NO. 12

FIELD ENGINEERS BULLETIN

U. S. COAST & GEODETIC SURVEY

DECEMBER 1938

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LEO OTIS COLBERT

MESSAGE FROM THE NEW DIRECTOR

To the Field Engineers:

From its inception at the beginning of the nineteenth century the Coast and Geodetic Survey has functioned on the broad scientific foundation proposed by Ferdinand R. Hassler. Now, in the middle portion of the twentieth century, we are continuing the concepts of those field engineers who have preceded our service generation.

The Survey has furnished practical details required by two great professions: the modern nautical chart for the navigator of all coastal waters of this country; and, the control of geographic positions fixed by geodetic methods, for the surveyor. It has made available to the scientist basic information for research in geophysics by a broad program of accurate field observations and comprehensive office analyses.

As Director of the Survey, in this first opportunity to address a message to the Association of Field Engineers, I wish to give expression to a feeling of just pride in the personnel who have made possible these accomplishments. From the individual this has required faithful service and willing acceptance of arduous assignments. It has meant duty under difficult conditions --often under the strain of inadequate facilities.

Of necessity, our functions have expanded as we have gained knowledge and experience through improvements on time-honored methods as well as by the application of new discoveries in different branches of science. It is only natural that we should desire to maintain the standards set by our professional predecessors by broadening our experience and knowledge, not only as individuals, but also as a group. Only by so doing may we have a more complete understanding of the variety of needs of commerce and science, and a fuller appreciation of the ways in which the results of our own work can supply these requirements. Constantly we see new opportunities for valuable service to meet ever-changing conditions. To do so involves both personnel and equipment.

We require more adequate facilities, and special efforts will be devoted toward this end. It is our hope that the prompt acquisition of additional equipment will be accomplished and that it will be possible to improve certain unfavorable conditions in the personnel situation. I wish to assure the Association of Field Engineers of my active personal interest in these matters and of my confidence in your wholehearted cooperation in any effort made toward the advancement of the effective work of the Survey.

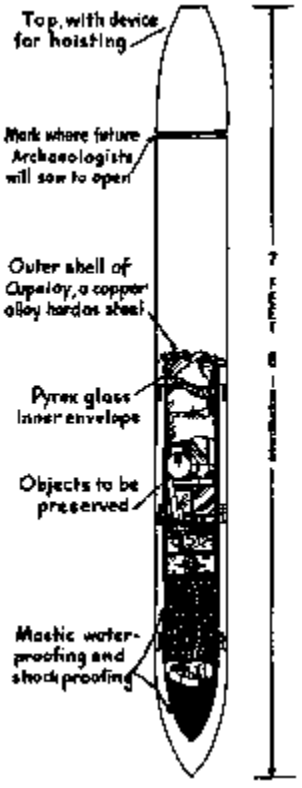
L. O. Colbert,
Director.

THE TIME CAPSULE

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

To those who are reading about the Time Capsule for the first time a brief description of it and its contents may be of interest.

The capsule is torpedo-shaped, 7-1/2 feet long and 8-3/8 inches in diameter. The outer shell consists of seven cast segments of Cupaloy (copper 99.4 per cent, chromium 0.5 per cent, silver 0.1 per cent) which is temperable to the hardness of mild steel and has corrosion resistance and electrical charasteristics similar to those of pure copper. The segments are screwed together hard and sealed with asphalt, the nearly invisible joints peened out and the outer surface burnished.



The inner crypt, 6-1/2 inches in diameter and 6-1/2 feet long, is lined with an envelope of Pyrex glass, set in a water-repellent petroleum base wax. Into this crypt,which was evacuated, washed, and filled with humid nitrogen, was placed the record of present day civilization.

This record includes about 35 articles in present day use, such as a can opener, tooth brush,safety pin, pipe, lipstick and even a woman's hat. About 75 samples of common materials such as silk, copper, asbestos, leather, etc., were included as well as United States money and samples of seeds sealed in glass tubes.

Books, speeches, excerpts from encyclopedias, etc., describing in logical order the arts, sciences, techniques, sources of information and industries of our time, and including Coast and Geodetic Survey manuals were reduced to three and one half small reels of microfilm and placed, together with a microscope, in the crypt. More than 22,000 pages of text or the equivalent of 100 ordinary books were reproduced on this microfilm. Instructions were included for making large reading machines such as those used in modern libraries.

Particular care was taken to protect the capsule from vandalism. It was buried 50 feet deep in swampy soil with elevation about 20 feet above sea level. Surveys extending over the past 40 years were examined to insure that the site was in relatively unchangeable area. Recovery of

the capsule will involve an expensive and difficult engineering operation, costing many times its possible intrinsic value.

Archeologists, 5,000 years hence, will appreciate this effort to preserve, a record of 20th century civilization and the Bureau is glad to have cooperated in locating the capsule so that the site can be readily recovered,

(Editor)

Early in August 1938, the Westinghouse Electric and Manufacturing Company requested the cooperation of the Coast and Geodetic Survey in the location of the time capsule, then in preparation for deposit 50 feet deep in the earth at the Westinghouse Building on the 1939 World's Fair Grounds in New York City. Accompanied by appropriate ceremonies, the capsule was deposited at noon, Eastern Standard Time, September 23, 1938, and was attended by a large group representing many branches of science, and particularly those persons who took some part in the adventure.

Briefly, the purpose of the adventure from an advertising standpoint was to stimulate interest in those sciences involved in the preservation of selected records of our present civilization for the examination of posterity in the year 6938.

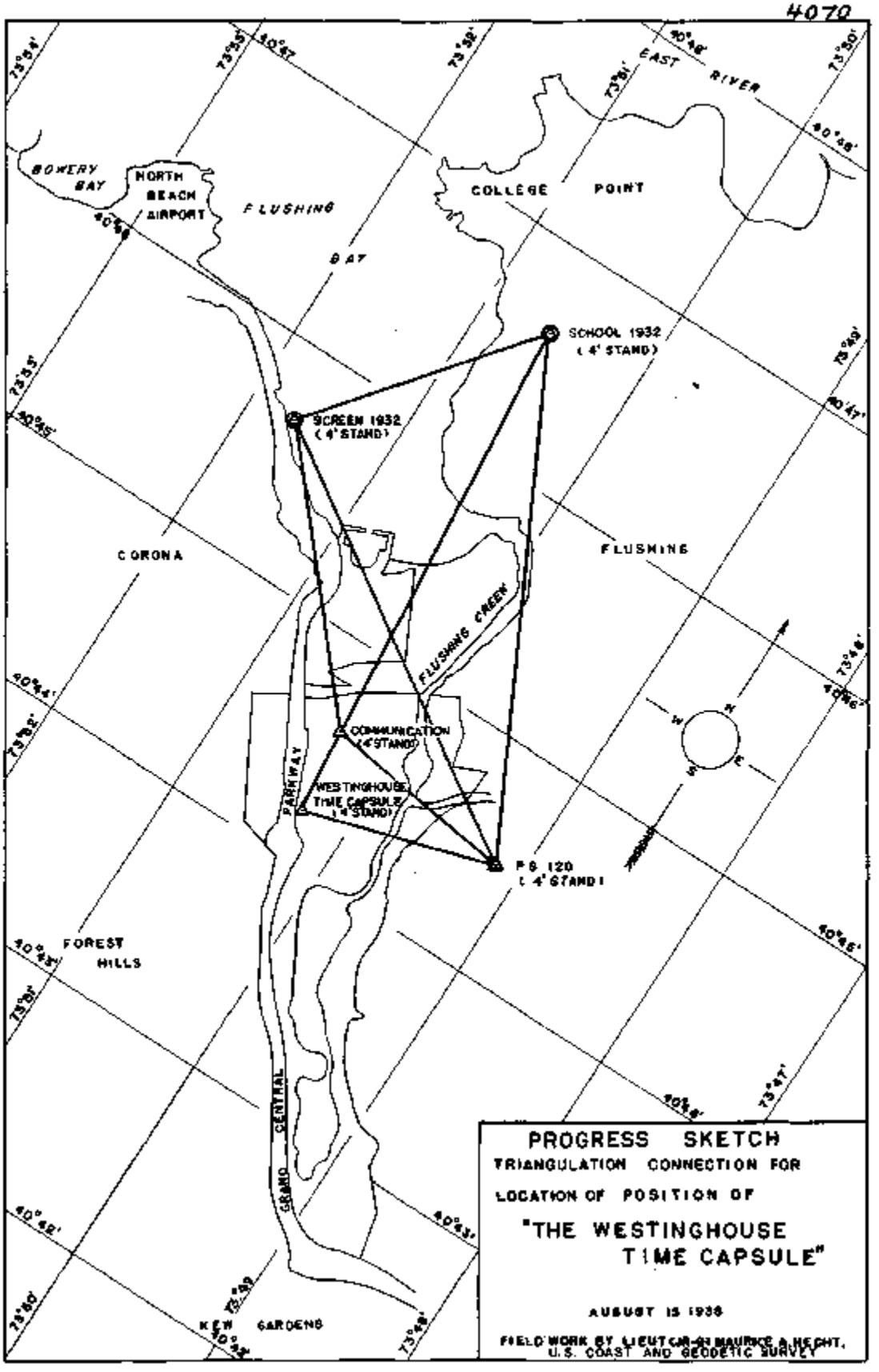
Those sponsoring the capsule realized that to be successful, the preparation of all the materials involved in its manufacture as well as its contents must of necessity be investigated very thoroughly from the standpoint of archeology, metallurgy, chemistry, etc., in order that the expected life of all materials used would be at least 5000 years. Therefore, it became a highly scientific venture, and considering the probability that the surface of the earth may be considerably changed during the interval and that present day features may be completely wiped away and replaced by others, it became necessary to describe the position of the capsule in both geodetic and astronomic coordinates to insure the possibility of its recovery. Therefore, the Coast and Geodetic Survey was requested to determine its latitude and longitude and describe the position in such a way that people 5000 years hence could, if necessary, redetermine it by observations on the stars.

Fortunately there are many first-order triangulation stations which form a part of the national horizontal control net in the vicinity of New York City and only a small amount of field work was required in order to establish new stations, and to determine the position of the capsule in relation to the North American Datum of 1927.*

The Coast and Geodetic Survey did not have funds available to be used for this purpose and the Westinghouse Company defrayed all necessary expenses except for the time of Lieutenant (j.g.) M. A. Hecht, who was in charge of the field observations, and for the use of the instrument during that period.

The observations were completed in a short period of about one week. Computations were made and the Westinghouse Company was furnished with the geographic position of the time capsule as referred to in the North American Datum of 1927 in sufficient time for its ceremonies on the 23rd of September, 1938.

* See "The Geographic Datums of the Coast and Geodetic Survey", by A. L. Shalowitz, this issue.


4070
EAST RIVER
BOWERY BAY
NORTH BEACH AIRPORT
FLUSHING BAY
COLLEGE POINT
SCHOOL 1932 (4' STAND)
SCREEN 1932 (4' STAND)
CORONA
FLUSHING
FLUSHING CREEK
COMMUNICATION (4' STAND)
WESTINGHOUSE TIME CAPSULE (4' STAND)
PARKWAY
PS 120 (4' STAND)
FOREST HILLS
GRAND CENTRAL
KEW GARDENS
PROGRESS SKETCH
TRIANGULATION CONNECTION FOR
LOCATION OF POSITION OF
"THE WESTINGHOUSE TIME CAPSULE"
AUGUST 15 1938
FIELD WORK BY LIEUT.COM.-GR MAURICE A. HECHT, U.S. COAST AND GEODETIC SURVEY

The position furnished, however, is strictly a geodetic one and probably differs considerably from the astronomic position due to deflection of the plumb line caused by the unequal distribution of mass in the earth's crust. Available time did not permit of making astronomic observations at the position of the capsule. Fortunately at Forest Park Triangulation Station, only five miles southeast of the time capsule, there is a coincident geodetic and astronomic station where the difference between the two positions is known. Therefore, in the event that the capsule has to be located by geographic coordinates and the positions of the triangulation stations in the immediate vicinity are not available, it only will be necessary for an observer to determine by astronomic means the location of Forest Park Station and from that point to extend a scheme of triangulation or traverse to the position of the capsule.

In order to preserve the record so that posterity may be informed of the time capsule, the Westinghouse Company published a small book describing the capsule and some of its contents. Copies are to be placed on deposit in some 3000 libraries in the world with the request that they be preserved for the particular purpose of recovering the capsule 5000 years hence. In this book the following instructions are given for locating the capsule, either by geodetic or astronomic means.

"WESTINGHOUSE TIME CAPSULE

Latitude	40° 44' 34.089	North of the Equator
Longitude	73° 50' 43.842	West of Greenwich

North American 1927 Datum

"The geodetic latitude and longitude of the time capsule has been determined by the United States Coast and Geodetic Survey by means of precise triangulation measurements from nearby stations of an extensive rigid Federal net comprising more than 50,000 stations distributed over the United States. The net extends from the Atlantic to the Pacific Ocean, across the entire North American continent, and is included between latitudes 25° and 49° North of the Equator, and longitudes 68° and 125° west from Greenwich, England. The net has been extended into Canada and Mexico by the two countries involved and the datum on which it is based is called the North American Datum of 1927.

"The accompanying sketch shows the first-order stations of the national net in the general vicinity of the time capsule. It should be noted that the latitude and longitude furnished for the capsule are geodetic and may differ by as much as 5 seconds or more from the latitude and longitude determined by astronomic observations alone. This is due to deflections of the plumb line from the vertical, which are caused by the attraction of mountain masses or other topographic features and by the unequal distribution of mass in the crust of the earth. These deflections can be determined only by comparison of geodetic and astronomic latitudes and longitudes at identical or nearly identical stations. No astronomic observations have been made at the point above the capsule. However,

at Station Forest Park, shown on the sketch, observations for astronomic longitude, latitude and azimuth have been made and furnish the following comparison:

Geodetic latitude	40° 41' 49"518
Astronomic latitude:	40° 41' 42"38
Geodetic longitude:	73° 51' 43"966
Astronomic longitude:	73° 51' 42"30
Geodetic azimuth to station School:	190° 07' 54"20
Astronomic azimuth to station School:	190° 07' 55"28

"Any operations for locating the capsule by astronomic means should be started as nearly as possible at station Forest Parko After this point has been located the measurement of a base line for the determination of distances and the extension of triangulation to the position of the time capsule can be done without difficulty.

