskan Peninsula	208	DI.	G. C. Jones	423	30	6,997									
Alaskan Peninsula	219	DI.	G. C. Jones	7,880	5,000	94,448	109	287	12	14	1	5	1	3	4
Alaskan Peninsula	229	DI.	G. C. Jones				13								
Alaskan Peninsula	231	GU.	E. W. Eickelberg	2,315	891	22,112	21	88	17	61	10	2		6	5
Aleutian Ids., Alaska	178,218	SU.	R. L. Schoppe	5,691	1,956	81,677	259	374	47	70	56	24		12	12
Aleutian Ids., Alaska	218	PI.	R. D. Horne	1,196	5,300	5,202	3	8	81	1,060	69	1		3	13
Philippine Islands				15,167	3,370	200,141	101	47	31	191	54	10		14	23
			Totals	89,461	48,742	1,315,015	2,265	1,406	551	2,998	1,311	127	6	160	121

OFFICERS ATTACHED TO SHIPS AND PARTIES DURING THE TEAR

1.	DISCOVERER:	R. L. Schoppe and G. C. Jones, Com'd'g, G. L. Bean, R. R. Moore, G. E. Boothe, L. S. Hubbard, P. C. Doran, H. A. Paton, L.C. Johnson, I. T. Sanders, C. A. Burmister, V. M. Gibbens, C. Le Fever, E. C. Baum, J. C. Tribble, Jr., J. T. Jarman, R. H. Tryon, H. J. Seaborg, G. W. Moore, K. B. Gile, S. N. Davis, and F. J. Soule.
2.	E. LESTER JONES:	L. C. Wilder, Inspr. of Constr., H. A. Paton, and S. B. Grenell.
3.	EXPLORER (New):	A. M. Sobieralski, Inspr. of Constr., J. H. Peters, C. A. Egner. B. H. Rigg, E. B. Roberts, C. A. Burmister, and W. E. Greer.
4.	EXPLORER (Old):	G. C. Jones and R. W. Knox, Com'd'g, L. C. Wilder, E. A. Deily. H. J. Oliver, Jr., J. C. Ellerbe, J. C. Tison, Jr., H.C. Applequist. J. E. Waugh, S. N. Davis, and W. Weidlich.
5.	GILBERT:	C. M. Thomas, Com'd'g, J. P. Lushene, C. A. George. F. J. Bryant, and D. M. Whipp.
6.	GUIDE:	F. H. Hardy and E. W. Eickelberg, Com'd'g, C. Shaw, W. D. Patterson, E. H. Bernstein, I. E. Rittenburg, R. C. Rowse, W. F. Malnate, G. M. Marchand, W. J. Chovan, K. S. Ulm, E. F. Hicks, Jr., E. E. Stohsner, H. C. Conerly, C. F. Chenworth, C. A. Schoene, W. Weidlich, and F. Seymour.
7.	HYDROGRAPHER:	G. C. Mattison, Com'd'g, L. P. Raynor, G. L. Anderson, P. C. Doran, E. R. McCarthy, E. C. Baum, E. B. Lewey, J. N. Jones, J. C. Tribble, Jr., J. T. Jarman, P. C. Weber, C. W. Clark, J. W. Stirni, G. W. Moore, and E. M. Sawyer,
8.	LIDONIA:	R. P. Eyman, Com'd'g, M. O. Witherbee, E. O. Heaton, H. A. Karo, G. E. Boothe, J. C. Bose, S. B. Grenell, J. H. Brittain, C. A. George, F. A. Riddell, K. S. Ulm, A. L. Wardwell, F. J. Bryant, W. R. Jackson, H. Troche, R. C. Overton, and C. R. Jones.
9.	MUKAWE:	F.L. Gallen, Com'd'g, J. C. Partington, C.A. Schanck, M. G. Ricketts, E. B. Brown, Jr., and E. L. Jones.
10.	OCEANOGRAPHER:	F. S. Borden, Com'd'g, H. Odessey, C. D. Meaney, H. E. Finnegan, P. A. Smith, E. B. Latham, E. H. Kirsch, J. H. Brittain, J. P. Lushene, J. C. Mathisson, E. F. Hicks, Jr., J. C. Bull, C. F. Chenworth, W. E. Greer, K. R. Gile, and F. E. Okeson.
11.	PIONEER:	R. D. Home, Com'd'g, H. Odessey, J. M. Smook, J. C. Sammons, R. J. Sipe, S. B. Grenell, R. L. Pfau, W. R. Porter, G. R. Fish, R. C. Bolstad, M. G. Ricketts, J. Laskowski, J. C. Ellerbe, W. R. Jackson, and E. W. Lariviere.
12.	PATHFINDER:	H. C. Warwick, Com'd'g, C. Pierce, H. J. Healy, W. R. Porter, G. E. Morris, M. E. Wennermark, W. J. Leary, and G. W. Hutchison.
13.	SURVEYOR:	A. M. Sobieralski and R. L. Schoppe, Com'd'g, C. A. Egner, G. L. Bean, J. M. Smook, E. B. Roberts, A. C. Thorson, J. C. Partington, J. Bowie, Jr., G. A. Nelson, J. D. Thurmond, H. J. Oliver, J. Laskowski, F. A. Riddell, J. C, Tison, C. R. Reed, W. F. Deane, W. R. Tucker, D. E. Sturmer, R. W. Healy, J. W. Wetzel, and E. G. Simmerman.
14.	WESTDAHL:	H. A. Karo and B. H. Rigg, Com'd'g, G. A. Nelson, G. E. Morris, W. F. Deane, and D. H. Konichek.
Shore Party No. 1:		E. R. McCarthy and. G. L. Anderson, Chief, H. F. Garber, J, C. Tribble, Jr., and P. A. Weber.
Shore Party No. 3:		W. M. Scaife, Chief, I. T. Sanders, O. J. Wagner, and G. R. Reed.
Air Photo Party "A":		L. W. Swanson, Chief, J. N. Jones, R. A. Gilmore, E. L. Jones, W. C. Russell, A. L. Wardwell, and W. R. Jackson.
Air Photo Party. "B":		H. A, Paton and R. J. Sipe, Chief, H. O. Fortin, and F. R. Gossett.
Coast Pilot Party:		K. G. Crosby.
Special Party;		E. R. Gossett.
Wire Drag Party:		I. E. Rittenburg, Chief, W. J. Chovan, H. C. Applequist, and E. E. Stohsner,
Liaison Officers:		B. H. Rigg, and H. E. Finnegan.
Field Stations:		Manila, P. I., F. B. T. Siems; Boston, E. B, Roberts, and R. R. Moore; New York, C. A. Egner, and T. J, Maher; New Orleans, L. D. Graham; San Francisco, R. R. Lukens; Seattle, R. W. Knox, F. H. Hardy, and I. R. Rubottom; Honolulu, T. H., J. H. Peters, and E. O. Heaton; San Juan, Puerto Rico, H. A. Cotton.
Washington Office:		G. T. Rude, Chief of Division; R. F. Luce, and G. D. Cowie, Asst. Chief; R. F. A. Studds, and H. B. Campbell, Chief, Section of Coast Pilot; J. Senior, Chief, Section of Vessels and Equipment, F. L. Peacock, Chief, Section of Field Work.
Other officers attached to Division of H. & T. on duty in Washington Office:		O. S. Reading; J. A. Bond; P. A. Smith, and J. S. Morton.

DIVISION OF TIDES AND CURRENTS

Summary of Statistics - 1939

P. C. Whitney, Chief of Division

R. C. Rowse - W. F. Malnate

Tide Survey - Sacramento and San Joaquin Rivers

Tide stations occupied	12
Number of bench marks leveled to	125

R. A. Marshall

Tide station inspection - Philadelphia Computing Office

Tide stations inspected	10
Number of bench marks leveled to	95

Other Field Activities of Division

Tide stations occupied for general purposes exclusive of hydrographic surveys	84
Tide stations inspected	68
Long-period current stations occupied	2
Short-period current stations occupied	23
Number of bench marks leveled to	775

Chief of Party	Locality	Length of Scheme	Area
		Miles	Sq. Mi.
	TRIANGULATION FIRST-ORDER		
F. G. Johnson	Grantsville-Tooele area, Utah	45	900
	Weber River area, Utah and Wyoming	115	2,925
	Manti area, Utah	85	1,700
	Beaver River area, Utah	95	1,820
	Muddy River area, Utah	140	2,755
	Winslow to Winkelman, Ariz.	110	1,430
	Silver City, N. Mexico, to Nogales, Ariz., and Paradise, Ariz., to Deming, N. Mex.	295	3,540
	Mexican boundary to Baldwin Lake, Calif.	305	4,380
A. P. Ratti	Erie to Boalsburg, Pa.	155	1,705
	Circleville to Fairhaven and Wilmington to Springfield, Ohio	125	1,280
	Vicinity of Selma, Ala.	23	80
	Mobile to Demopolis, Ala.	155	2,480
	Demopolis to Russellville, Ala.	145	2,030
	Childersburg, Ala., to West Point, Miss.	120	1,200
	West Point to Winona to Greenville, Miss.	170	1,600
	Holton to Muncie, Ind.	80	720
	Liberty to Stilesville, Ind.	85	765
C. D. Meaney	Long Prairie to Bemidji, Minn.	115	1,230
	Frazee to Remer, Minn.	70	700
	Minot to Westhope, N. Dak.	60	600
	Waverly to Pocahontas, Iowa	120	1,200
	Thomson to Polo, Ill.	15	180
	Dudley to Saint Marys, Mo., and Scopus, Mo., to Elco, Ill.	130	1,560
	Fredericktown to Ironton, Mo.	40	480
C. D. Meaney and A. P. Ratti	Hudson River, Hudson to Albany, N. Y.	60	660
C. D. Meaney	Lonoke, Ark., to Monroe, La., and Monticello to Arkansas City, Ark.	205	2,050
A. C. Thorson and A. N. Stewart	Mexican boundary to Riverside, Calif.	220	3,080
	Warm Springs to Strawberry, Nev.	130	1,560
R. A. Earle	Laurel Hill, Fla., to Mobile, Ala. (including Niceville to Laurel Hill, Fla., and Pensacola to Century, Fla.)	180	1,620
A. C. Thorson	Earthquake investigation, Brea, Calif.	9	36
	Fields to Crane, Oregon	90	1,800
	Vicinity of Crater Lake, Oreg.	240	6,175
	Lookout Mt. to Stanley, Idaho	50	1,100
	Earthquake investigation, Point Reyes to Petaluma, Calif.	50	1,500
F. B. Quinn	Jackson, Ala., to Bassfield, Miss.	85	850
	Centerville to Marshfield, Mo.	95	950
	Angie to Laurel Hill, La.	90	720
	Bolivar to Sheldon, Mo.	65	780
	Rockport to Waverly, Ill.	50	500

Chief of Party	Locality	Length of Scheme	Area
		Miles	Sq. Mi.
	TRIANGULATION FIRST-ORDER (cont.)		
P. L. Bernstein	Greensburg to Kingman, Kans.	70	700
	Manville to Thermopolis, Wyo.	180	2,520
	Mason to Forest City, S. Dak.	165	2,310
	Marshall, Okla., to Siloam Springs, Ark.	140	1,400
	Monroe County, N. Y.	30	800
	Hornell to Owego, N. Y.	95	1,140
A. N. Stewart	Featherville to Stanley, Idaho	50	1,000
	TRIANGULATION SECOND-ORDER		
L. C. Johnson	Queen Creek area, Ariz.	60	1,320
F. B. Quinn	Kentwood to Garyville, La.	55	500
P. L. Bernstein	Corpus Christi to Brownsville, Texas	140	840
F. G. Johnson	San Clemente Island, Calif.	3	3
	Vicinity of Coronado, Calif.	2	2
	Vicinity of Riverside, Calif.	15	45
M. A. Hecht	Westinghouse Time Capsule, N. Y.	3	3
	BASE LINE SECOND-ORDER		
F. G. Johnson	Coronado, Calif.	0.8	
	TRAVERSE FIRST-ORDER		
A. C. Thorson	Earthquake investigation, Palmdale, Calif.	10.4	
A. C. Thorson	Earthquake investigation, Gorman, Calif.	9.7	
	RECONNAISSANCE FIRST-ORDER		
O. S. Risvold	Manti area, Utah	85	1,700
	Coalville to Mt. Lovenia, Utah	30	300
	Beaver River area, Utah	95	1,820
	Muddy River area, Utah	140	2,755
	Washington County, Miss.	40	360
	Winslow to Winkelman, Ariz.	110	1,430
	Hagerstown to Parkton, Md.	55	550
	Thurmont to Point of Rocks, Md.	25	250
Holmes Ficklen	Hayward, Wis., to Baraga, Mich.	155	2,325
	Oquawka to Galesburg, Ill.	30	300
	Orr to Namakan Lake, Minn.	35	525
	Thomson to Polo, Ill.	15	180
	Rockport to Waverly, Ill.	50	500
	Success to Marshfield, Mo.	40	560
	Laura to Watseka, Ill.	100	1,100
William Mussetter	Southwestern California	525	7,460
	Vicinity of Crater Lake, Oreg.	240	6,175
	McKittrick to Fresno, Calif.	130	3,900
	Santa Barbara to Maricopa, Calif.	40	800
	Sacramento to Round Top, Calif.	95	2,850
	Sacramento River Valley, Calif.	145	6,600
F. B. Quinn	Angie to Laurel Hill, La.	85	680

Chief of Party	Locality	Length of Scheme	Area
		Miles	Sq. Mi.
	RECONNAISSANCE SECOND-ORDER		
O. S. Risvold	Kentwood to Garyville, La.	55	500
	Queen Creek area, Ariz.	60	1,320
C. W. Clark	Corpus Christi to Rio Grande Texas	135	1,080
W. Mussetter	Lucerne Valley to Helendale, Calif.	30	600
	Wilsona to Fairmont, Calif.	60	1,050
	Fairmont to Santa Barbara, Calif.	40	600

LEVELING

Chief of Party	Locality	No. of miles of 1st order	No. of miles of 2nd order	Total no. of miles of 1st and 2nd order
C. I. Aslakson	Illinois	72.7	81.6	154.3
	Indiana	69.3	95.5	164.8
	Kansas	---	181.9	181.9
	Kentucky	7.3	93.2	100.5
	Maryland	14.6	15.5	30.1
	Michigan	1.3	166.5	167.8
	Minnesota	94.7	134.9	229.6
	Missouri	5.9	143.6	149.5
	Ohio	26.0	1.0	27.0
	Virginia	---	56.8	56.8
	Wisconsin	---	69.7	69.7
R. A. Earle	Colorado	141.2	---	141.2
	Missouri	---	3.5	3.5
	Nebraska	23.3	270.3	293.6
	New Mexico	23.4	505.5	528.9
	Texas	93.4	559.6	653.0
	Wyoming	14.6	---	14.6
K. B. Jeffers	Arkansas	114.7	158.9	273.6
	Kentucky	---	33.1	33.1
	Louisiana	521.0	165.4	686.4
	Mississippi	405.8	32.7	438.5
	Missouri	---	16.3	16.3
F. B. Quinn	Colorado	43.0	160.0	203.0
	Idaho	15.0	177.0	192.0
	Montana	8.2	61.3	69.5
	Nebraska	39.7	541.2	580.9
	North Dakota	33.7	444.2	477.9
	South Dakota	0.5	240.9	241.4
R. C. Rowse	California	9.7	---	9.7
G. R. Shelton	Arizona	9.7	263.5	273.2
	California	209.2	1140.7	1349.9
	Nevada	---	114.2	114.2
	South Dakota	---	116.9	116.9
	Wyoming	28.3	150.0	178.3
E. E. Stohsner	California	305.3	---	305.3

ASTRONOMICAL OBSERVATIONS

Chief of Party	State	Number of Determinations: Latitude	Longitude	Azimuth
A. P. Ratti	Alabama			1
	Indiana			1
A. J. Hoskinson	Alabama	1	1	
	Arkansas	1	1	
	Louisiana	1	1	
	Nevada	--	--	1
	New Mexico	1	1	1
	New York	2	2	1
C. D. Meaney	Arkansas			1
F. B. Quinn	Louisiana			1
P. L. Bernstein	Texas			1
R. L. Pfau	Alaska	1	2	2

GRAVITY OBSERVATIONS

Chief of Party	State	Number of Determinations: New	Check
R. W. Woodworth	Arizona	17	
	California	25	
	Delaware	2	
	Idaho	8	
	Illinois	1	
	Kansas	3	2
	Maryland	8	1
	Missouri	1	
	Nevada	2	
	New Jersey	31	
	New Mexico	3	
	Oklahoma	14	5
	Pennsylvania	2	
	Texas	8	3
	Virginia	3	
	Wyoming	5	
R. L. Pfau	Alaska	2	

SUMMARY OF STATISTICS

Geodesy - Fiscal Year 1939

Activity	Number
Triangulation:	
First order	5,147 miles
Second order	278 "
Base lines, second order	0.8 "
Reconnaissance:	
First order	2,265 miles
Second order	380 "
Leveling:	
First order	2,331.5 "
Second order	6,195.4 "
Astronomical observations:	
Latitude stations	7
Longitude stations	8
Azimuth stations	10
Gravity determinations	147
Traverse, first order	20.1 miles

DIVISION Of TERRESTRIAL MAGNETISM AND SEISMOLOGY

Summary of Statistics - 1939

N. H. Heck, Chief of Division
O. W. Swainson, Assistant Chief of Division
J. H. Peters, In charge Honolulu Magnetic Observatory to March 9, 1939
E. O. Heaton, In charge Honolulu Magnetic Observatory from March 10, 1939 to December 31, 1939
H. A. Cotton, In charge San Juan Magnetic Observatory
A. K. Ludy, In charge Cheltenham Magnetic Observatory
R. E. Gebhardt, In charge Sitka Magnetic Observatory
John Hershberger, In charge Tucson Magnetic Observatory
W. D. Patterson, In charge special construction work at Tucson and Sitka Magnetic Observatories

Magnetics

Field Determinations

Chiefs of Magnetic Parties - E. H. Bramhall, H. S. Cole, S. A. Deel, H. E. McComb.