"A study of conditions in and around New York City would indicate that there will be no chance 5000 years from now of recovering any of the triangulation stations shown on the sketch except possibly Forest Park. This station is located in Forest Park, Borough of Queens, New York City, 6 meters north of Park Lane and 70 meters east of the easterly line of Forest Parkway (extended). It is marked by a cross in a granite post 0.15 meter square and. 0.6 meter long embedded in a mass of concrete 0.9 meter square and 1.2 meters deep.

"It should be noted that according to the present system in use in this country, the distance from the Equator to either pole is divided into 90 degrees (°) and each degree is equal to 60 minutes (') or 3600 seconds ("). The unit of length is the meter. At station Forest Park one second of latitude equals 30.846 meters, and one minute equals 1850.77 meters.

"A more detailed description of the triangulation net of the United States and of the North American Datum of 1927 will be found in the capsule".

The United States money, which was included with the other matter in the Time Capsule, consisted of a dollar bill, a silver dollar, half dollar, quarter dollar, dime, nickel and a penny, making a total of $2.91. Some financial wizard has figured that if the archeologist who digs up the capsule in the year 6938 could collect two percent compound interest on this amount from the date of its burial, he would possess a fortune of more than 29 quintillion dollars ($29,000,000,000,000,000,000.00).

A NEW TYPE OF NAUTICAL CHART

C. K. Green, Hydrographic and Geodetic Engineer
Assistant Chief, Division of Charts
U. S. Coast and Geodetic Survey

Until the advent of echo sounding the average mariner gave but little thought to the configuration of the ocean bottom while cruising in deep water. As long as his course was free from dangers it mattered little whether the depth under his keel was 200 fathoms or 2,000 fathoms, or whether the vessel at the moment was passing over a submarine knoll or a steep sided canyon. Occasionally, perhaps, he would speculate as to the character of the invisible "Davy Jones Locker" that lay a mile or so below, but not from the viewpoint of the navigator. He could not utilize the charted depths for fixing his position without stopping the ship and measuring the depth with a wire - a time consuming procedure resorted to in exceptional cases only, such as when making landfall in thick weather. For ordinary navigation in deep water it was not practicable to use this method.

The development of echo sounding apparatus for commercial use has introduced a new concept in marine navigation, for now it is possible to obtain a continuous profile of the bottom with the vessel underway. This means that deep water bottom relief has become important to the mariner, since it is available for practical use in guiding his ship. The more faithfully the chart depicts this relief the closer the mariner will be able to relate his depth readings to the chart and the more certain will be his position.

In the usual method of charting, only a small percentage of the soundings obtained on the surveys can be shown because the chart is generally on a much smaller scale than the surveys. Thus a considerable amount of the detailed information furnished by modern echo sounding surveys is not available to the user of the conventional chart. For example the present edition of chart 5101 (figure 1), which covers 12,000 square nautical miles of the Pacific Ocean from San Diego to Santa Rosa Island, California, shows in most areas the maximum number of soundings that could be charted on such a scale (l:235,000) without impairing its legibility - yet these soundings represent but two percent of the total furnished by the recent surveys. Despite the fact that the charted depths have been carefully selected, full use has not been made of the remaining 98 percent of the soundings. It was therefore important to adopt a method of charting by which a maximum use could be made of the known data in this area.

The most useful method of meeting this requirement is by means of contours. By drawing these curves first on the smooth sheets, use is made of all the soundings on the surveys and therefore bottom shapes can be charted which cannot be shown by soundings alone. From the cartographic standpoint each curve is, of course equivalent to charting an infinite number of soundings, and for the navigator these contours, or depth curves, show at a glance which features along the ship's proposed course may be particularly suitable for position determination by echo sounding and he may even shape his course accordingly. The selection of a contour interval which best meets the needs of the navigator is a matter involving many factors, among which are the thoroughness of the available surveys, the nature of the submarine relief, and the scale of the chart.

Chart 5101A (figure 2) was constructed with these considerations in mind. It covers the same area as chart 5101 (figure 1) and is on the same scale. Both charts were compiled from the same accurately controlled modern surveys. The 50-fathom depth curves shown in blue and labeled at frequent intervals are based on a quarter of a million soundings of which only a small number are charted. Soundings which represent the greatest or least depths over the important features and a few others to facilitate reading the contours are all that are needed on this type of chart. All areas less than 50 fathoms deep are covered with a light blue tint to emphasize where greater navigational precautions may be necessary, and within these areas the conventional number of soundings and the usual depth curves are shown. The chart contains a table which may be used to correct echo soundings taken by instruments calibrated for velocities of sound differing from the average determined for the chart. Such corrections usually are relatively small.

The difference in character between the two charts is striking. Chart 5101 contains three times as many soundings as the new chart, yet the latter discloses a wealth of useful submarine information not discernible on the former. The curves bring into prominence such remarkable features as the several steep slopes between San Clemente Island and the mainland. These slopes afford excellent "lines of position" to the vessel equipped with the new chart and an echo sounder. With a speed of 15 knots, the change in depth would be 100 fathoms per minute for five consecutive minutes while crossing some of these slopes. Such sharp delineations are comparable to ranges on land but, unlike land ranges, they are available at all times--even in thick fog. The area covered by the chart is in general extremely rugged and good "landmarks" are numerous.

The valuable use of depth curves in navigation is exemplified on a small section of chart 5101A reproduced at scale (figure 3). Here is an actual case; a vessel departed from the whistle buoy off San Diego and obtained echo soundings at intervals of one minute for 40 minutes and then at intervals of 12 minutes. The exact time of each sounding was entered in her log, as was her dead reckoning course of 255° true and her speed of 15.0 knots. This sailing occurred prior to the publication of chart 5101A and in so far as the log indicates, the course believed to have been made good is as shown by the dashed red line. However when the line of soundings is compared with the depth curves of the new chart, it is found that the course actually made good was 261° true and the speed 14.3 knots (shown by the solid red line in the figure). The soundings in red are those obtained by the vessel and the relative spacing along the line is exactly as recorded in the log. For the sake of clarity, every other sounding is omitted where minute soundings were recorded. Note how nicely the soundings fit each curve, especially the 487 and 497 fathoms which fix the vessel's position both in latitude and longitude. Had the new chart been available to the navigator of this vessel he would have known, after crossing the first few curves, that he was either north of his course or was not making good his speed (see 107 fathom sounding on the dead reckoning line). Still more important, the chart would have shown in advance when he might expect to cross features of value to him. For instance, after crossing the 10 miles of flat valley he would have known that the vessel was again approaching a fairly steep slope, so that he could begin sounding at shorter intervals in order better to fix his positions with regard to the ridge being crossed.

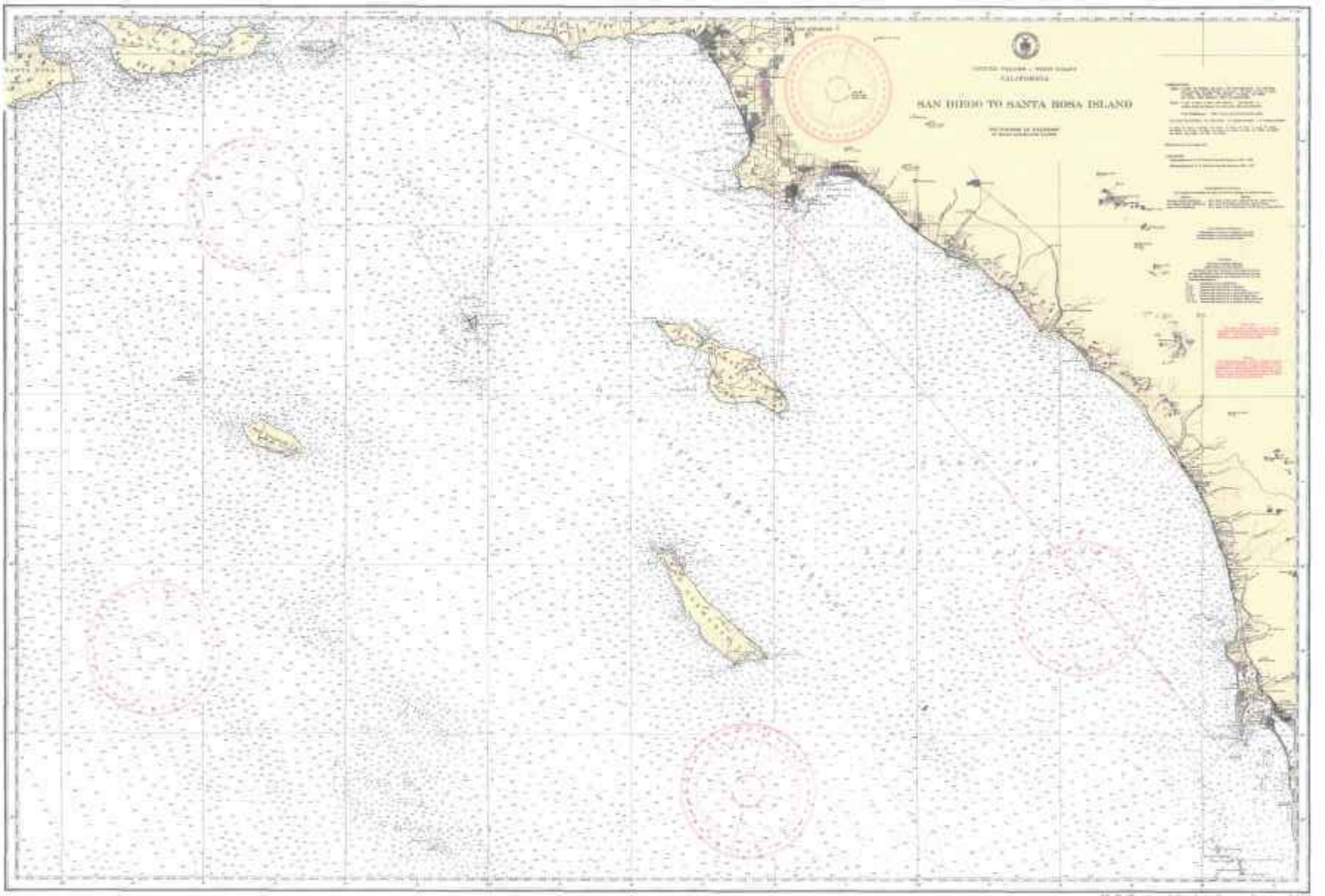


FIGURE 1 - CHART 5101
(Approximately one-fifth actual scale)

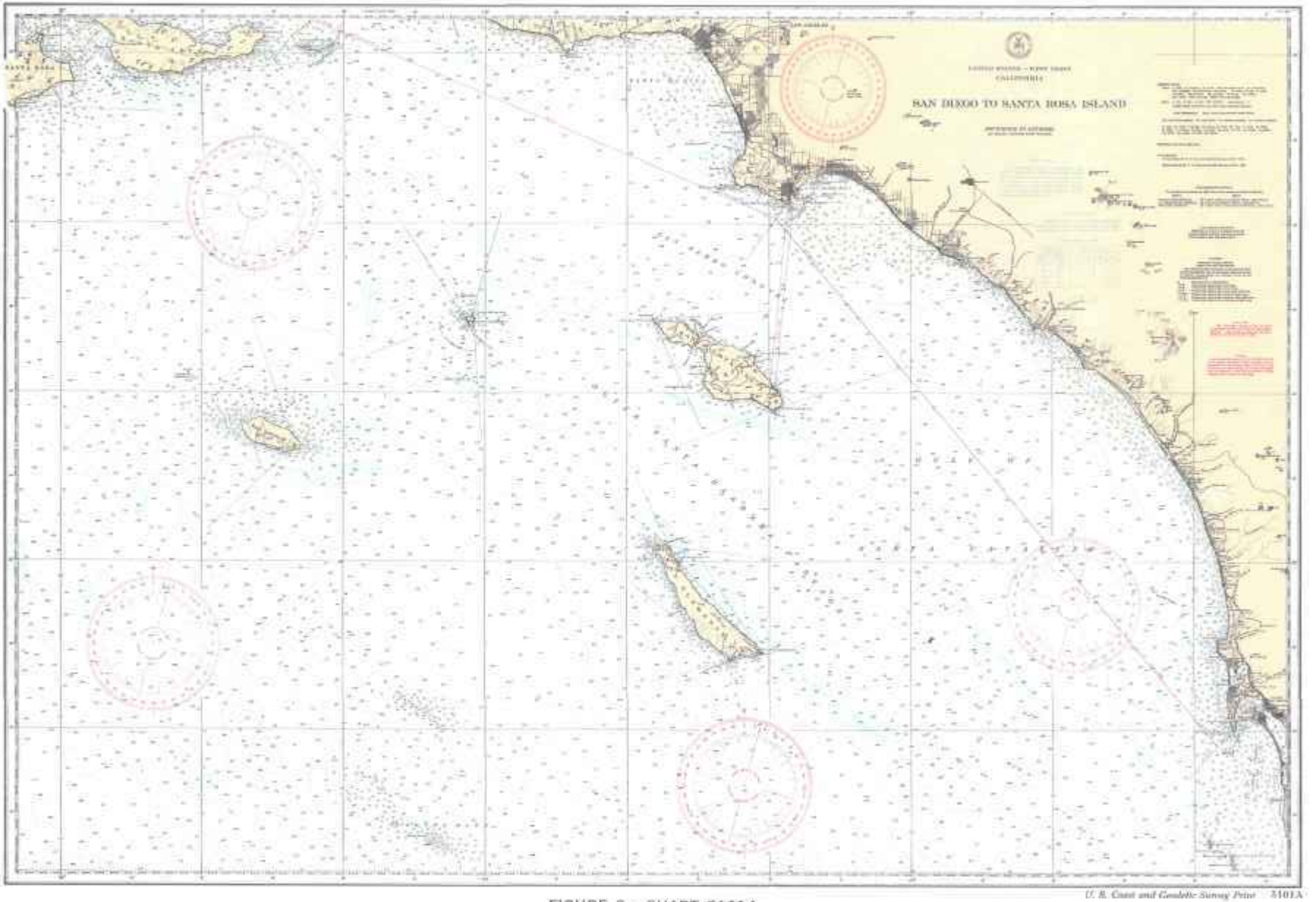


FIGURE 2 - CHART 5101A
(Approximately one-fifth actual scale)