Magnetic Parties	
No. of stations, Declination Determinations only	43
No. of stations, Declination and Horizontal Intensity	4
No. of stations, Declination, Horizontal Intensity, and Dip Determinations	36
Geodetic Parties	
No. of Declination Determinations only	650
No. of Horizontal Intensity and/or Dip Determinations	0
Hydrographic and Topographic Parties	
No. of Declination Determinations only	93
No. of Horizontal Intensity and/or Dip Determinations	0
No. of magnetic observatories in operation	5
Additional Observations not included in 1938 report	
Declination only by Geodetic Parties	155
Declination Only by Hydrographic and Topographic Parties	44

Seismology

Earthquakes reported	425
Seismological instruments in Use;	
Accelerographs	42
Displacement meters	6
Weed seismographs	11
Tiltmeters	3
Shocks recorded, strong-motion instruments	7
Vibration observations made	231
No. of teleseismic stations in operation	20
No. of stations reporting to Science Service for immediate determination of epicenters by Coast and Geodetic Survey	26
Epicenters reported to Science Service	40
Deep well acoustic stations	1

DIVISION OF CHARTS

The commissioned personnel during the 1939 fiscal year consisted of:

Chief of Division	K. T. Adams
Assistant Chief of Division	C. K. Green
Chief of Field Records Section	T. B. Reed
Chief of Aeronautical Chart Section	C. M. Durgin

Some of the outstanding accomplishments of the division during the year were:

The compilation and printing of seven new nautical charts. At the close of the year five new charts were being compiled and six new charts were being reproduced by lithography.

The issue of Chart 5101A, a new type of nautical chart. which contains numerous depth curves and which was especially prepared for the use of commercial and naval vessels equipped with echo-sounding devices.

The printing of new editions for 81 nautical charts.

The compilation and printing of two new Regional Aeronautical Charts (scale 1:1,000,000); and two new Direction Finding Aeronautical Charts (scale 1:2,000,000). The compilation and printing of the first of a series of aeronautical charts for Alaska (scale 1:1,000,000). The printing of 106 new editions of previously published aeronautical charts.

The issue of nautical charts for the year was about the same as for 1938, but the issue of aeronautical charts increased 23 per cent.

The demand for the manual "Practical Air Navigation" was surprisingly large, over 14,000 being issued during the year and in view of the Civil Aeronautics Authority pilot training program, it is expected that the issue for 1940 will be even larger.

The total number of impressions made on the printing presses was 8,105,105 as compared with 7,099,304 for 1938, which number itself was vastly in excess of the number in any other year in the Bureau's history.

February 8, 1939.

FIELD MEMORANDUM NO. 1 - 1939

UNITED STATES COAST AND GEODETIC SURVEY

VALUE OF KEEPING DAILY NOTES FOR DESCRIPTIVE REPORTS

It is apparent from recent descriptive reports that a large number of our field officers keep a day-to-day journal or notebook of information for the descriptive reports of each topographic and hydrographic survey during the progress of field work thereon. The Bureau recommends this procedure as an excellent practice and desires that it become universal.

Such a journal tends to assure a more complete, more accurate and more valuable descriptive report and helps to avoid the omission of important details. It also preserves a desirable freshness of outlook to the time of writing the complete report.

A complete set of notes is especially valuable when the topographer or hydrographer for any reason cannot write the descriptive report, or in the case of hydrographic surveys, the plotting may have to be done by another individual who may not have personal knowledge of the field work. For example, it has sometimes been necessary to have hydrographic surveys plotted at the Washington office. In all such cases the daily notes and written comments of the officer making the survey are invaluable.

The entries in such a journal or notebook should, of course, be neatly made, probably in general from rough memoranda accumulated during the day. Early entries should be reviewed from time to time and any inaccuracies carefully ruled out or the entry restated if necessary. Every entry should be initialed by the maker, and each journal and notebook accompanying an incompletely plotted smooth hydrographic survey or part of a survey submitted to this office for completion should be authenticated by the Chief of Party.

Notebooks which have served their purpose can be destroyed after the complete descriptive report has been prepared.

L. O. Colbert.

Director.

December 9, 1939.

FIELD MEMORANDUM NO. 2 - 1939

UNITED STATES COAST AND GEODETIC SURVEY

Research work recently completed on the Parkhurst theodolites indicates that some of these instruments have been badly damaged by improper handling in the field. Analysis of the abstracts of field observations, supplemented by additional tests in the office laboratory, indicate that some instruments have been misused.

Attention of all field officers is therefore directed to the following two causes of principal instrument damage.

First, the ball races on which the movable slide of the micrometer runs have been badly dented by tightening the two screws which are located on the side of the micrometer box. These screws are carefully adjusted in the office and should <u>never</u> be tightened in the field.

Second, there is evidence that on certain field parties an attempt has been made to remove eccentricity of the graduated circle by manipulating the four eccentricity adjusting screws. In each case serious distortion of the circle resulted which rendered it unfit for field use and necessitated its regraduation.

Chiefs of parties will hereafter not attempt either of the above adjustments in the field without first obtaining the specific authority of this office and will instruct all other personnel in their party accordingly.

If any theodolite is not giving accurate observations, and the reason is not apparent, a full report concerning the difficulty, accompanied by the "Abstract of Directions," should be forwarded to this office.

L. O. Colbert.

Director.

CIRCULAR LETTER

March 27, 1939.

To: All Chiefs of Party.

From: Director,
U. S. Coast and Geodetic Survey.

Subject: Descriptions of Triangulation Stations and Bench Narks.

A great deal of difficulty is experienced in preparing the descriptions of triangulation stations and bench marks in a form suitable for publication or for lithographing. Perhaps few people realize the great amount of additional work that such revision requires. The most important steps in this process are as follows:

1. Descriptions of triangulation stations and of bench marks must be compiled from the original description and recovery cards, putting the compiled descriptions in the standard forms adopted for publication and copying them on the typewriter, using double or treble spacing to facilitate their editing.

2. It then becomes necessary to check the compiled descriptions for all factual data taken from the cards, as distances and directions, and to see that such data are themselves consistent; i.e., feet with meters, directions with azimuths, spelling of proper names appearing more than once, et cetera.

3. When this is done, the compiled and checked description is carefully edited and then retyped in form for lithographing.

4. The master copies are proof-read and made ready for the lithographer.

The point of this circular is to call upon chiefs of party and through them, upon their observers and those in charge of units on their parties, to see that descriptions are written carefully and painstakingly, so far as practicable, with the purpose in mind that they be in finished form for printing as mailed into this office. If each person assigned to such work can be impressed with the tremendous amount of additional work required of the personnel of this office in typing, checking, and copying these data so they can be distributed, I am certain that each one will take steps to furnish the material in a form that will save us much of this trouble. The wasted efforts can be avoided through careful planning by the chief of party and those in charge of the various units of a party by seeing that the descriptions are written in uniform fashion throughout; that they furnish only the basic and essential facts required to locate a station; that all the figures and facts given are consistent within themselves and have been checked; and that the description is as brief as possible, consistent with completeness.

The following paragraphs concerning writing of descriptions should be studied carefully in an attempt to improve the results obtained from the field.

Complete descriptions should be written on Form 525 for all new stations established by the Coast and Geodetic Survey.

Complete descriptions should be written on Form 525 for all stations which have been established by other organizations and which are being used by this organization for the first time. Do not have a reference on the card to the effect that additional information may be obtained from descriptions provided by the organization which established the mark.