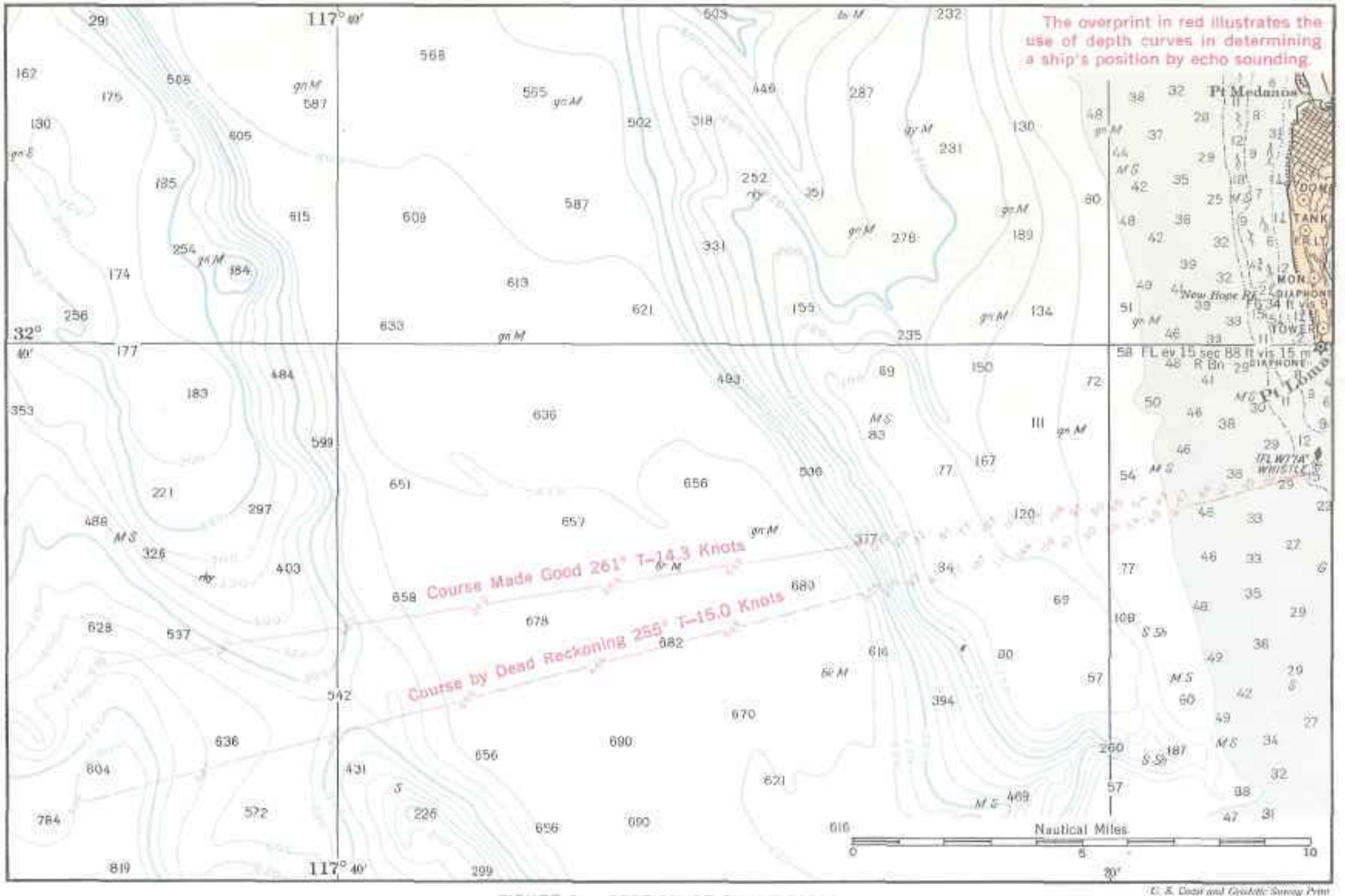
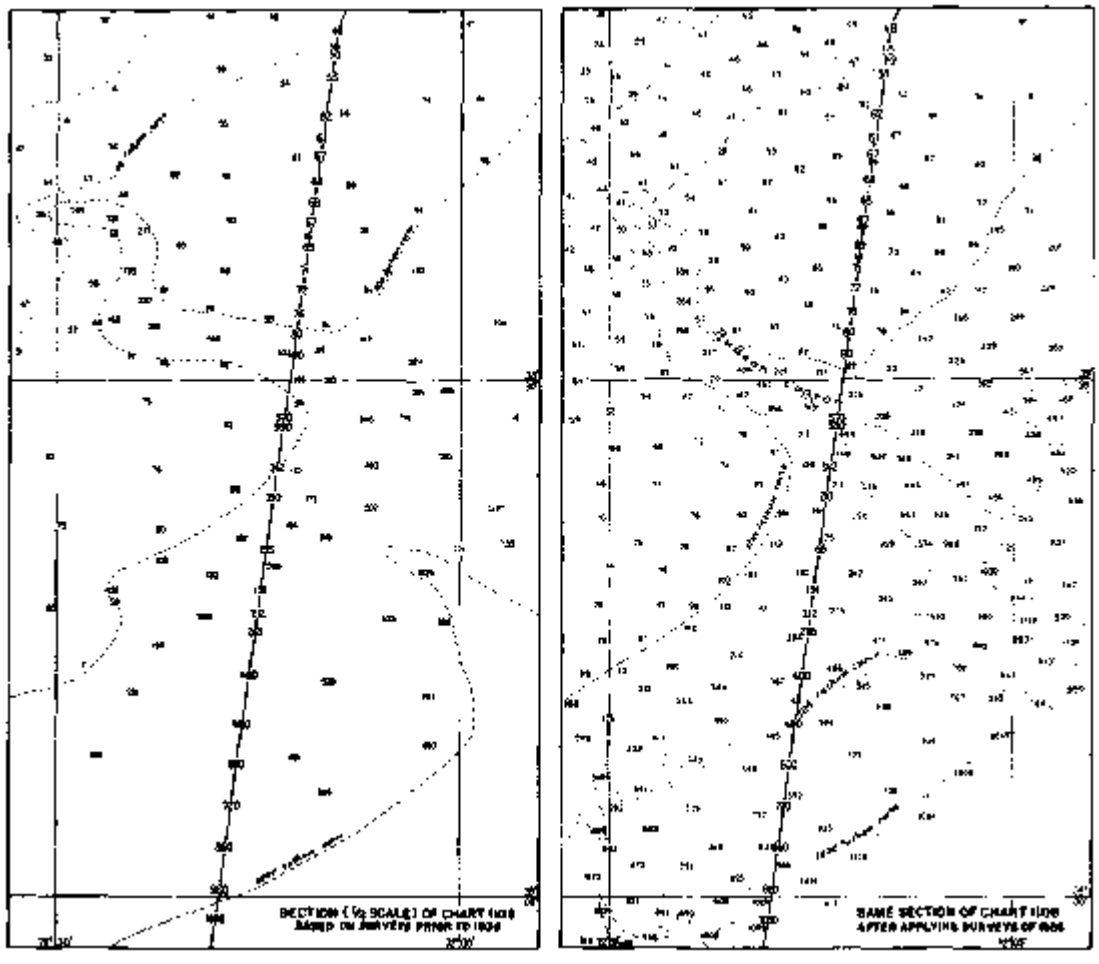


FIGURE 3 — SECTION OF CHART 5101A

The development of this type of chart is the logical outgrowth of the application of acoustics to hydrographic surveying and to navigation. Such a chart could not have been compiled a few years ago, for detailed well coordinated surveys of extensive offshore areas were not possible with the instrumental equipment of the time. The introduction of echo sounding in marine surveying furnished an economical means of obtaining bottom detail, while the development and successful application of radio acoustic ranging by the Coast and Geodetic Survey provided the necessary horizontal control. Both of these developments were indispensable to the construction of the new chart.



ADEQUATE AND INADEQUATE SURVEYS - 100 MILES OFFSH0RE

These two sections of Chart 1108 show what the modern methods of surveying have meant in charting an offshore area. The chart to the left was compiled from surveys based on dead reckoning control whereas the chart to the right was based on the latest methods using RAR control and echo soundings. The depths in larger figures are actual echo soundings recently obtained by a vessel crossing the Hudson Canyon.

THE GEOGRAPHIC DATUMS OF THE COAST AND GEODETIC SURVEY

A. L. Shalowitz, Cartographic Engineer
U. S. Coast and Geodetic Survey

In the century and a quarter since the organization of the Coast Survey the Bureau has used a number of geographic datums for the horizontal control of its geodetic work. The reasons for this together with the technical and historical development of the present North American Datum of 1927 are the subject of this paper.

Much of the material included here was prepared by the writer during the winter of 1934-5 for a series of lectures on the activities of the Bureau to a group of cartographic engineers just entering the Service. All of the fundamental concepts of geodesy and cartography referred to in this article can be found in any of the standard texts on the subjects or in the various publications of the Bureau, the novelty of the present article being in the manner of presenting the material. It is hoped that the treatment is sufficiently clear to benefit those who possibly, like the writer, have found their vision of some of the broader phases of the Bureau's work slightly dimmed by the passage of time and by the concentrated attention required in a highly specialized field.

The Early Surveys of the Bureau

Geodetic surveying is that branch of surveying that takes into account the curvature of the earth. In the survey of a large country like the United States it is necessary that geodetic principles be applied to the survey operations if accurate results are to be obtained. It was this fundamental concept of surveying that motivated Professor Ferdinand Hassler, the first Superintendent of the Coast Survey, in insisting at the outset that the framework of our charts be based upon a rigid system of geodetic control. And to his broad vision and foresight is due the high standard of accuracy and precision that has characterized the Bureau's activities from its inception to the present time.

Since it is necessary to take account of the curvature of the earth in extensive surveying operations it follows that the shape and dimensions of the earth must first be known before the geographic positions of points can be determined.

The Figure of the Earth

While it is customary to associate the roundness of the earth with the Middle Ages when Columbus attempted to reach Asia by a westward course, actually the notion of a spherical earth dates back to centuries before the beginning of the present era. Just when this transition of thought from a flat to a round earth took place is somewhat doubtful. However, to Pythagoras, the Greek philosopher, who lived about 540 B. C. appears to be due the first clear statement regarding the spherical shape of the earth.

When we think of the earth with its numerous mountain ranges and ocean deeps, we think of it as an irregular mass. A little reflection, however, will show us that actually these elevations and depressions, when considered in relation to the actual size of the earth are, for most practical purposes, insignificant. The highest

known elevation is 29,141 feet, the elevation of Mt. Everest above sea level, while the greatest known ocean deep lies to the eastward of the island of Mindanao in the Philippine Archipelago where a depth of 35,401 feet (5,900 fathoms) was found. Compared to the earth's mean diameter of 41,770,104 feet, this elevation and depression if represented on a globe 14 inches in diameter would amount to approximately one one-hundredth of an inch, an amount scarcely perceptible to the eye. Normally these irregularities are merely matters for the hydrographer and topographer or for use in such studies as the investigation of the effect of topography on the direction and intensity of gravity. But even when we ignore the numerous hills, valleys, and ocean basins, the shape of the earth is far from spherical.

The true figure of the earth, as distinguished from its topographic surface, is taken to be that surface which is everywhere perpendicular to the direction of the force of gravity and which coincides with the mean surface of the oceans. Under the continents and islands this surface may be conceived to be that which would coincide with the water surfaces in narrow sea-level canals if they were extended inland through the continents. This surface is quite irregular. In the vicinity of high lands, it is tilted upwards while in the neighborhood of valleys and bodies of tidal waters it has the reverse tilt. There is no geometric solid that exactly represents its shape, and because of this it has been given the name Geoid, a non-committal term meaning that the earth is Earth Shaped. It is quite obvious that to use such a surface, even if its exact shape were known, would lead to difficulties and complications in geodetic and cartographic work that would hardly be justified by the results obtained. The problem, therefore, has been to adopt that mathematic surface which best approximates the true figure for the particular problem involved.

For many purposes we may assume the earth to be a sphere, and such assumption greatly simplifies our problems. If we require a closer approximation to the true figure we adopt what is called the oblate spheroid or ellipsoid of revolution, with two unequal axes. Should a still greater degree of exactness be required we would adopt the ellipsoid with three unequal axes and any section in any direction through the center would be an ellipse. Still further exactness indicates that the southern hemisphere is somewhat larger than the northern, and that all polar sections are slightly oval, this leading to the name ovaloid.

The Clarke Spheroid of 1866

From many precise measurements and various investigations the true or geoidal surface of the earth has been found to approximate closely the oblate spheroid, and no closer approximation has ever been needed for practical geodetic work. Geometrically, the oblate spheroid may be considered as generated by revolving an ellipse about its minor axis; hence the name "ellipsoid of revolution" which is used interchangeably with "spheroid". From the nature of the figure, any section parallel to the equator is a circle, and any section through the poles is an ellipse.

The lengths of the axes of the generating ellipse, corresponding to the polar axis and equatorial diameter of the earth, have been the subject of study from time to time and with each new accession of data and development of scientific thought, new values

have been derived. The two most important determinations of the elements of the spheroid, in so far as the geodetic work of this Bureau is concerned, are those made by Bessel in 1841 and Clarke in 1866. In both cases the calculations were based upon the measurement of meridian arcs in various parts of the world outside the continent of North America. Clarke's investigation is generally regarded as the more precise and later observations have shown that for this part of the globe it represents the true figure somewhat better than the spheroid of Bessel. The comparative values in meters are as follows:

	Equatorial Radius Meters	Polar Semi-diameter Meters
Bessel (1841)	6,377,397.2	6,356,079.0
Clarke (1866)	6,378,206.4	6,356,583.8

These represent compressions of 1/299.2 and 1/295.0 respectively.

Prior to February 1880, the work of the Survey was developed on Bessel's Spheroid of 1841. Since 1880 the Bureau has adopted the Clarke Spheroid of 1866 as the reference spheroid for all its formulas, computations and tables. In referring to reference spheroids it is customary to append to the word spheroid, the name of the investigator and the date of making the determination, thus -- Bessel's Spheroid of 1841, Clarke's Spheroid of 1866, etc. The date of adoption has only a local value.

Astronomic versus Geodetic Determinations of Geographic Positions

With the adoption of a spheroid of reference for a country and the adjustment of all angles and lengths, arises the question, "How shall the geographic positions of the various triangulation points in the control net be determined?" Shall they be computed with respect to a single latitude and longitude so chosen as to place the adopted surface of reference in its best position on the true surface as regards the country as a whole, or shall several such latitudes and longitudes be adopted throughout the area so as to place each portion of the surface of reference in its best position on the true surface? To answer this involves a consideration of several important fundamental facts.

Astronomic Determinations

The position of a point on the surface of the earth, with reference to the equator and to a principal meridian may be determined by observations on the stars. These observations consist in measuring the angular distance the particular heavenly body is above the observer's horizon, as indicated by the spirit level on his instrument. Since gravity acts at right angles to this level surface, the astronomic observations will be referred to the direction the plumb line assumes at the point of observation. This direction will be normal to the geoidal surface, since the latter is by definition a surface that is everywhere normal to the direction of the force of gravity.

Geodetic Determinations

By geodetic determinations are meant those latitudes and longitudes that are computed through, the network of triangles from the measured angles and distances by starting from some pre-determined latitude and longitude of one of the triangulation stations. Geodetic coordinates are determined with respect to the normal to the spheroid at the point of observation and not with respect to the plumb line direction at that point. Where the geoid and the reference spheroid coincide the normal will have the same direction as the plumb line and the astronomic and geodetic values at that point will be in agreement. At all other points, differences will be found to exist, their magnitude depending upon how closely the adopted spheroid fits the geoid at those particular points. For the Clarke Spheroid of 1866, differences varying up to a minute of latitude have been found to exist. These differences between observed and computed positions corresponding to the astronomic and geodetic values of the point are variously referred to as plumb-line deflection, deflection of the vertical, and station error.

If there were no deflections of the vertical or station errors, the determination of the correct relative positions of different points on the surface of the earth would be a simple matter and could be done by astronomic observations alone.

Some idea of the relation of the spheroid, the geoid, and the topographic surface may be had from a study of figure 1. It will be observed that the geoidal surface coincides with the surface of the ocean and that it intersects the spheroid at some distance out from the shoreline.

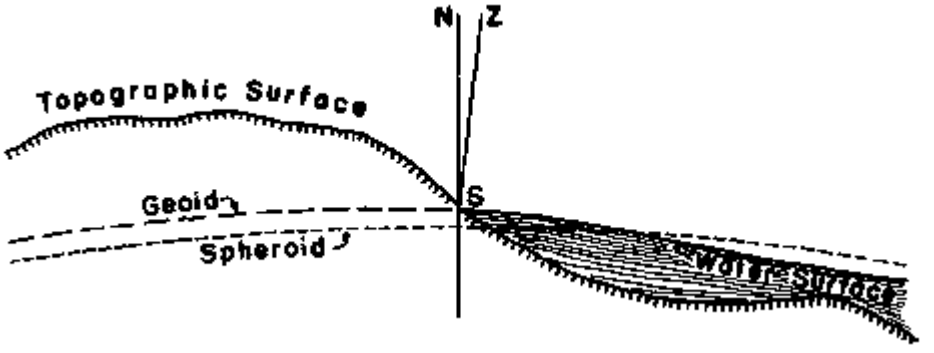


Figure 1. Showing relationship of spheroid, geoid and topographical surface.

In the figure,

NS = Normal to spheroid
ZS = Direction of plumb line = normal to geoid
ZSN = Deflection of plumb line = station error.

GEODETIC DATUMS

From what has been said it should be quite clear that, on account of the varying deflection of the vertical, if only astronomic

observations are used for the determination of geographic positions, distances and directions between points cannot be determined accurately. Many cases are on record of decided deflections of the vertical,one of the classic examples being on the island of Puerto Rico where the distance between the astronomic latitude stations at Ponce on the south coast and San Juan on the north coast was found to be about one mile longer than the distance as computed from the triangulation. This corresponded to an angular difference of 56 seconds between the astronomic and the geodetic latitudes and was due to the irregular distribution of masses at the surface, since it will be recalled that Puerto Rico consists of a high mountain range running east and west, with the deep water of the Atlantic Ocean to the north and the Caribbean Sea to the south.

It follows then that accurate surveys of large areas cannot depend entirely upon astronomic determinations. The survey of a local area can be oriented by determining astronomically the latitude and longitude of one point and the azimuth of one line, and from these values computing the remaining points of the survey by the ordinary trigonometric methods. This will usually suffice, if the survey is a detached one such as an offlying island or some outlying section. But just as soon as this survey is joined to or overlapped by other surveys similarly oriented, discrepancies will arise. Each survey will be consistent within itself on the adopted spheroid but common points will be found to have different geographic values.

Independent Datums in the United States

In beginning the mapping of any large area such as the United States, it is inevitable that for a time many detached triangulation systems will exist in each of which the geodetic datum is necessarily dependent only upon the astronomic stations connected with that particular system. This, in fact, was the condition of the primary triangulation in this country during the first fifty years or so of the Bureau's active operation. As examples of such detached portions of triangulation there may be mentioned the early triangulation in New England and along the Atlantic Coast, a detached portion of the transcontinental triangulation centering on St. Louis and another portion of the same triangulation in the Rocky Mountain region, and three separate portions of triangulation in California, in the vicinity of San Francisco, Santa Barbara Channel, and San Diego. With the lapse of time these separate pieces expanded until they touched or overlapped, causing gaps, overlaps, or offsets at the junctions.

In any engineering or scientific undertaking involving a large area, it is important that a full coordination and correlation be secured of the surveys, maps and charts of the country. A hydrographic or topographic feature on the earth can have but one geographic position and it should be so shown on every map or chart on which it appears. This can be accomplished only through the use of a single geodetic datum for the entire area; that is, by having the position of a single point in the country as the initial or datum to which all other stations are referred.

The condition described above prevailed in this country until the transcontinental triangulation joined all these detached portions and made them one continuous triangulation. As soon as the office computation of this arc was completed in 1899 it became necessary to discard the old independent datums on which the various

portions were based and to substitute one standard datum for the whole country.

The United States Standard Datum

In the selection of a single geodetic datum for a country like the United States, both theoretical and practical considerations must govern. Of the former may be mentioned the requirement that the adopted datum should not differ widely from the ideal datum which would place the triangulation system in such position that no serious error would occur in any part of the system; and of the latter must be mentioned first, the desirability that the adopted datum should produce minimum changes in the various publications of the Survey, including its charts; and second, the desirability, other things being equal, of adopting that datum which allows the maximum number of positions already in the office registers to remain unchanged, thereby requiring a minimum amount of new computation.

In determining the best geographic position of the station that was to define this geodetic datum, the station errors at a large number of triangulation points scattered throughout the country were studied starting with an assumed value of one of the points. From this data a latitude, longitude and azimuth were computed for Station Meades Ranch in central Kansas which made the sum of the squares of the differences between the astronomic latitudes, longitudes and azimuths and the geodetic latitudes, longitudes and azimuths a minimum. This computed value was found to be so near the value obtained by basing the position on the datum previously in use in the New England states that the latter was adopted to save the labor of recomputing all the triangulation of the northeastern part of the country. On March 13, 1901 it was officially given the name United States Standard Datum.

The adoption of this datum, therefore, did not affect the positions which had been used for geographic purposes in New England and along the Atlantic Coast to North Carolina, nor those in the states of New York, Pennsylvania, New Jersey and Delaware.

The North American Datum

Early in the year 1913, both Canada and Mexico adopted the United States Standard Datum as the datum for their triangulation, and because of the international character it thus assumed, the designation was changed from "United States Standard Datum" to "North American Datum". The important thing to remember, in this connection, is that while the two designations are different they refer to the same datum. They may be used interchangeably unless the date of adoption is material.

The North American Datum may be defined in terms of the position of the station Meades Ranch as follows:

Latitude	39° 13' 26".686
Longitude	98° 32' 30".506
Azimuth to Waldo	75° 28' 14".52

Points are then said to be on the North American Datum when they are connected with the station Meades Ranch by a continuous

triangulation, through, which the corresponding latitudes, longitudes, and azimuths have teen computed on the Clarke Spheroid of 1866, as expressed in meters, starting from the above data.

Station Meades Ranch was selected as the basis for the North American Datum because it was near the center of area of the United States and because it was common to two great arcs of triangulation extending across the country, one along the 39th parallel and the other along the 98th meridian.

It is of interest to note that in the reduction of 765 astronomic stations in connection with the Supplementary Investigation in 1909 of the Figure of the Earth by J. F. Hayford, it was indicated that the adopted datum approaches closely the ideal for which the sum of the station errors in latitude, longitude and azimuth would each be zero.

The North American Datum of 1927

At the time of the adoption of the U. S. Standard Datum in 1901, the primary triangulation system of the United States consisted of a meager skeleton joining the arc near the Atlantic Coast with that near the Pacific Coast. Since then it has grown until to-day it consists of a large number of interconnected loops that cover the country in checkerboard fashion from the Atlantic to the Pacific and from the Canadian border to the Gulf of Mexico.

As the various arcs in the loops were observed they were adjusted by the Method of Least Squares to the arcs already completed in order that the results would be consistent when made available for engineering purposes. When any loop was completed, the total discrepancy in closure was adjusted into the last arc that closed the loop. This method of adjustment was unsatisfactory because it frequently imposed unfavorable conditions upon the last arc and short arcs were forced to absorb loop closures that were out of all proportion to their lengths. However, such method had to be followed, otherwise the whole system of triangulation would have had to be readjusted every time a new loop was closed.

With the completion of the triangulation framework in the western part of the United States in 1926, the logical necessity arose of undertaking a unified adjustment of the whole region. This was no small job and special methods had to be devised whereby such an extensive system could be adjusted with sufficient accuracy at comparatively small cost. Such a method was worked out by Dr. Oscar So Adams under the direction of Dr. William Bowie, then Chief of the Division of Geodesy of this Bureau, and is known as the "Bowie Method of Triangulation Adjustment". By this method the discrepancies in loop closures are distributed along the various arcs in a manner somewhat similar to that used in the adjustment of a first-order level net.

Inasmuch as the Figure of the Earth Investigations in 1909 had shown that the position of Meades Ranch on which the North American Datum depended approached closely the ideal for this country, its position was held fixed in this final adjustment.

But while the position of Meades Ranch remains the same as heretofore, there is an important difference between the two datums. At the time of the adoption of the United States Datum it

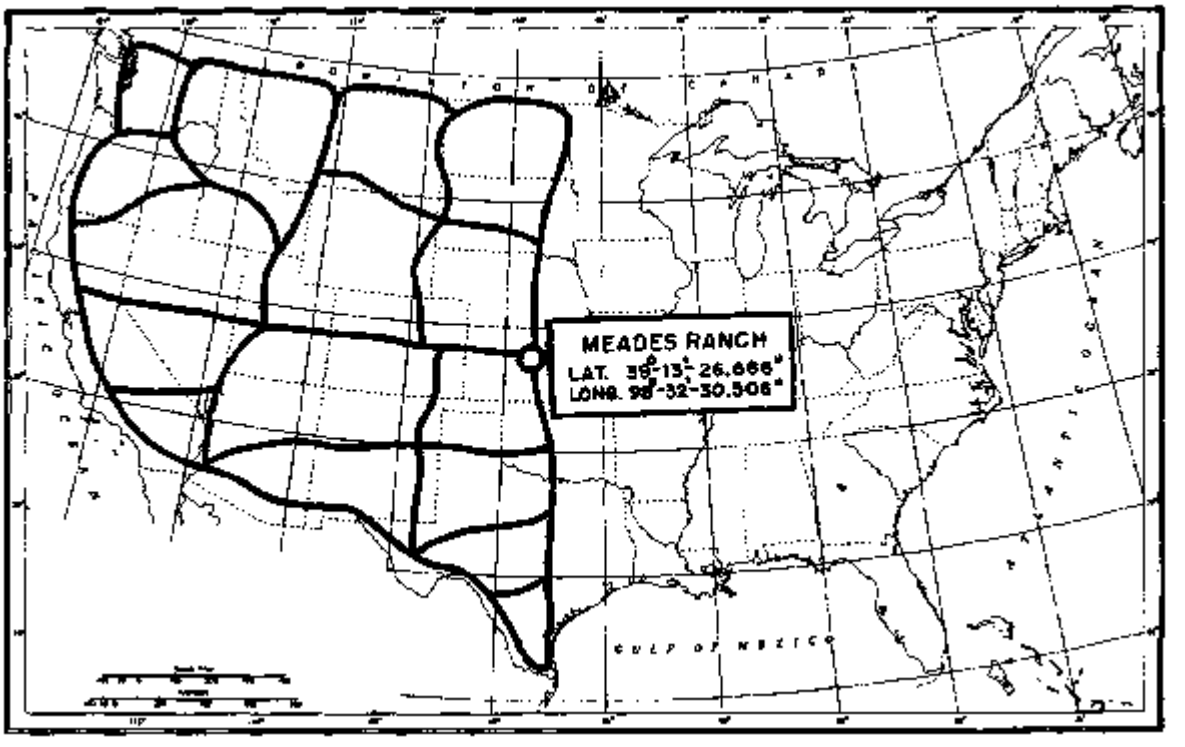


Fig. 2. Location of Station Meades Ranch and Triangulation Loops Used in Adjusting Western Half of United States.

was not yet fully established that an arc of triangulation tends to swerve in azimuth, so to speak, as the distance from the starting point is increased; hence in that adjustment all azimuths carried through the triangulation were made to depend upon the single standard azimuth adopted for the line Meades Ranch to Waldo.