The reconnaissance description should not be accepted for the description of a new station, nor the recovery note of an old station. Reconnaissance descriptions contain references to plowed fields, burned haystacks, signs on gates, wagon ruts, and other data of temporary nature. This information, copied into descriptions and recovery notes, is worse than useless after a few years and is often misleading.

Where directions are necessary, they should be given from the town nearest the station. Descriptions have been submitted which gave unnecessary, detailed instructions for going from one town to another. Such information can be obtained from road maps. It is realized that some descriptions have to be lengthy simply because there are no means of finding the station except through a detailed description of the routes or trails leading to it. Fortunately, however, these stations are few. If a station is placed on a prominent or unique point which is well known to people in the vicinity, directions as to how to reach it should be omitted. In addition to being unnecessary, changes in roads, or one mistake in the directions for reaching the station, will lead one astray.

The correct name of a station of another organization which is used, whether re-marked or not, should be ascertained and used, with the initials of that organization placed in parentheses after the name. For example, the station "Wheal Kate", established by the U. S. Lake Survey, should be written "Wheal Kate (U.S.L.S.)". When occupying a station previously established by this Bureau, or by another organization, it should be stated clearly what old marks are found, if and how re-marked, and what new marks were established. This should include a description of the marks and monuments and of the letters, numbers, etc., identifying the station.

The use of abbreviations which are understandable only to the one who writes the description, misspelled words, ambiguous statements, and such, should be avoided. These practices add to the amount of work to be done by the editor and to the danger of changing the intended meaning. To the local user of our data, incorrect spelling of geographical names is a bad reflection on the Bureau. The good will of an owner of property on which stations are located will likely be impaired if his name is misspelled in a description, or if it is used as a station name and incorrectly stamped on the mark.

Recovery notes should be written on Form 526 for stations established by this Bureau. Recovery notes should be written on Form 526 for stations established by other organizations if these stations have been used and described previously by the Coast and Geodetic Survey.

Recovery notes which are direct copies of the original description are not wanted. In some cases the recovery notes which have been sent to the office appear to be exact copies of the original descriptions, but close examination has shown that there probably were changes from the conditions which existed when the original descriptions were written, and the text of the recovery notes varied from that of the earlier descriptions. This presents a difficult problem in revising descriptions, and these changes can easily be overlooked or accidentally omitted. Discrepancies and changes in conditions should be plainly indicated in the recovery notes.

Recovery notes have been submitted with directions and distances from stations to reference marks at variance with those given on the original descriptions. When a new measurement differs from an old one, the correct value should be decided upon before leaving the station. If the earlier value was wrong, a statement to this effect should be made on the recovery note. The distances should be measured twice, once with the metric scale and once in feat. The two measurements, using meters in one case and feet in the other, should be compared, and if not in agreement, remeasurements should be made.

The finished description as furnished the office should be:

(1) Correct as to data.

(2) Grammatically correct and concise.

Correctness of the data can be attained only if a careful check is continually kept upon observers and recorders. The observer should be responsible to the chief of party for the correctness of data. The recorder should write the description directly into the sketch book or record book when the measurements are made, and the observer should check it. All measurements should be made accurately. All distances should be measured independently in feet to 0.01 foot, and in meters to 0.001 meter. Each party should carry a conversion table and convert the measurement in feet to that in meters and compare this value with the measured metric length as a check against errors. Every figure, of either a distance or a direction, every notation of a point of the compass, should be checked and the record should indicate that this has been done.

With regard to grammatical correctness and conciseness of descriptions, the computer or one man on the party with at least the rating of observer, and who is a good typist, has a good command of English and who is painstaking and willing to follow exact instructions, should be assigned to <u>edit</u> the <u>checked</u> descriptions as turned over by the individual observers. He <u>should</u> read all descriptions to detect ambiguity or other errors, and make changes when necessary. Whenever a major change is made, the observer should be consulted. It may be found necessary to make a field inspection occasionally to clear up an ambiguity in a description. Every error found in the descriptions by the <u>field editor</u> should be corrected in <u>red ink</u>.

The field editor should not degenerate into a description writer for all observers who merely turn over notes to him to write descriptions. Each description as turned over to the field editor by the observer must be complete in all details.

The chief of party should examine the edited descriptions to ascertain that this work is being properly accomplished, and that the descriptions being sent to the office are suitable for reproduction for general distribution.

Read carefully also the following references:

Special Publication No, 120, Manual of First-Order Triangulation, page 106.

Special Publication No. 145, Manual of Second- and Third-Order Triangulation and Traverse, page 110.

Special Publication No. 140, Manual of First-Order Leveling, page 31.

Your cooperation in this matter is urged in order that we may obtain records in this office in a form that will eliminate much of the wasted effort necessary heretofore.

L. O. Colbert.
Director.

CIRCULAR LITTER

March 27, 1939.

To: All Chiefs of Geodetic Parties.

From: The Director,
U. S. Coast and Geodetic Survey.

Subject: Sign Posts at Survey Monuments.

In order to aid in the preservation, and to serve as a means of easy recovery, of control survey monuments, you will, in so far as practicable, set wooden posts adjacent to concrete monuments which are set flush with the surface or which project but a few inches above the ground. These posts will be set for monuments established along public highways in rural districts, along the rights of way of railroads, in wooded areas, and along the shore lines of rivers, lakes or oceans. These posts need not be set for monuments established along business streets or in residential sections of cities, on the grounds of schools or churches, in cemeteries, in cultivated farm lands, or on bare mountain tops. For horizontal control survey monuments established in cultivated fields and set below the surface of the ground, these posts shall be set at the reference marks.

The post used shall be of commonly available stock at least 4" x 4" in cross section, set at least three feet in the ground and projecting at least 18" above the surface. It shall be painted white and shall have the legend "USBM", "US △ " or "US △ REP. MK." stenciled in black letters on the surface facing the monument. The top of the post shall be neatly dressed to a pyramid shape. The post should be set at least three feet and not more than five feet distant from the monument in a location where it will not affect subsequent survey operations. The description of station should state that these posts have been set.

Stencils with the letters "US", "BM", "REF", and "MK" are being prepared and will be mailed to the chiefs of parties requiring them.

You will call the attention of highway, county and local engineers to these monuments and enlist their cooperation in the preservation and maintenance of the markers and posts. For monuments established along roads controlled by State Highway Departments you will notify the Division Engineer. If the highways are maintained by the County, you will notify the County Engineer. In those states where the Works Progress Administration is operating local control survey projects you should acquaint the directing head of the survey with the locations of these points. In so far as possible you should establish personal contact with these engineers and explain the purpose of the surveys, in order that they may use them in their local surveys and thus have a personal interest in preserving them.

You will please acknowledge receipt of this circular letter. These instructions are to become effective immediately.

L. O. Colbert.
Director.

CIRCULAR LETTER

May 19, 1939.

To: All Chiefs of Parties.

From: The Director,
U. S. Coast and Geodetic Survey.

Subject: Recovery Notes for Triangulation Stations.

Prior to 1916, triangulation stations were not described on cards, instead the descriptions were written in books and filed in the library. Hence, whenever descriptions of stations prior to that date are required in the field, it is necessary to secure these volumes from the library and photostat them. This process is laborious and expensive.

An attempt is now being made to prepare lithoprints of descriptions and recovery notes as they are received from the field. In order to accomplish this the recovery notes for old stations should be adequate, carefully typed, and should constitute a complete description of the station.

Therefore, the following instructions will be carefully complied with by all chiefs of party for rendering recovery notes on all stations established prior to 1917 and on those stations established subsequent to 1917 whose original descriptions are not complete or correct.

(1) The recovery note should constitute a complete description. It should state definitely what old marks are recovered, how the station is re-marked and what new marks are established.

(2) It shall be compared with all available previous descriptions or recovery notes and any discrepancies shall be specifically explained.

(3) All distances and directions shall be compared with previous descriptions and any discrepancies specifically noted and verified.

(4) Recovery notes shall be written on <u>one side</u> of the card only. If there is insufficient space, a second or third card shall be used and all cards numbered and cross referenced.

(5) If new directions to reach a station are given, explanation should be made as to why the previous directions were unsatisfactory.

(6) If previous measured distances are slope distances, new horizontal measurements should be made and indicated as such to explain the difference in distance. It is always assumed that measured distances are horizontal unless otherwise stated.

(7) Compass directions, when given, should be reasonably accurate. In recovery notes recently received from the field, errors of from 45° to 180° were found in compass directions.

(8) Notes should be used to describe the type of marks only when they fit the case exactly. Thus, note "6d" should not be used to de-

scribe a mark set in an iron pipe for "6d" refers to a standard disk set in a tile.