When the final adjustment was made, information had accumulated which showed that geodetic and astronomic longitudes anywhere in the United States were subject to probable errors of less than 0".5 and that about the same degree of accuracy could be expected for astronomic azimuths. The Geodetic azimuths, however, were found to be subject to probable errors as great as 5". Therefore, by introducing a number of observed astronomic azimuths into the triangulation the probable azimuth errors were reduced and the orientation of the network in the new adjustment greatly strengthened. Since astronomic observations are referred to the direction of the plumb line and not to the normal to the spheroid, the astronomic azimuths must be corrected for the plumb line deflections at the stations in order to refer them to the normal to the spheroid to which the computed latitudes and longitudes are referred. These corrected azimuths are called true geodetic or Laplace azimuths and the correction is called the Laplace correction. This correction can be computed by means of the Laplace equation if an astronomic longitude has been observed at the station as well as an astronomic azimuth. Such stations are called Laplace stations.

If we denote the astronomic values by A and the geodetic values by G (in the case of the azimuth, G is the true geodetic or Laplace azimuth), then by the Laplace equation,

$$A - G \text{ in azimuth} = -[(A - G) \text{ in longitude}] \sin \theta$$

value of gravity at the base station, the gravity at the new station may be computed easily by a simple formula.

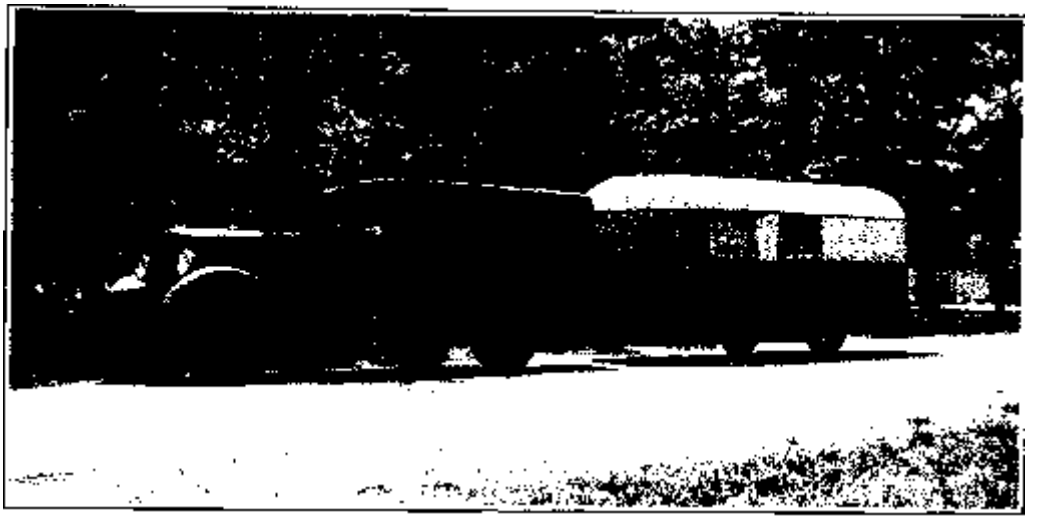
Spring gravity instruments, commonly known as gravimeters, are of many different types, but all of them are based upon the principle that the distortion of the spring varies with the attraction of gravity. These instruments, of course, can only be used for relative determinations of gravity.

Brown Gravity Instrument
Pendulum receiver, in which the pendulum is swinging, is set in a hole in the ground and surrounded by about 60 lbs. of plaster of Paris. The rectangular box above contains the photoelectric device for recording the pendulum beats.

The Brown Pendulum Apparatus, named after the late Lieutenant E. J. Brown, who devised and perfected it, and now employed by the Coast and Geodetic Survey, is a pendulum instrument. The pendulum is of invar metal and swings on an agate knife edge. The beats of the pendulum are recorded on a chronograph through a system employing a photoelectric cell, amplifier, and relays. The accurate time necessary in this work is obtained by recording, by radio, the Naval Observatory time signals directly on the same chronograph record as that on which the pendulum beats are recorded. The exact number of beats of the pendulum is determined over a six-hour period. Since the six-hour interval can be determined with a probable error of about ± .002 seconds of time it is apparent that a very accurate determination of the period of the pendulum can be made.

The best of the spring instruments probably have smaller probable errors than the pendulum instruments, but they can be used only for relative determinations at points short distances apart, whereas the distances over which the pendulums may be transported are unlimited. There is still room for improvement in both types of instruments, and there are indications at present that a combination of both types of instruments will be used in the near future in the gravity survey of an area.

Several advances in field methods and equipment have been made during the past year. The most notable of these was the use of two sets of Brown gravity apparatus to obtain two simultaneous determinations of gravity at each station. The use of a house trailer, in which much of the equipment, such as the radio, chronograph, amplifiers, batteries, and chronometer are mounted has done much to offset the additional labor involved in using two Brown instruments.



Truck and Trailer of Gravity Party

Radio receivers, amplifiers, and chronograph are permanently housed in the trailer, which also provides office facilities.

* * * * * * * *

Contemplated Improvements to Instruments

At the present time a study of pendulum instruments is being conducted with a view toward revision of the Brown instrument for the purpose of obtaining greater accuracy and speed. It should be remembered that the final result sought in pendulum observations depends upon exact determination of the period of the pendulum, that is, the length of time needed for the pendulum to make a single beat. The period can be found if an accurate method for recording time is accomplished for an even number of the beats, when these beats are made under precisely similar conditions, or when corrections can be applied for conditions which are not similar.

The development of the crystal chronometer by the Bell Research Laboratory is a marvelous forward step in securing the exact time needed for gravity work. Rigorous field tests by Coast and Geodetic Survey observers have indicated that this chronometer will maintain a rate under field conditions that is accurate to within about 1 part in 10 million.

Errors in gravity measurements with pendulums have been partly due to lags in relays. Photographic recording can be applied to eliminate the mechanical relays. The time is recorded by interrupting a beam of light by a rotating arm on the synchronous motor of the crystal chronometer. The pendulum beats are recorded on the same record through the use of photo-electric tubes.

Temperature corrections, always uncertain, probably can be reduced to a minimum by thermostatic heat control, which will maintain a specified temperature within about 0.01°C. Such temperature control will permit the use of bronze pendulums which are more stable than the invar ones now in use. It is essential that non-magnetic pendulums be used in multiple-pendulum instrument.

At least three pendulums probably can be used in a new instrument. All three pendulums will be mounted in the same plane, and upon the same support. The two outer pendulums will be arranged to swing in opposite phase isochronously. The center pendulum will not be swung for period measurement, but it will record any lack of isochronism of the outer pendulums by showing an amplitude which will increase in amount as the outer pendulums are thrown out of phase. This type of instrument has been used

with signal success by Dr. Vening Meinez, of the Dutch Geodetic Commission in his special gravity instrument for observations at sea. The use of three pendulums with two swinging in opposite phase, eliminates the necessity for determining the movement of the pendulum case by means of an interferometer as now is necessary with the Brown instrument.

The Brown gravity instrument was a great step forward in pendulum gravity instruments, in that it employed a photoelectric device to record the pendulum vibrations. This permitted the case to remain sealed during the entire time the instrument was in the field. The pendulums were raised, set in motion, stopped, and lowered by an ingenious mechanical device invented by Lieutenant Brown. Previously it had been necessary to remove the pendulum from the support each time the instrument was transported and to reinstall it upon arrival at the new location. When it is realized that the period of the pendulum can be changed appreciably by so small a mass as a speck of dust clinging to it, it is plain that this handling caused small errors. It was therefore necessary to take many observations with different pendulums at each station to obtain the desired accuracy. Observations usually extended over two days while with the Brown instrument it is necessary only that they be extended over 6 hours to obtain somewhat greater accuracy than formerly was obtained by the longer observations.

Typical Gravity Station
Campbell, Alabama.

Pendulum instruments are housed in tent and connected by cable to permanent instruments in the trailer.

The Coast and Geodetic Survey has conducted gravity surveys and investigations for a number of years primarily for the purpose of development of more accurate formulae to express the shape of the ellipsoid. These formulae are necessary in the reduction of precise surveys, such as the first order triangulation and leveling nets which have been extended over the country to provide a fundamental and accurate datum for all engineering works and detailed surveys. The rapid development of geophysical prospecting for oil and minerals within the earth's crust has revealed an immediately practical use for standard gravity stations at frequent intervals over the country. The correlation of gravity observations with geological and geophysical data was studied extensively by Hayford, and later ably carried on by Bowie. The great contributions to the science of geophysics of these outstanding men are well known and appreciated by all geologists and geophysists. The concise exposition of the fundamentals underlying isostasy and the quantitive proof of many of the basic hypotheses by these two men, have resulted in the general acceptance of isostasy as a principle rather than a theory. Bucher, for example, in his "Deformations of the Earth's Crust," published in 1936, devotes 37

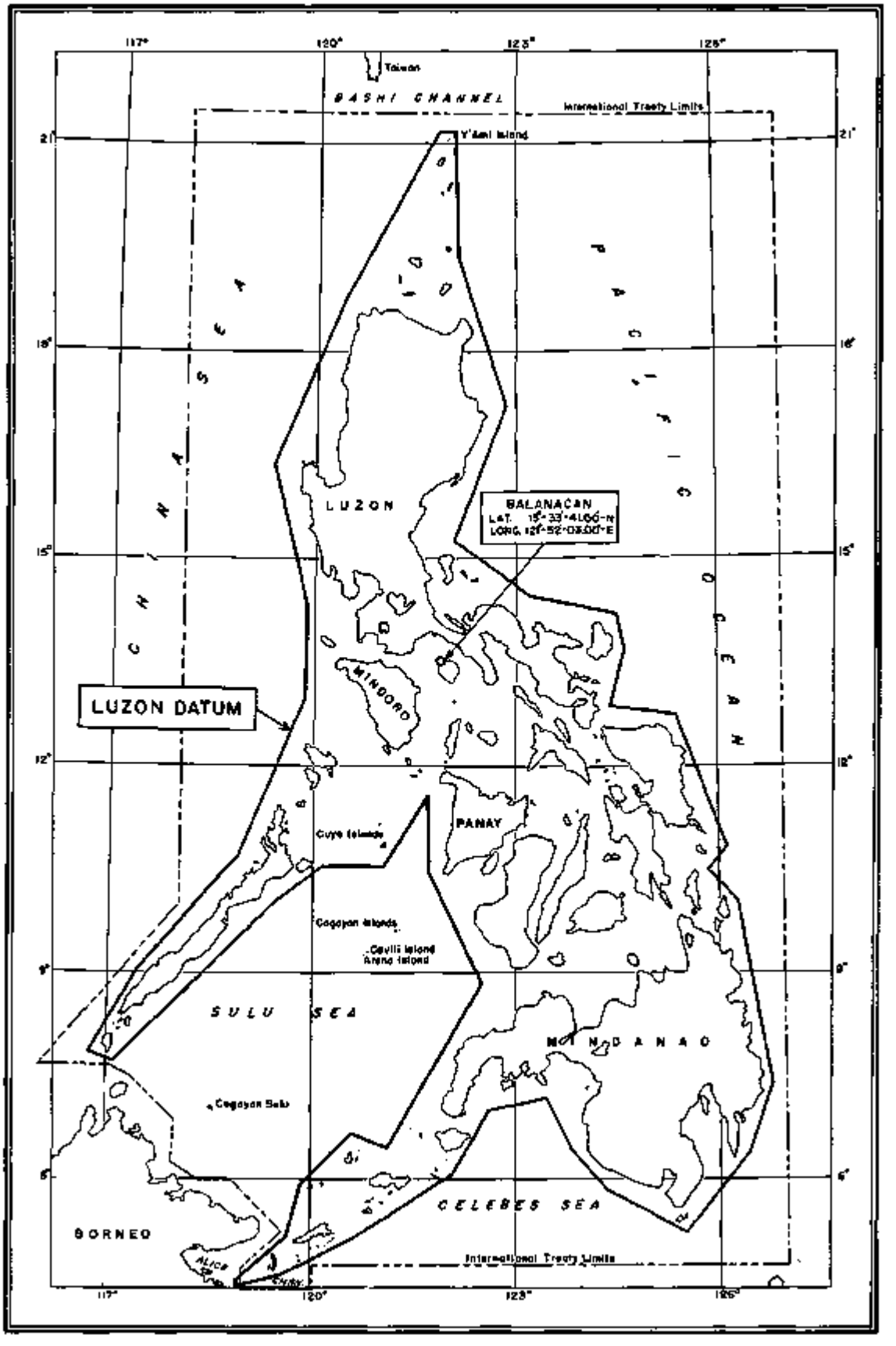


FIGURE 4 - DATUM USED IN THE PHILIPPINE ISLANDS

although supplemented by theoretical inference and approximate results from other regions. While this was an attempt to establish a Philippine datum, the incompleteness of the available data made it unwise to adopt the latter name. The Luzon datum is defined in terms of the coordinates of Station Balanacan in Marinduque Province as computed on the Clarke Spheroid of 1866 as follows:

Latitude	13° 33' 41".000 North
Longitude	121° 52' 03".000 East
Azimuth to Baltasar	9° 12' 37".000

The publication issued by the Bureau of the Coast and Geodetic Surveys, Manila, P. I. entitled "The Triangulation of the Philippine Islands" (in two volumes) contains the geographic positions (on the Luzon datum) of all triangulation executed by this Bureau from 1901 to the end of 1927 except the triangulation of the city of Manila which is published in a separate volume under that name. For work subsequent to 1927 reference must be had either to the field or office computations.

Practically all the islands of the Archipelago have now been connected to the Luzon Datum (see Fig. 4) except a few scattered islands in the Sulu Sea and off the northeast coast of Borneo.

Puerto Rico and Vicinity

Puerto Rico Datum

Prior to 1901 the triangulation on Puerto Rico was based upon the San Juan Astronomic Datum and the other islands had their own independent datums. When the inter-island connection was made the Puerto Rico Datum was adopted from a study of a number of astronomic observations on the island of Puerto Rico and adjacent islands as the best geodetic datum for Puerto Rico, Mona Island, Vieques, Culebra and the Virgin Islands. The datum is defined in terms of the position of Cardona Island Lighthouse on the south coast of Puerto Rico as follows:

Latitude	17° 57' 31".400
Longitude	66° 38' 07".530
Azimuth to Ponce Southwest Base	128° 36' 26".2

No volume has yet been published giving the final positions on the Puerto Rico Datum. To obtain geographic positions on this datum recourse must be had to the field or office computations.

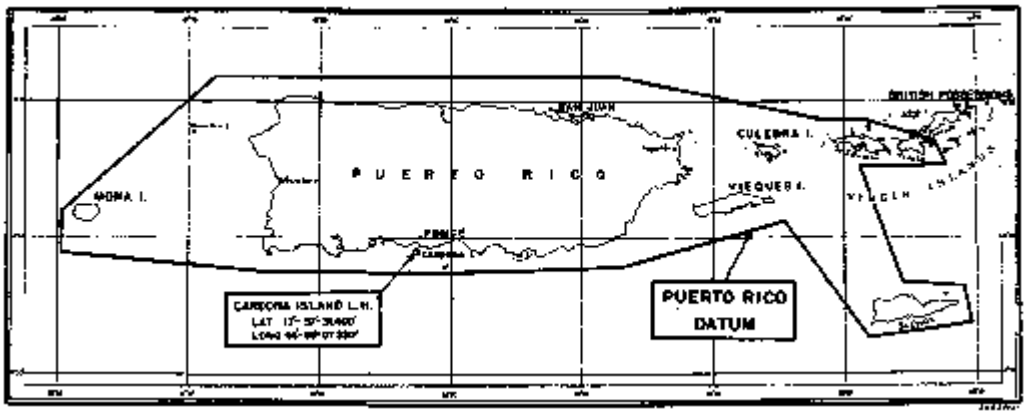


FIGURE 5-DATUM USED IN PUERTO RICO AND THE VIRGIN ISLANDS

Canal Zone

Although the Canal Zone is under the jurisdiction of the Isthmian Canal Commission, both the Atlantic and Pacific approaches to the Canal have been surveyed by the Coast and Geodetic Survey. The main scheme of triangulation across the Canal Zone was done by the Isthmian Canal Commission but the adjustment was made by this Bureau.

Prior to 1911 two datums were in use in the Canal Zone, both astronomic. In Limon Bay and vicinity the work was based on the astronomic determination (telegraphic longitude) of station Colon Lighthouse as established by the U. S. Navy Department in 1877 and was known as the Colon datum. In Panama Harbor and vicinity the work was referred to the astronomic position (telegraphic longitude) of the southeast tower of the Panama Cathedral, also determined by the U. S. Navy Department in 1877.

Panama-Colon Datum

When the triangulation connection was made between Limon Bay and Panama Harbor and the work adjusted, discrepancies were found to exist between the two datums in use and therefore it became necessary to adopt a single standard datum for the entire Canal Zone. This was accomplished by selecting station Balboa Hill which was central to the whole area and computing its latitude and longitude through the triangulation both from Colon Lighthouse on the one side and Panama Cathedral on the other. These values were then averaged to give the standard latitude and longitude after correction for the computed effects of topography and compensation.

The adopted datum was named Panama-Colon and is defined in terms of the position of station Balboa Hill as follows:

Latitude	9° 04' 57".367
Longitude	79° 43' 50".313
Azimuth to Salud	185° 02' 39".54

The published Report of the Isthmian Canal Commission for 1911 contains the geographic positions on the Panama-Colon datum of the main and secondary triangulation accomplished by the Commission. All triangulation done by the Coast and Geodetic Survey, both prior and subsequent to 1911, has not yet been published but is available from the office files.

Alaska

In Alaska, as in the United States and the Philippines, commercial considerations governed largely the distribution of surveys. The development of the fishing industry in Southeast Alaska, the opening of the gold fields in the Klondike region and around Nome, the beginning of the Alaska Railroad in Resurrection Bay, all emphasized the need for early publication of charts. This meant the execution of triangulation at various detached points. The triangulation in each section was based on independent astronomic data in that section. These detached portions were extended from time to time until many of them overlapped, and with this overlapping came the difficulty of making the charts fit. Each chart was correct in itself, but when joined together the shorelines would not fit. To correct this, it was necessary to adopt a geodetic datum for each section where overlapping triangulation existed.

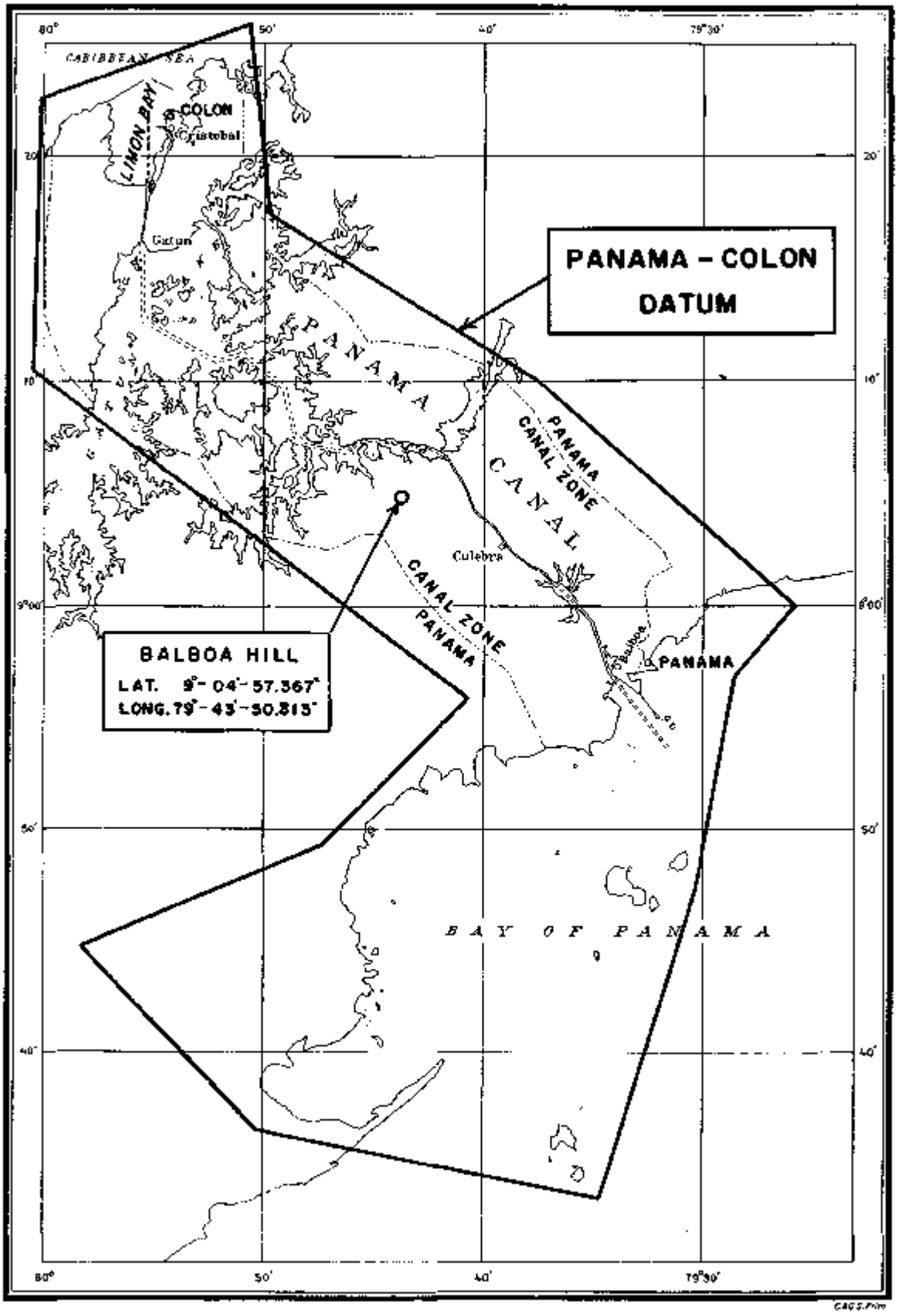


FIGURE 6 - DATUM USED IN CANAL ZONE

Up to a few years ago there were four principal datums in use in Alaska, namely, Southeast Alaska, Yukon, Valdez, and Unalaska. The first of these has now been superseded by the North American Datum of 1927, but because the bulk of the hydrographic and topographic surveys of Southeast Alaska are plotted on this datum, having been made prior to the connection with the North American Datum of 1927, a brief account of its development will be given. Brief mention will also be made of the other three datums which are still in use. No starting data for the various datums except the Yukon will, however, be given in this article because these values are not final and will be superseded as soon as the several gaps in the triangulation of Alaska are bridged, when all will be recomputed on the North American Datum of 1927. This will place all the triangulation of Alaska, Canada, United States and Mexico on a single geodetic datum, a most enviable position in so far as the control of maps and charts is concerned.

Southeast Alaska Datum

The field work for the triangulation of Southeast Alaska dates back to 1882. Toward the end of 1901 the computation of a continuous framework of triangulation had been completed. Nine different groups of triangulation were joined together by this computation to make one continuous scheme on one datum, known as the Southeast Alaska Datum. In the determination of this mean datum eight astronomic longitude stations, all chronometric, and 32 astronomic latitudes were used. There were also various astronomic azimuths that were held fixed because the triangulation was considered too weak to carry the azimuth.

The Southeast Alaska Datum applies to all triangulation in Alaska between Dixon Entrance and Mount St. Elias. With the extension of the triangulation by the Canadian Government through British Columbia, a connection was effected between the work in Southeast Alaska and that in the United States. This permitted the recomputation of the work in Southeast Alaska on the North American Datum of 1927. At the present time the positions are available on the new datum for practically all of Southeast Alaska, the only exceptions being the triangulation between Yakutat and Dry Bays and a section along the Alaskan-Canadian boundary from westward of Skagway to Mount St. Elias. These are in the process of being reduced to the 1927 Datum.

Yukon Datum

This datum was used for the triangulation along the 141st meridian, the boundary between Canada and Alaska, and covers the area from Mount St. Elias to the Arctic Ocean. The Yukon Datum is based on one astronomic station near the crossing of the 141st meridian and the Yukon River. The geographic positions of points along the boundary have been computed on the Clarke Spheroid of 1866.

While the ultimate connection with the North American 1927 Datum will change the geographic positions of the boundary monuments and the triangulation points used in their determination, these monuments will however be considered for treaty purposes as defining the 141st meridian. Hence the Yukon Datum will remain the official datum for the 141st meridian work.

The Yukon Datum is defined in terms of the coordinates of station "Boundary" at the Yukon River, astronomically determined as

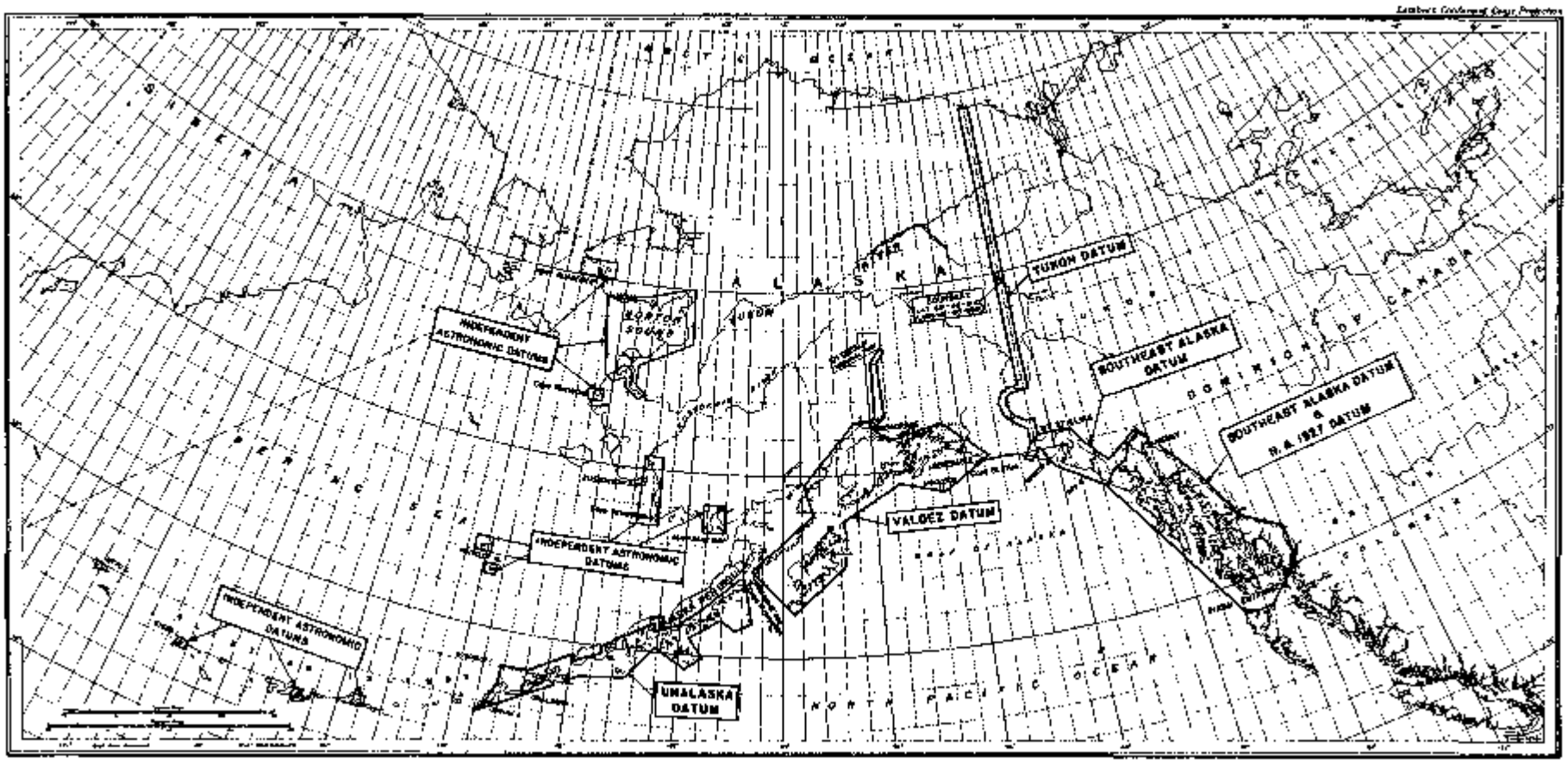


FIGURE 7 — ILLUSTRATING VARIOUS GEOGRAPHIC DATUMS IN USE IN ALASKA

flllows:

Latitude	64° 40' 51".42
Longitude	141° 00' 00".00
Azimuth to station "Bald"	270° 00' 00".00

The only published volume giving these positions is that issued by the State Department in 1918 entitled "Report of International Boundary Commission." Copies of these positions are also available in our own office files.