(9) Stations established by other bureaus, such as the U. S. Geological Survey, U. S. Engineers, U. S. Lake Survey, General Land Office, and others, as well as state and county boundary monuments, to which connections are made, should be described as new stations and not as recovery notes. The initials of the bureau which established the station should be placed in parentheses after the name of the station: (U.S.G.S.) (U.S.E.). The description should be complete, for the descriptions by the other bureaus usually are not on file in this office. It should be clearly stated what old marks were found, whether the station was re-marked and how, and what additional reference marks were established. The description should also state whether the old station was used as one of the stations in the new scheme or whether a new station was established nearby and connection made to the old station by measured distance and azimuth.

(10) The typing should be clear and legible, with a minimum of erasures.

(11) The initials of the person editing the card should appear in the lower right-hand corner of the card.

L. O. Colbert.
Director.

ACCUMULATIVE AUTHOR INDEX

	Vol.	Page
ADAMS, K. T.		
Buoy Control for Offshore Surveys	2	67
Echo Soundings	2	46
Echo Sounding, the Graphic Recorder	6	57
Engraved Charts	10	93
Fathometer Operation, A Trick of the Trade	2	59
Hydrographic Recording	2	57
Reproduction of Original Surveys	10	165
Report on Echometre	4	81
Star Sight Positions (Hawaiian Islands)	2	10
Use of a Theodolite as a Telescopic Pelorus	2	60
ADAMS, O. S.		
Adjustment of a Complete Quadrilateral When All Lengths are Measured	4	17
Some Results Obtained in the Readjustment of the Triangulation in the Eastern Half of the United States	4	10
ANDERSON, G. L.		
Taut-Wire and Sun-Azimuth Traverse Computations	11	53
Taut-Wire, Sun-Azimuth Traverses (Discussion)	12	78
ARMY & NAVY REGISTER - (Reprint from)		
Good Will for the Services	7	55
Loyalty	3	110
ASLAKSON, C. I.		
Gravity Observations and Their Uses	11	14
Marking Gravity Stations	11	49
Operation of a Large Steel Tower Triangulation Party, The	8	115
Precise Alignment	13	1
Rapid Method of Determining Approximate Spherical Excess in Triangles	6	43
Theodolite Micrometer Tests	13	84
AUSTRALIAN SURVEYOR - (Reprint from)		
Auto Helio Beacon	3	95
BAINBRIDGE, W. H.		
Hurricane of September 2, 1935		
BERGER, L. H. (from Civil Engineering)		
Care of Surveying Instruments, The	13	140
BERNSTEIN, E. H.		
Some Supplemental Uses of Air Photo Topographic Sheets	3	82
BERNSTEIN P. L.		
Trucks and Triangulation	13	121
BILBY, J. S.		
Circuit Closure	11	28
Notes on Marking Triangulation	7	25
Notes on Recovering and Remarking Stations	6	83
BOLSTAD, R. C.		
Air Photo Compilation Methods (Effect of Humidity on mountings)	7	186
BOOTHS, G. E.		
Improved Clearness in the "clicks" of Price Current Meters	4	111
Tide and Current Survey of Buzzards Bay, Mass.	4	109
BORDEN, F. S.		
Aluminum Mounted Topographic Sheets	5	34
Azimuth Buoys	2	76
Buoy Control for Offshore Surveys	2	71
Coastal Triangulation	3	26
Cost of Hydrography	4	48
Dorsey Fathometer, Operating Notes	10	122
Gulf of Maine Temperature	2	92
How Shall We Distinguish Fourth Order Triangulation Stations	3	106
Measuring Strong Currents in Comparatively Deep Water	2	62
RAR Sono-Radio Buoy	10	142
Serial Temperatures	4	112
Taut-Wire, Sun-Azimuth Traverses	12	71
Tidal Observations at Sea	11	112
BOWIE, JOHN, JR.		
Horses, Hydrographers and Hypsography	11	113
Theodolite Circle Tests	3	44
BOWIE, WILLIAM		
Earth as an Engineering Structure, The	3	63
Natural Resources	8	77
Possible Cause of Sub-Surface Earthquakes, A	5	44
Progress of the Expanded Plan for Control Surveys	3	18
Status of Federal Control Surveys, The	6	14
Reinforcing Concrete Bench Marks	5	57
BRAMHALL, E. H.		
Magnetic Observations in Alaska (Extract from Season's Report)	13	175
BRITTAIN, J. H.		
Computation of Plane Co-ordinates	9	49
BROWN, C. D. (From The Canadian Surveyor)		
Survey Pests	13	95
BROWN, R. L.		
Use of Range Finders for Hydrographic Surveying	5	84
BURGER, W. H.		
Plotting Arcs of Circles with Large Radius and Comparatively Small Angle at the Center	4	62
BURMISTER, C.		
Hydrography - Echo Soundings - Limitations	1	19
CAMPBELL, H. B.		
The 1931 Season in Southwest Alaska, Ship DISCOVERER	4	95
CARMICHAEL, TROY (From Engineering News-Record)		
Where the Decimal Point Goes	13	72
CARPENTER, J. C.		
Geodetic Surveys and Mapping	7	67
CHOVAN, W. J.		
Compilation of Aerial Photographs of the East Coast of Florida	3	35
Method of Improving Poor Quality Leadline	7	54
CHURCH, E. F.		
A Hint to Topographers	3	98
CIVIL ENGINEERING - (Extracts from)		
Geodetic Control Essential	5	95
CLARK, E. S.		
Rodman's Reverie	8	2
COLBERT, L. O.		
Message from the New Director	12	1
COMMONS, GEORGE C.		
Correcting Closure Error	12	193
CONNAUGHTON, JAMES E.		
Strange Property Descriptions, Eastern Long Island	13	58
COWIE, G. D.		
Adjustment of a Complete Quadrilateral When all Lengths are Measured	4	17
Buoy Control (East Coast of Florida, 1931)	3	101
Co-ordinating the Triangulation in the Vicinity of Norfolk, Virginia	6	20
Determination of Velocity of Sound in Sea Water in Cape Cod Bay	4	88
Notes on Star Observations	2	20
Rating of Patent Logs	3	67
Relating Magnetophone to Buoy Anchor on RAR Buoy Control Hydrography - Methods Used on the LYDONIA	4	16
Sono-Radio Buoy	10	147
Use of Range-Finders for Hydrographic Surveying	5	83
CROSBY, K. G.		
Rack and Worm Sextant	5	114
Report on New Type of Hydrographic Sextant	5	114
CROWTHER, E. T.		
Newspaper Publicity	9	88
DEANE, W. F.		
Hydrographic Signal with Triangular Gross-Section	3	91
DEETZ, C. H.		
Map Projections	5	1
Simplicity in Maps	13	134
Thomas Alexander Harrison (1853-1930), a Tribute	6	24
DEILY, EARLE A.		
Neptune Oriental	10	72
New Shoals for Old	13	34
DORSEY, H. G.		
Electromagnetic Hydrophones or "Magnetophones"	12	209
Fathometer, Type 432	5	53
Lighted Survey Buoys (comment)	13	26
Notes on Fathometer Operation	4	99
Portable Depth Recorder	13	100
Portable RAR Stations	3	72
Portable RAR Transmitter of Unique Design	7	34
Radio Acoustic Ranging Circuits	11	99
Sono-Radio Buoy Improvements (comment)	13	130
The Transmission of Sound Through Sea Water	2	28
White Light Echo Soundings	4	111
DREISONSTOK, J. Y.		
Creating a Horizon	5	61
DURGIN, C. M.		
Savannah, Georgia to Jacksonville, Florida, Triangulation, Coastal Co-Ordinating Scheme	7	50
EGNER, C. A.		
By-products of Chowan River Survey	5	90
Can You Equal It?	3	114
Coastal Triangulation	3	22
Framing of Wooden Scaffolds	8	52
Peculiar Refraction Condition at Bear Mountain, N.Y.	6	31
Range Finders and Balloons	3	107
Short Counterweight Buoy for Use in Shoal Water	4	80
Tall Wooden Triangulation Towers	6	23
Tubes for Mailing Sheets	3	104
Use of Aluminum Sheets	3	93
EICKELBERG, E. W.		
Aluminum Mounted Topographic Sheets	5	33
Bering Sea Survey	13	73
Bosshardt-Zeiss Self-Reducing (Double Image) Tachometer, Report of Inspection of the	9	45
Division of Terrestrial Magnetism and Seismology, The	10	172
Electrification of Ship's Patent Logs	2	51
From Season's Report (1929) Ship EXPLORER	1	14
Gas Engine Driven Sounding Machine	2	42
Lituya Bay, Gulf of Alaska	10	136
Local Magnetic Disturbances	5	22
New System of Conducting Magnetic Survey	4	87
Second International Polar Year Program	6	45
Sono-Radio Buoys in 1938 (Extract from Season's Report)	12	199
Topographic Methods and Equipments	2	78
Turning Lines in Precise Dead Reckoning	3	94
Use of Navigational Ranges for Obtaining Compass Deviations, The	9	33
ELLIS, E. P.		
Extracts from Reports on Hydrographic Sheets	4	91
ELLISON, W. A., Jr.		
Fishing Hardships on Georges Bank	5	77
EMPIRE SURVEY REVIEW - (Reprints from)		
Life in a Survey Ship	8	82
Geodetic Diplomacy	6	53
Scottish Bard and English Rover	11	60
ENGINEERING NEWS-RECORD - (Reprint from)		
Grief Book	3	17
ENGLE, F. G.		
Automatic Brake Sounding Machines	11	61
EVENING STAR, WASHINGTON, D. C. - (Editorial from)		
Century of Service	4	117
EVERETT, G. H.		
Geographic Names	11	105
EWING, MAURICE		
Frequency of Water Waves	10	65

	Vol.	Page
EYMAN, R. P.		
Demountable Pipe Topographic Stand	10	161
Fathometer Operation in Shoal Water	6	55
Protractor Pitting for Wire Drag	10	159
Rapid Method of Swinging Ship, A	6	82
Sono-Radio Buoys in 1938 (Extract from Season's Report)	12	200
Sono-Radio Buoy Improvements (comment)	13	133
Special Drag Work (Extracts from Descriptive Report)	12	131
Tracking Down Survey Buoys	13	106
FAILY, CRAWFORD F.		
Heeling Error in Radio Direction Finder Bearings	13	93
FARWELL, R. F.		
Critique of American Collision Law	7	100
FASSETT, F. G.		
Georges Bank, Valley of Mystery	2	24
FINNEGAN, H. E.		
Use of Pipe Drag on Wire Drag Survey	5	109
Small Scale Sheets for Form Lines	11	108
FISH, G. R.		
Second Order Leveling in Arkansas	5	125
FORNEY, STERMAN - (Letter from)		
Transfer of Alaska to the United States	5	35
GARNER, C. L.		
Control Survey Criteria (comment)	13	118
New Method of Measuring First Order Bases	5	71
Refraction (on first order triangulation)	2	44
Time Capsule, The	12	2
GILMORE, ROSS A.		
Fishing in the Aleutian Islands with a Lead Line for a Topographic Sheet	9	32
Plane-Table Traverse by Wire	13	71
GRAHAM, L. D.		
Plotting Three Point Fixes without the Use of a Protractor	7	91
GREEN, C. K.		
"Average"- Hydrographic Survey, The	10	179
Electric Sounding Clock	5	112
New Type of Nautical Chart, A	12	7
GRENELL, S. B.		
Grinding the Points of Croquill Pens for Inking Celluloid Sheets	7	196
Ohio Flood-Relief Work	11	4
Projector for Transferring Detail from Odd-Scale Photographic Compilations to Hydrographic Sheets, A	9	23
GRIFFIN, R. H. (from Civil Engineering)		
Care of Surveying Instruments, The (comment)	13	144
HANSON, EARL		
Big Business is Boarding the Trawlers	2	36
HARDY, F. H.		
Extracts from Season's Report - Ship GUIDE	9	55
Fathometer Dial Speed Regulation	12	114
From Season's Report, Commanding Officer, Ship SURVEYOR, Southwest Alaska, 1930	3	108
Uses of Computing Machines on Board a Survey Vessel	1	13
HARTLEY, H. H.		
Plane Table Notes	9	89
HEATON, E. O.		
Control Surveys of Rochester, New York and Atlanta, Georgia	6	67
Rapid Method of Determining Approximate Spherical Excess in Triangles	6	43
Use of Sidereal Chronometers for Star Sight Observations	4	116
Wireless Longitude Observations in Mid-Pacific	5	70
HECHT, M. A.		
Rating of Patent Logs	3	67
HECK, N. H.		
Early Observations in the Red Sea	10	85
International Geodetic & Geophysical Union Meetings, Stockholm, Sweden, 1930	2	39
Montana Earthquake of October 18, 1935, The	9	38
Origin of the Submarine Valleys Along the Southern Edge of Georges Bank, The	3	87
Recording of Strong Earthquake Motions	4	26
Reinforcing Concrete Bench Marks	5	57
Reminiscences of Wire Drag Work	3	47
Sounding to Granite	9	62
Start of the Acoustic Work of the Coast & Geodetic Survey, The	5	45
Submarine Scarp off Cape Mendocino (comment)	13	32
Tidal or Seismic Sea Waves	7	29
Visit to Massachusetts Institute of Technology Surveying Camp	8	79
HEMPLE, H. W.		
Auxiliary Switch Used on Motor Truck, Employed in Erecting Steel Towers	3	99
Care of Surveying Instruments, The (comment)	13	145
Centering the Tripod Head	2	57
History of the Local Control Surveys Project	8	16
Pointing with Instrument put of Focus	2	60
Rejection of Observations on Initial When Observing Horizontal Directions	5	113
HICKS, E. F.		
Short Counterweight Buoy for Use in Shoal Water	4	80
HORNE, R. D.		
Triangulation, (Smoke Difficulties Over Cities)	6	50
	1	18
HOUGH, F. W.		
Taking Out the Mean	4	113
HUBBARD, L. S.		
Distortion of Sheets, and Adjustment of Traverses	1	35
Refraction on Georges Bank, 1931	5	58
Review of Astronomical Work and a Study of Errors (Georges Bank, 1930)	3	13
Summary of Data for Buoy Control, Georges Bank	4	25A
INSPECTOR, SAN FRANCISCO FIELD STATION		
Strong Motion Seismographs	7	126
JEFFERS, K. B.		
Basic Bench Marks in New Orleans	13	98
JONES, B. G.		
Common Errors of Inexperienced Personnel in the Compilation of Air Photographs	9	40
Nine-lens Air Camera in Use, The	12	120
Topographic Instruments, Equipment and Methods	2	74
JONES, G. C.		
Gasoline Driven Sounding Machine, Another Type	7	33
New Design for Launch Sounding Chair	3	97
Skiff Wire Drag, The	12	133
JONES, DR. H. S. F.R.S. (From "Nature")		
Royal Research Ship RESEARCH	10	107
JORDAN, G. F.		
Least Depth on Shoals Effectively Determined	13	83
Toward a More Perfect Chart	13	137
KARO, H. A.		
Extracts from Season's Report, 1936	11	86
Glacier Bay (Extract from Season's Report)	12	202
Topography in Glacier Bay (Extract from Season's Report)	12	233
KARP, M. A. (from Engineering News-Record)		
Sign Language Numerals	12	192
KASTER, H. B.		
The Spherant, an Instrument for Observing Hour Angle or Latitude Directly	2	78
KAUFMAN, H. P.		
ABC of Triangulation Adjustment, The	8	88
Impressions of a Mathematician in the Field	8	23
KAY, JOHN D.		
Flight Check of Aeronautical Charts	11	91
KESSLER, W. W.		
Disturbance by Earthquake While Observing	8	80
KIRSCH, E. H.		
Special Fishing Charts of Georges Bank	5	75
KNOX, R. W.		
Gasoline Driven Sound Machine	7	31
Velocity of Sound in Sea Water, Coast of Northern California	1	20
LAMBERT, W. D.		
Note on Reducing Inclined Angles to Differences in Azimuth	3	61
LANDE, L. C.		
Test Radial Plot of Nine-lens Photographs, A	12	126
LATHAM, E. B.		
Study of Refraction on the Boulder Dam Survey	12	181
LEFEVER, CURTIS		
Shell Mounds of the Pacific Coast and Their Relation to the Rate of Erosion	1	34
LOCKERBIE, A. A.		
Triangles Again	8	112
Transparent Diagonal Scale, The	8	113
LUCE, R. F.		
Establishment of Range Beacons for Measured Mile Speed Course	9	98
LUKENS, R. R.		
From Season's Report (1929) Ship SURVEYOR	1	15
Loss of the "Jefferson"	4	40
Mutiny of the Schooner "EWING"	3	83
The "PATHFINDER" in the Typhoon of 1905	9	10
Through the Straits of Magellan on the PATTERSON	13	16
LUSHENE, J. P.		
Gravity Observations in the Bahama Islands	5	98
LYON, T. C.		
The Foucault Pendulum Experiment	8	20
MacMILLAN, D. H.		
Echo Sounding in Harbour Hydrography (from The Dock and Harbour Authority)	12	136
MAHER, T. J.		
Check on Fathometer Soundings, A	4	85
Coast Survey on the Pacific Coast, The	8	126
MALNATE, W. F.		
Speed Plotting on Radio Acoustic Ranging	12	88
MARBOIS, A.		
United States Coast Pilots, The	12	90
MARCHAND, G. M.		
Air Photographs in Hydrographic Surveying	12	231
Sono-Sadio Buoys in 1938	12	194
KATHISSON, J. O.		
Serial Temperatures by Bathythermograph	13	108
MATTISON, G. C.		
Circles for Plotting Positions on Sounding Line	6	81
Coral Shoals of Palawan	4	115
Lighted Survey Buoys	13	24
Plotting Circular Arcs on Offshore Hydrographic Sheets Without Use of Beam Compass	9	43
Taut-Wire Sun-Azimuth Traverses (Discussion)	12	76