Valdez Datum

This datum applies to the work on the south coast of Alaska from Controller Bay in the vicinity of Cape St. Elias to Kialagvik Bay on the Alaska Peninsula as well as the triangulation around Kodiak Island. It also includes a stretch of work in the interior in the vicinity of the Alaska Railroad from Anchorage to Mt. McKinley National Park.

There is no published volume giving the geographic positions of points on this datum, but the data are available from the office files.

Unalaska Datum

On this datum is based the triangulation along the south coast of the Alaska Peninsula from Cape Kuyuyukak to Umnak Island, including most of the offlying islands. Only a short connection is necessary to bring together the work on this datum with that on the Valdez Datum. When this is accomplished it is expected to place all the points on the latter datum.

There is no published volume of points on the Unalaska Datum and recourse must be had to the office files.

Independent Astronomic Datums

Besides the four principal datums just described there are a number of independent astronomic datums that were established to control small detached surveys on offlying islands or other remote places. Among these may be mentioned several small harbors in the Aleutian Islands, Nushagak Bay, Cape Newenham to north of the Kuskokwim River, Norton Sound, Port Clarence and the Pribilof Islands. Names are not usually appended to such datums but they are referred to as "Independent astronomic datums".

THE HAYFORD SPHEROID OF 1909

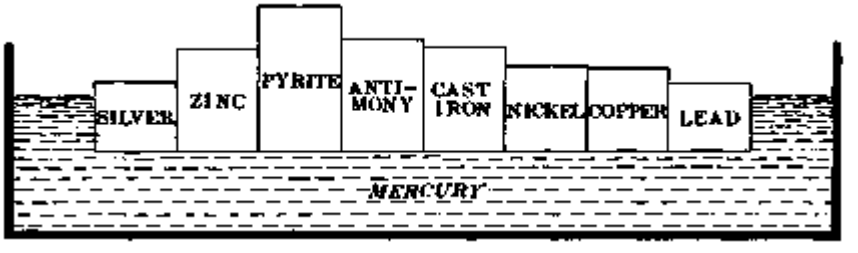
Before concluding this article on geographic datums brief mention should be made of an investigation of the Figure of the Earth by J. E. Hayford in 1909 while Chief of the Computing Division of this Bureau. While the spheroid which Hayford deduced does not enter into any of our computations it deserves mention here because of its international character, having been adopted by the International Geodetic Association, and because in its determination the theory of isostasy was given its first quantitative test.

What is Isostasy?

It will be recalled that the plumb line, to which astronomic

observations are referred, is deflected toward land masses and away from large bodies of water. This topographic deflection for any station can be computed from the Newtonian equation for the force of attraction between two masses. If no other force acted upon it, this topographic deflection would represent the total plumb line deflection at the station, or the station error, and would be equal to the difference between the astronomic and geodetic determinations of the station. A comparison, however, of the topographic deflection with the station errors shows the former to be much larger than the latter. That is to say, the attractive force of the topography, which takes into account the density of the earth, is found to be greater than is required to bring into agreement the astronomic and geodetic determinations of the station. Although this fact was known for many years, and it was suspected that the densities of the material immediately beneath the surface were unequal, no reasonable explanation for its existence was advanced until 1855 when Archdeacon Pratt of Calcutta published his now famous ideas on the floating crust hypothesis from a study of plumb line deflections in India.

According to this theory the average densities of the earth's crust from the surface down to a depth of about 58 miles vary from place to place and if it is assumed that the average density under the coastal plains is normal, then under the continents and larger islands it would be less than normal while under the oceans it would be greater than normal. This means that every unit section of the earth's crust contains the same amount of matter and hence exerts the same pressure on the subcrustal material. To this condition of equilibrium between the crust and the subcrust, the name "isostasy" has been given, meaning "equal standing" or "equal pressure". Figures 8 and 9 illustrate the principle of isostasy.



Pig. 8. Illustration of Isostasy after Pratt
(From Isostasy by Wm. Bowie.)

The blocks of metal, all lighter in density than mercury, have equal masses and cross sections. Each displaces the same amount of mercury and thus sinks to the same level as the other blocks. The upper surfaces of the blocks stand out at different heights, the lighter the block the higher it stands.

The lower surfaces of the prisms define what may be called the depth of compensation, that is, the depth at which the excess of material represented by that portion of the continent which is above sea level is compensated for by a defect of density in the underlying material. The continents will be floated because they are composed of relatively light material; and similarly the floor of the ocean will be depressed because it is composed of unusually dense material. It is generally regarded that the mountains and

the oceans are the result of the deficiency and excess of density, respectively, in the crustal prisms under them rather than that the deficiency and excess of density in the prisms are due to the mountains and oceans above them. It is well to remember that isostasy is a condition of rest and quiet and not one of force and movement.

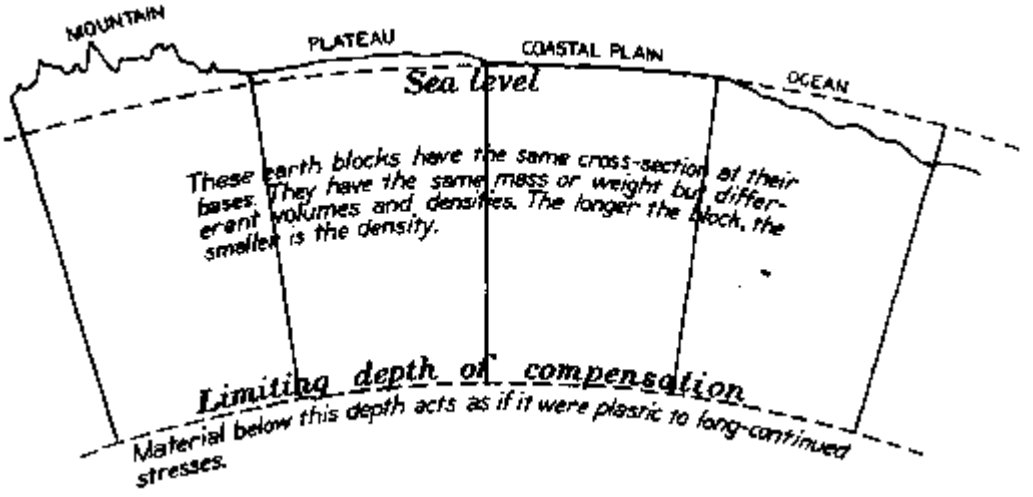


Fig. 9. From Isostasy by Wmo Bowie.

If the earth's crust should be out into blocks of equal horizontal cross section by vertical planes, each block would have very nearly the same mass as each of the other blocks. The blocks would exert the same pressure on the subcrustal material. It is not definitely known what is the cross section of the block which may be in isostatic equilibrium independently of the surrounding blocks but it is probably of the order of magnitude of 50 or 100 miles square.

Hayford's Investigation

The investigation made by Hayford of the Figure of the Earth differed materially from that made by both Bessel and Clarke. The latter utilized the "arc method" in computing the dimensions of the spheroid whereas Hayford used the "area method".

In the arc method, in its simplest form, the linear distance between two points on a meridian is measured by means of triangulation and the angular distance between them is determined from the observed difference in their astronomic latitudes. The deflections of the vertical, that is, the difference between the observed latitudes and the latitudes as computed through the triangulation were treated as accidental errors and least square adjustments applied to the observed values.

In the area method as used by Hayford, a network of triangulation computed on the basis of a single geodetic datum was studied in relation to numerous astronomic observations of latitude, longitude and azimuth distributed throughout the United States and the observed deflections of the vertical were compared with the computed topographic deflections.

By assuming that the condition called isostasy actually exists in the United States, it was possible by assuming different depths of compensation, to determine at what depth the computed topographic deflections most nearly agreed with the observed deflections. The investigation disclosed that the compensation was most nearly complete at a depth of about 122 kilometers or 76 miles. (Later investigations have indicated that 58 miles is probably more nearly the depth of compensation). Therefore, in determining the elements of the spheroid from deflections of the vertical data Hayford applied corrections to the astronomic data for the deficiency of mass under land masses and excess of mass under water areas.

Hayford's investigation gives values larger than those determined by Bessel and Clarke, and this seems to be in accord with theory since by considering deflections of the vertical as systematic with respect to the topography the effect would be to reduce the station errors and hence to bring the spheroid into closer agreement with the geoid.

The derived values are as follows:

Equatorial Radius	6,378,388 meters
Polar Semi-diameter	6,356,909 meters
Compression	1/296.96

While the Hayford Spheroid most nearly fits the geoidal surface in the United States, the Bureau has never adopted it as the spheroid of reference, expediency dictating against any change involving such an immense amount of labor without practical advantage accruing either to its geodetic or cartographic work. However, it probably will have large future use in scientific studies involving the determination of the figure and size of the earth from geodetic and gravimetric measures.

International Ellipsoid of Reference

The figure of the earth as deduced by Hayford was adopted, with slight modifications, by the International Geodetic and Geophysical Union in 1924 as the best available figure for the earth as a whole. Instead of using the flattening of 1/296.96, they decided to use 1/297 exactly. This gives a Polar semi-diameter of 6,356,912 meters or 3 meters greater than the value published by Hayford. The spheroid has been given the name International Ellipsoid of Reference.

THE IMPORTANCE OF DATUMS IN CARTOGRAPHY

Geographic datums are to cartography what tidal datum planes are to hydrography. And just as soundings must first be reduced to the same plane of reference before studies of changes can be made, so in cartography must we make certain that the maps or charts we are to study are referred to the same geographic datum; otherwise a comparison by grids may lead to very faulty conclusions. This is particularly true in the case of comparisons between modern surveys and those of an early date, many of the latter having been based on independent astronomic datums. In this connection it should also be noted that many of our modern surveys in continental United

States are on the North American Datum. These are gradually being converted to the North American Datum of 1927.

Spheroids and Datums

From what has been said about spheroids and datums, it should be quite clear that no relation exists between a geographic datum as such and a spheroid of reference. Points may be inconsistently located on the same spheroid, as for example where the triangulation of a country consists of a network of independent schemes each based on its own astronomic position but all computed on the same spheroid. Unless the various networks were connected they would not be on the same datum. It follows then, that points to be on the same geodetic datum must necessarily be referred to the same spheroid, but points referred to the same spheroid need not be on the same geographic datum.

In all the survey work of this Bureau only one spheroid of reference is used at this time, namely, the Clarke Spheroid of 1866, but as has been seen, there are a number of geographic datums in use.

Officers surveying in remote regions should be alert to their opportunities to contribute valuable information to other branches of science, such as anthropology, volcanology, glaciology and, in fact, all of the earth's sciences.

The Aleutian Islands, where several of the Bureau's vessels are currently working, provide one such opportunity. In a recent letter to the Coast and Geodetic Survey, Dr. Ales Hrdlicka, Curator., Division of Physical Anthropology, United States National Museum, who has been studying this region during his past 13 years of exploratory expeditions to Alaska, requested the Bureau's cooperation in his investigations.

This area is very interesting from an anthropological viewpoint. It is known that when the Russians made their first visit, the Aleutian Islands were well populated and that some of these people mummified their dead and deposited them in holes and caves of difficult access. Dr. Hrdlicka's studies of the skeletal material obtained in his discoveries indicate they antedate the Aleut.

In the summer of 1938, caves and old human sites on the Islands of Four Mountains and on nearby Umnak Island were explored. Three caves were found and 51 boxes and barrels of material collected. Some findings amounted to no less than a resurrection of ancient culture, the existence of which had never before been suspected. On Agattu Island evidence was found of a chipped-stone industry which is attributed to the pre-Aleut people.

Another opportunity to contribute to science is in Glacier Bay, Southeast Alaska, where surveys were begun in the spring of 1938. Elsewhere in this issue will be found a preliminary report of Lieutenant H. Arnold Karo, Commanding Officer of the Motor Vessel Westdahl, in which he describes to some extent the glaciers of the bay. Undoubtedly this report will be of interest to geologists.

A REVIEW OF PROGRESS

Gilbert T. Rude, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Upon assuming the duties of Chief of the Division of Hydrography and Topography in April 1931, the writer accepted with pleasure the invitation of the Editor of the Field Engineers Bulletin (No. 3, June 1931) to send a message to the field force of the Coast and Geodetic Survey. In that message the then new chief of division asked sincerely the cooperation and help of his colleagues in advancing the work of the division and in extending our knowledge of the art of hydrographic and topographic surveying in order fully to maintain the high standards of the service in line with modern scientific developments and modern needs. Almost eight years have now passed and a summation of our accomplishments for that period and a review of our progress may be timely and may be of benefit to us, provided we view it not with satisfied complacency but with the purpose of refreshing our outlook whereby we may be spurred on to even greater accomplishments. While satisfied that there are great developments to look forward to, frankly I am satisfied with the progress you have made to date and it has given me great pleasure and satisfaction to have been head of the division during this period and to have been able to share in the combined accomplishments of the corps of engineers comprising the field and office force of the Coast and Geodetic Survey.