	Vol.	Page
McARTHUR, L. A.		
Leveling Cooperation in Oregon	4	5
MCCARTHY, E. R.		
Special Sounding Lead Used in Manila Harbor, P.I.	5	115
Wooden Towers for Triangulation	8	56
MCCARTHY, R. L.		
Lead Shot Buoy Spacer for Wire Drag	9	36
McILWRAITH, C. G.		
Sono-Radio Buoy, The	10	143
McKAY, E. C.		
Recent Improvements in Standard Automatic Tide Gage	11	88
MEANEY, C. D.		
Extracts from Report on Atlantic Coast Arc, First Order Triangulation	7	48
Recovery of an Important Triangulation Station	6	50
Testing Graduated Theodolite Circles	7	88
MEDINA, MANUEL		
New Connection of the Geodetic Triangulations of Mexico and the United States of America Across the Frontier of Both Countries	4	38
MILITARY ENGINEER - (Reprints from)		
U. S. Naval Surveys	4	116
Working Without Maps	4	122
MIRICK, R. F.		
Sign Language Numerals(from Engineering News-Record)	12	192
MITCHELL, H. C.		
Area Triangulation	4	112
Control Survey Criteria	13	114
Old Surveys and New	4	53
MITCHELL, T. J.		
Rectangular Coordinates	10	69
Survey for Correcting Tax Descriptions, A	7	73
MOORE, GLENN W.		
Difficulties in First-Order Leveling	10	87
Taut-Wire Sun-Azimuth Traverses (Discussion)	12	79
MOORE, WARREN L.		
Field Method of Changing the Scale of Topographic Features	9	14
MORRIS, G. E., Jr.		
Bogoslof Island	10	110
Resurvey of Taku Inlet, The (from The Alaska Sportsman)	12	44
MURCHIE, Capt. P. A.		
Letter of Appreciation	8	26
MURRAY, H. W.		
Submarine Scarp off Cape Mendocino, California	13	27
MUSSETTER, WILLIAM		
Larger Station Marks Required in Texas	3	104
Problem of Reconnaissance, The	8	110
NELSON, G. A.		
Aluminum Mounted Topographic Sheets	5	31
NAUTICAL GAZETTE - (Extracts from)		
Temperature Depths Graphs, Logarithmic Plotting	10	91
Plea for the Other Side (Re - "Dial Navigator")	10	95
Wireless Sounding Apparatus	5	69
NAUTICAL MAGAZINE - (Reprints from)		
Extract from July 1935	9	68
Mistakes We Make	4	108
Review of Bulletin	5	125
ODESSEY, H.		
Bomb Returns, Radio Acoustic Ranging	8	136
Speed Plotting on Radio Acoustic Ranging	12	86
PACIFIC MARINE REVIEW - (Reprint from)		
Personal Equation at Sea, The	4	42
PARKER, J. W.		
Extracts from "The Need for Speech Training for Engineers"	4	86
PARKER, W. E.		
Determination of Velocity of Sound, Georges Bank	6	38A
Operation of Two Ships Using the Same Pair of Hydrophone Stations	5	18
Plotting and Adjustment of the 1932 RAR Buoy Control Scheme on Georges Bank	6	36
Triangular Hydrographic Signal Towers		75
Use of Range Finders for Hydrographic Surveying	5	79
Use of Telescopic Alidade for Obtaining Bearings	5	68
Variation in Salinity, Coasts of Louisiana & Texas	7	57
Velocity of Sound in Sea Water	7	6
Water Signals and Buoys Used by Ship HYDROGRAPHER	8	50
PARKHURST, D. L.		
Planetable Clamp for Metal-Mounted Plane-table Sheets	10	160
PARTINGTON, J. C.		
Aluminum Mounted Topographic Sheets	6	22
PATON, H. A.		
Hydrographic Signal with Triangular Cross-Section	3	91
Outboard Motor for Hydrography	7	128
PATTERSON, W. D.		
Fault Noises Studied as Possible Earthquake Warnings (from Engineering News-Record)	12	47
More Speed	3	105
Keeping on the Sounding Line	3	97
Plotting and Adjustment of the 1932 RAR Buoy Control Scheme on Georges Bank	6	33
Stagger the C.O.'s and Execs	3	107
PATTON, R. S.		
First Hundred and Fifteen Years, The	4	1
Mapping from the Air	7	130
Message from Our Director	2	1
Moriches Inlet: A Problem in Beach Evolution	7	93
Relation of the Tide to Property Boundaries	13	44
Scientific Work of the Coast and Geodetic Survey	7	36
PEACOCK, F. L.		
Calibration of Radio Direction Finder	2	38
Chernikeeff Electric Log, The	2	49
Interesting Submarine Configuration off California Coast	6	5
Organization of the Party on Ship OCEANOGRAPHER for Hydrographic Work on Georges Bank, 1930	3	28
Steering on Ship OCEANOGRAPHER (Abstract)	3	81
PIERCE, CHARLES		
An Unique Station Mark	6	38
One Way to Build a Tall Signal	2	60
Plotting Three Point Fixes Without the Use of a Protractor	13	155
Special Station Marks	5	109
Triangulation - Ship Intersection Method	13	20
PRICE, T. M., Jr.		
First Thousand Years of Finding New York	12	142
Recoveries by Old Maps and New Photographs	12	208
RAPPLEYE, H. S.		
Preparation of Bench Mark Descriptions, The	7	20
RAYNOR, L. P.		
Aluminum Mounted Topographic Sheets	5	32
Calibration of Taut-Wire Apparatus	12	84
Consol Oil for Rust Prevention	12	232
Lines of Position-Sumner Bisectrix	1	31
Sono-Radio Buoy "Gulf" in 400 Fathoms	13	148
READING, O. S.		
Aerial Photography and Coast Surveys	3	9
A Fifty Inch Precision Copying Camera	8	140
Lessons of the Expanded Photo-Mapping Work of the Coast & Geodetic Survey in Relation to Plans for Accelerated Mapping	8	118
Nine-Lens Aerial Camera of the C. & G. S., The	9	56
Notes on Control for Aerial Photographs	3	68
Projection Ruling Machine of the Coast & Geodetic Survey, The	10	133
Sacramento - San Joaquin Delta Project, The	4	50
REED, T. B.		
Changes in Shoreline, Coast of Louisiana	8	78
Determination of Velocity of Sound in Sea Water in Cape Cod Bay - Wire Base Test Line	4	89
Salinity & Temperature Diagram	4	14D
Summary of Data for Buoy Control Georges Bank	4	25A
Theoretical Velocity of Sound in Sea Water (Georges Bank) and Its Practical Use in RAR Hydrography	5	37
Velocity of Sound Diagrams	5	43A & B
Velocity of Sound in Sea Water (Coast of Maryland, 1933)	7	115
REESE, MARSHALL H.		
Additional Notes on Air Photo Compilation	9	70
Air-Photo Topographic Sheets, East Coast of Florida	5	124
RIDDELL, F. A.		
Relating Magnetophone to Buoy Anchor on RAR - Buoy Control Hydrography - Methods Used on the HYDROGRAPHER	4	15
The 432 Type Fathometer	5	50
RIESENBERG, CAPTAIN FELIX		
Dial Navigators, The	9	13
RIGG, B. H.		
Long Island Sound Mystery Solved by a Wire-Drag Party	3	50
Use of Air Topographic Sheets for Hydrographic Control	3	79
Wire Drag Tester	2	59
RINGWOOD, T. E.		
Advantages of Geodetic Control for Cadastral Surveys	7	70
RITTENBURG, I. E.		
Pacific Coast Wire Drag Survey	13	81
Search for Lost Plane, Great Salt Lake, Utah	10	98
Tide and Current Survey of New York Harbor	6	63
Wire Drag Surveys, Pacific Coast, 1934-1937	11	9
ROBERTS, E. B.		
Gyro Equipment of the HYDROGRAPHER	5	64
Roberts Offshore Tide Gage	7	8
Watch the Unoccupied Stations	4	114
ROBINSON, V. H. (from Nautical Magazine)		
Echo Sounding Recording Gear, The	4	96
ROWSE, R. C.		
Aluminum Mounted Topographic Sheets	5	30
RUDE, G. T.		
Determination of the Compass Error, The	4	35
Earth's Rotational Force and Navigation	7	42
Echo Sounding, The Graphic Recorder	6	57
HYDROGRAPHER, The	3	40
Message from a New Division Chief	3	51
Review of Progress, A	12	32
RUSSEL, H. N.		
Notes on Bubble Sextants and Gyro-Horizons	6	54
SCAIFE, W. M.		
Triangulation Equipment for Mountain Work in Alaska	4	78
SCEOPPE, RAY L.		
Extracts from Season's Report, 1937	11	117
SCIENTIFIC BOOK, CLUB REVIEW - August 1936 - (copy from)		
Capt, Heck's Book Selected by Scientific Book Club Review	10	90
SENIOR, JACK		
Floating Signals	4	115
Sono-Radio Buoy	11	25
SERAN, H. A.		
Calibration of Taut-Wire Apparatus, Ship OCEANOGRAPHER	8	3
Hurricane of Aug. 23, 1933 at Norfolk, Virginia, The	7	58
Recent Legislation	5	126
Some Personal Recollections of Over 20 Years Ago	1	37
Taut-Wire and Sun-Azimuth Traverse Control - Atlantic Coast - Maryland and Virginia	9	5
Taut-Wire Measuring Apparatus	7	1

	Vol.	Page
SERVICE, J. H.		
Comparison of Velocity of Sound Tables of British Admiralty with those of the U. S. Coast & Geodetic Survey	1	32
SHALOVITZ, A. L.		
Conversion of Radio Bearings to Mercatorial Bearings	5	101
Data for Studying the Transmission of Sound Through Sea Water	2	79
	5	118
Examination of Charted Shoal Areas	7	32
Extract from Report on Hydrographic Sheet 5085	4	113
Extracts from Reports on Hydrographic Sheets	4	91
Geographic Datums of the Coast & Geodetic Survey, The	12	10
Hydrography - Slope Corrections for Echo Soundings	1	19
Proposal to Honor Isaac Ingalls Stevens	13	125
Treatment of Rocks on Hydrographic Surveys	6	27
Treatment of Rock Symbols on Hydrographic Surveys	7	125
Transmission of Sound Through Sea Water (Comments)	3	103
Units for Recording, Reducing and Plotting Soundings	6	80
SHAW, H. S.		
Jefferson Davis: An Early Friend of the Coast Survey	5	14
SHELTON, G. R.		
Correcting Inclined Sextant Angles	2	47
SHEPARD, F. P.		
Canyons South of Georges Bank	6	39
Echo Sounding in Submarine Valleys	7	127
Origin of the Submarine Valleys Along the Southern Edge of Georges Bank, The	3	87,90
SIEMS, F. B. T.		
Azimuth Buoys	2	76
Determination of Position by Sun or Star and Two Fixed Objects	1	28
Drawing RAR Distance Circles of Long Radii	3	99
How Shall We Distinguish Fourth Order Triangulation Stations?	3	105
Improvised Erasing Machine	3	97
Light-Star Sights	12	95
Notes on Fathometer Operation	5	49
Notes on Fathometer Operation	4	97
Reduction of Inclined Angles to Horizontal Angles	3	60
Southwest Alaska, The 1931 Season, Ship SERVEYOR	4	94
SIPE, R. J.		
Triangulation in Narrow Inlets	12	68
SMITH, PAUL A.		
Eccentric Reduction Diagram	4	34A
How Shall we Distinguish Fourth Order Triangulation Stations?	3	106
Operation and Organization, First Order Triangulation	4	12
Recent Acoustic Work of the U. S. Coast and Geodetic Survey	8	60
Side Equation Test Used in the Field	4	29
Some Reflections on Echo Sounding	13	59
Submarine Valleys	10	150
The Fifteenth International Geographic Congress, Amsterdam, 1938	12	53
Three Point Fix: Graphical	9	97
Triangulation, Need of Short Lines in Cities	4	47
Watch the Unoccupied Stations	4	115
SMITHSON, K. H.		
It Happened in a Field Station	13	160
SMOOK, J. M.		
Deep Sea Electric Bombs	9	84
SOBLERALSKI, A. M.		
Applying Surveys, Not on the North American Datum, to the Chart	4	107
Character of Bottom, Need of Standardization	2	77
Extracts from Season's Report, 1936	11	57
How Shall We Distinguish Fourth Order Triangulation Stations	3	105
Improved Method of Transferring Shoreline, etc.	2	57
Long Line Triangulation in Alaska, 1933	8	8
Plotting Three Point Fixes without the Use of a Protractor	3	52
Report of Assistance Rendered	8	137
Use of Aluminum Sheets	3	94
SOULE, F. M.		
Echo Sounding on Submarine "NAUTILUS"	5	67
STOHSNER, E. E.		
Santa Clara Valley Subsidence Has Now Reached 5 Ft.	11	37
STUDDS, R. F. A.		
Bridge Windshields	11	66
Effect of Current on Soundings	5	110
Stranding and Salvaging of "FATHOMER" in the Typhoon of Aug. 15, 1936, Port San Vicente, P.I., The	10	124
Unusual Hydrographic Party, An	12	135
SUTHERLAND, O. P.		
Unique Broken Base Method, A	9	101
SWAINSON, O. W.		
Fathometer Corrections	3	104
Harnessing Earth's Forces with P.W.A. funds	12	111
Improvements for Fathometer	3	95
Launch Hydrophone Station	2	61
Longer Red Light Signal	3	93
On Transmission of Sound Through Sea Water	3	102
Portable RAR Set	3	77
Position by Sun or Star Fixes; Comment on	3	101
Former Article	1	26
RAR and Sound Wave Propagation Theory	3	101
Refraction (Comments on Previous Articles)	2	58
Rigid Control for the Survey of an Offshore Bank	2	61
Sextant Illumination	4	111
Serial Temperatures	3	103
Star Sights at Buoys	3	104
Smaller & Oftener	10	1
Velocity of Ray Paths of Sound Waves in Sea Water	4	111
White Light Echo Soundings		
SWANSON, L. W.		
Lead Shot Buoy Spacer for Wire Drag	9	36
Trailer for a 16-foot Skiff, A	12	129
Whitewash Signals	12	220
SYME, G. F.		
Geodetic Control for North Carolina Highways, Its Advantages and Its Probable Effect on Engineering Practice in the State	5	23
TAYLOR, PAUL		
Cost Statistics, Offshore Hydrography in the Gulf of Mexico	11	32
Magnetic Observations at Sea	11	68
THOMAS, C. M.		
How a Quick Position was Obtained with One Angle and a Range on Three Old Triangulation Stations in Northwest Luaon, P. I, Across Nagabungan Inlet	7	129
Table for Reduction to Center	2	48
THORSON, A. C.		
Precast Post Lifter	8	120
THURMOND, J. D.		
Leveling in Texas	5	125
TIMM, M. F.		
Sono-Radio Buoy Improvements	13	128
TRIBBLE, J. C. Jr.		
Making and Detonating RAR Bombs on Georges Bank	2	53
TISON, J. C. Jr.		
The 432 Type Fathometer	5	50
VINCENT, ALMOR M.		
Sono-Radio Buoy Developed on Ship GUIDE, 1936	11	73
Sono-Radio Buoys in 1938	12	194
WARWICK, H. C.		
Hydrographic Survey Aids	13	11
Use of Color Filters on Geodetic Instruments, The	10	104
WHITNEY, PAUL C.		
A Biblical Accounting of the Use of the Lead Line	9	16
Division of Tides and Currents	11	22
Hints for Securing Accurate Tidal Datums	6	10
Meteorological Effects on River Levels	5	116
Some Notes on Tidal Observations	7	18
WILDER, L. C.		
Motor Vessel E. LESTER JONES	13	162
Special Survey, Sitka, Alaska	13	151
Training Section, The	2	63
WILSON, R. M.		
Strength of Three-Point Locations	11	40
WISE, G. D.		
Lamentable Ditty, A	13	80
WOLD, K.		
Norwegian Geographic Survey	1	11
WOODWORTH, R. W.		
Astronomical Determinations in Central America	12	224
City Triangulation Gadgets	4	64
New Second Order Theodolite and Coastal Triangulation, The	4	43
YLVISAKER, LENVIK		
Surveying and Mapping Methods (Extracts from "Civil Engineering")	4	11