With the development during this period of our precise shoal water fathometer, the Dorsey fathometer No. I, and of our deep water fathometer, the Dorsey fathometer No. III, I think we can claim without fear of contradiction that we are leading hydrographic services in accuracy of depth measurement by indirect methods. The fact that we can measure a depth of 120 feet, the maximum depth of the Dorsey fathometer No. I, within a tenth of a foot; that we can record with this instrument a perfect tidal curve, accurate within a tenth of a foot, while at anchor 30 miles offshore, is certainly an attainment of precision in indirect methods of sounding not easily surpassed.

With this accuracy, however, we naturally should not be satisfied; the record is visual. Our next development should be an automatic graphic record to make full use of this accuracy, since the fallible human eye may miss, as a supposed stray, indications of a menace to navigation which would be indicated on the profile of a graph. I can assure my colleagues that we have this need in mind and its development awaits only the opportunity and time with our small force.

While we have made marked progress in our instruments and technique on offshore hydrographic surveying, I am quite sure you are not satisfied with the lack of progress in the methods employed on our inshore surveys. Neither is the chief of the division nor are his colleagues in the office. We can assure you, however, that the division is not unmindful of the need for new equipment, has given serious consideration to the problem and is formulating plans to remedy the deficiency. Lack of funds and insufficient personnel in our staff have made it impossible to undertake the improvement of both the offshore and inshore methods at the same time. If our tentative plans mature, your leadlines will soon be replaced with recording fathometers for small-boat hydrography.

In the field of radio acoustic ranging, already well developed at the beginning of this period, we have made marked progress. The automatic sono-radio buoy, costing only about $150.00 each and with a maintenance cost of about $1.00 a day, has replaced the station ship costing about $60,000.00 with a maintenance cost of $150.00 a day.

Advantageous use has also been made of devices developed by other organizations. We are indebted to the British for the taut-wire apparatus. You in the corps of field engineers have developed a technique most successful and economical in combining the taut-wire traverse with our survey buoy system, replacing the more expensive method of radio acoustic triangulation developed for the Georges Bank survey before the taut-wire was available.

On land our nine-lens air camera has been developed during this period, not only reducing the time required for topographic surveys compiled from air photographs, but increasing the accuracy of the results. At an elevation of about 14,000 feet this camera photographs at a single exposure an area of about 120 square miles on a scale of 1:20,000, each photograph 34 inches square. From these photographic surveys we are now able, too, to further the progress of hydrographic parties by locating in advance by radial line plots the positions of identifiable signals for their use in starting the hydrographic surveys immediately at the beginning of a project. The large area surveyed by a small hydrographic party in the upper Chesapeake Bay area the past summer is indicative of the results we may expect as these methods become standardized.

In addition, you have contributed in many minor improvements in technique and methods too numerous to sum up here, but in the aggregate adding in no small measure to the total accomplishments of our field units. It suffices here to have mentioned the outstanding ones.

It may not be out of place to enumerate in general the areas in which modern surveys have been completed during this period. On the Atlantic coast, offshore hydrographic surveys have been made over the whole of Georges Bank. They have also been extended from Chesapeake Bay entrance to Block Island from the coastline well out beyond the 1,000-fathom curve. During the course of these surveys, a number of submarine valleys, indenting the continental shelf, have been thoroughly and accurately surveyed and the topography of the coastal slope made known in detail for the first time.

In the Gulf of Mexico, complete hydrographic surveys from the coastline out beyond the 100-fathom curve have been completed from the Mississippi Passes almost to the Rio Grande.

On the Pacific coast, offshore hydrographic surveys have been extended from San Francisco Harbor entrance to the waters at the Mexican boundary, from the coast line offshore to the 2,000-fathom curve.

In addition to the extension of surveys of the inland waters of Southeast Alaska, modern surveys have been completed from the Sanak Islands in Western Alaska 300 miles to the westward to the Islands of Four Mountains in the Aleutians.

In addition to the progress on our offshore hydrographic surveys, we have also been able to advance the surveys of our intra-

coastal waterways. In the fall of 1952 allotments of funds were made available by the Public Works Administration and for the next three years intensive surveying operations were carried on in these areas. The principal through intracoastal waters were thoroughly and adequately surveyed from New York Harbor to Miami and from Apalachicola, Florida, to Corpus Christi, Texas. By means of thorough preliminary plans made at the inauguration of this project with the Chart Division, which also shared in this allotment of funds, the large amount of data resulting from these field surveys was the basis of complete new charts of the intracoastal waters, practically all of which have now been issued.

In addition, complete surveys, including first order triangulation, topography, and hydrography have been extended along the Florida Keys to Key West.

On the Pacific coast, the southern part of Puget Sound was resurveyed during this period and the Columbia River . Surveys, the triangulation, topography, and hydrography, have been extended from the mouth of the river to Portland, Oregon.

For many years prior to this period our coastal control had been in deplorable condition on the Atlantic, Gulf, and Pacific coasts. The inadequately monumented triangulation established many years ago had practically disappeared, only relatively few of the old stations being recoverable. As soon as Public Works Administration funds were available, operations for the reestablishment of coastal control were started and during the period a net of second-order triangulation was extended along practically the entire Atlantic and Gulf coasts from Maine to Corpus Christi, Texas and on the Pacific coast from Half Moon Bay to the Mexican boundary, in addition to the control established on Puget Sound and on the Columbia River.

It has been possible here but to touch on the outstanding accomplishments during this period. In the meantime you have also carried to successful completion many relatively minor projects; you have developed, too, methods and technique which show only in the increased amount and accuracy of the resulting field data. The hydrographic surveys as made today with precision fathometers; radio acoustic ranging, sono-radio buoys and taut-wire traverses, present a most intricate operation. As one visits your vessels engaged on offshore hydrographic surveys he is forcibly reminded of a well-oiled smoothly functioning piece of delicate machinery, each cog fitting perfectly into its neighbor.

We still have in prospect many difficult areas over which we will be extending modern surveys during the years to come. I might mention the Gulf of Maine and the Gulf of Mexico from the Mississippi Passes to Key West, over both of which only reconnaissance surveys were made many years ago. Modern surveys must also be made on the Atlantic Coastal shelf from Chesapeake Bay to the Straits of Florida to replace the reconnaissance surveys consisting of dead reckoning beyond the IE-fathom contour, made before the advent of radio acoustic ranging. We have in Alaska large areas wholly unsurveyed - the remainder of the. Aleutian Islands west of the Islands of Four Mountains, the whole of Bering Sea and particularly the area from Unimak Pass to and including Bristol Bay and the south side of the Alaska Peninsula. Of the numerous unsurveyed areas in Alaska, mention is made of only these three areas because they are under immediate consideration. Many of the

unsurveyed areas present unique problems in carrying on adequate surveys at reasonable costs.

So long as the tides ebb and flow; so long as the currents and the waves take toll of our coastline and man-made changes bring obsolescence to our charts, we shall have the serious problem of repeated surveys to maintain our intracoastal and harbor charts up to date.

I wish each of you to know that your many hours of intense concentration on our problems and your hearty cooperation in solving them successfully are realized and appreciated by myself and the other administrative officers of the Bureau. I am sure I can depend upon your continued cooperation in solving our future problems.

TRAINING OF MARITIME COMMISSION CADET OFFICERS

To assist the United States Maritime Commission in a program designed to provide competent officers for the merchant marine, the Coast and Geodetic Survey has undertaken the supplemental training of fifteen cadet officers aboard vessels of the service. During the past season five of these officers were assigned to the OCEANOGRAPHER, four to the LYDONIA, two to the HYDROGRAPHER, and four to the GUIDE. Those assigned to the OCEANOGRAPHER and LYDONIA were given a short preliminary period of instruction in the Washington office.

The young men entrusted to the Coast and Geodetic Survey were especially selected on a basis of merit from the graduates of the various State nautical schools, and all hold marine licenses. Reports of their progress and interest have been most encouraging.

The vessels of the Bureau, in addition to providing opportunities for experience in seamanship and navigation, have furnished instruction in the finer phases of navigation as practised in the service, particularly in the comprehensive use of the nautical chart, modern acoustic sounding methods, sextant piloting, magnetic and gyro compass adjustment, and the importance of tides and currents in navigation.

Upon completion of their training, which will cover a period of approximately six months, these cadet officers will be assigned as junior officers to vessels of the merchant marine. It is hoped that their training in the Coast and Geodetic Survey will prove of special value, not only to themselves in providing instruction and experience in phases of navigation not usually encountered by the young navigator, but also to the Coast and Geodetic Survey in having in the merchant marine a group of officers who are familiar with the aims and problems of our service, and conscious of its value to the maritime world. Incentive will thus be provided them to cooperate with us to the fullest extent, and to inculcate in their fellow officers a spirit of cooperation.

The New U. S. C. & G. S. S. EXPLORER

THE NEW AND OLD EXPLORER

Extending 900 miles from Unimak Pass toward the Siberian Coast, the Aleutian Islands have presented for many years a survey problem to officers of the U. S. Coast and Geodetic Survey. While of no great importance commercially, their position naturally gives them importance in connection with National defense, and a complete hydrographic survey of the whole area becomes necessary.

These surveys were started at Unimak Pass in 1934 by the Ships SURVEYOR and DISCOVERER. After the immediate vicinity of Unimak Pass was surveyed, the DISCOVERER began operations toward the eastward along the south coast of Alaska Peninsula and the SURVEYOR alone continued the surveys to the westward in the Aleutians. During the past season the PIONEER joined the Alaskan fleet and operated with the SURVEYOR in the Aleutian Islands.

These surveys have now been carried to the Islands of the Four Mountains, 200 miles westward from Scotch Gap, Unimak Pass. In view of the fact that Uhalaska is the only base in the Islands for supplies and fuel oil, the problem becomes more acute as the work progresses farther westward, and since this area comprises one of the stormiest in the world as to weather and one of the foulest as to hidden dangers to navigation, it soon became apparent that well-found modern vessels of long cruising radius would be required if the surveys were to be continued in this area.

With these obvious facts for the basis of discussion, conferences were held with the Bureau of the Budget and with the Public Works Administration and finally funds were made available by the Administration for the Coast and Geodetic Survey to construct a new ship for the replacement of one of its old units. It is contemplated to replace the 35-year old EXPLORER (450 tons) with this new vessel. It is proposed to assign the new EXPLORER to the Aleutian Islands and the SURVEYOR to southeastern Alaska where the old EXPLORER has been operating for many years.

The new EXPLORER will have a light displacement tonnage of about 1500 tons, will be 198 feet 8 inches between perpendiculars, 38 feet moulded beam, 23 feet moulded depth and will have a draft of about 16 feet. Accommodations will be provided for 90 officers and men.

The ship was designed and specifications drawn by Mr. George G. Sharp, a prominent naval architect of New York City. Mr. Sharp incorporated the general arrangement plan of the Bureau into the specifications with the result that the EXPLORER will be one of the finest and most modern of survey vessels. Special consideration has been given to the quarters of both the officers and crew. In the past it has been impossible with the size and type of ships of this Bureau to provide comforts and recreation facilities for the officers and men when operating in remote areas of Alaskan waters. Some consideration has been given in the design of the new ship to correct this condition.

Following the trend of modern design for marine construction, this vessel will have a raked stem, cruiser stern, with two of the steel decks continuous throughout the length of the ship. The entire construction will be of steel and fireproof material so fire hazards will be non-existent.

The main propelling unit will consist of four impulse steam turbines, or their equivalent, connected to a single propeller by a two-pinion, single-case, double-reduction, double-helical gear. The ahead turbine and gears are to be designed to deliver a rated power of 2000 shaft horsepower, at 130 R.P.M. with the steam pressure at 300 pounds and 200° superheat. It will be designed to operate continuously, if necessary, at 10% overload. The turbines will be designed to develop 100% normal ahead power with 130% normal backing power.

Two water tube boilers will be installed, each having heating surfaces sufficient to evaporate 18,000 lbs. of steam per hour at 325 lbs. gage pressure and 200° superheat. Under normal conditions at cruising speed, which is about 14 knots, the ship will have a cruising radius of approximately 7,000 miles.

Safety has been given major consideration in the design of the new EXPLORER. Double bottoms and eight watertight bulkheads will keep the ship afloat under ordinary conditions even with two of the compartments completely flooded. The equipment and fittings will consist of the latest standardized types used in marine construction embodying safety, reliability and service, with a maximum of efficiency. In addition to the regular surveying equipment which will include the latest designs of fathometer and echo sound equipment, other modern installations will include automatic whistle operators, radio telephone, fire and smoke indicators, clear vision screens in the pilot house windows, gyro compass and pilot, etc.

The ship will be constructed by the Lake Washington Shipyards located at Houghton, Washington. This firm submitted a low bid of $892,000 and contracted to complete the ship within 420 days. Upon completion of construction in the spring of 1940, it is planned to give the new EXPLORER a shakedown cruise along the California coast and then to leave for surveys in the Aleutian Islands about June 1, 1940.

The old EXPLORER which this new vessel replaces has had a long career in carrying on surveys of this Bureau and it may prove interesting to those who are not familiar with the history of the ship to review several of the outstanding events in connection with her field work. The ship was built for the Coast and Geodetic Survey by Pusey & Jones, Wilmington, Delaware, in 1904, and was accepted for the Government by a representative of the Coast and Geodetic Survey - the late Captain R. L. Faris, who was designated as Commanding Officer.

On December 29, 1904, the ship was officially commissioned and a part of the crew was transferred from the Coast and Geodetic Survey Ship BLAKE. It is interesting to note in passing that of the ten men which comprised the crew of the EXPLORER while outfitting, nine were of Scandinavian descent. Although the ship was officially accepted and commissioned at the end of 1904, it was not until March 9, 1905 that she left the shipyard. This period was spent in outfitting the ship and preparing her for field work, most of which was done by the ship's force.

The officer personnel of the EXPLORER at that time consisted of the following: R. L. Earls Commanding; L. M. Eurman, 1st Watch Officer; J. T. Goldsborough, Chief Engineer; G. C. Ballard, Surgeon; E. Vance Miller, Captain's Clerk and N. H. Heck, Aid. Before the ship began her regular field season, however, some additional

officers and men were assigned and some were transferred to other vessels. Among the new names appearing in the wardroom were A. L. Giacomini and M. F. Flannery.

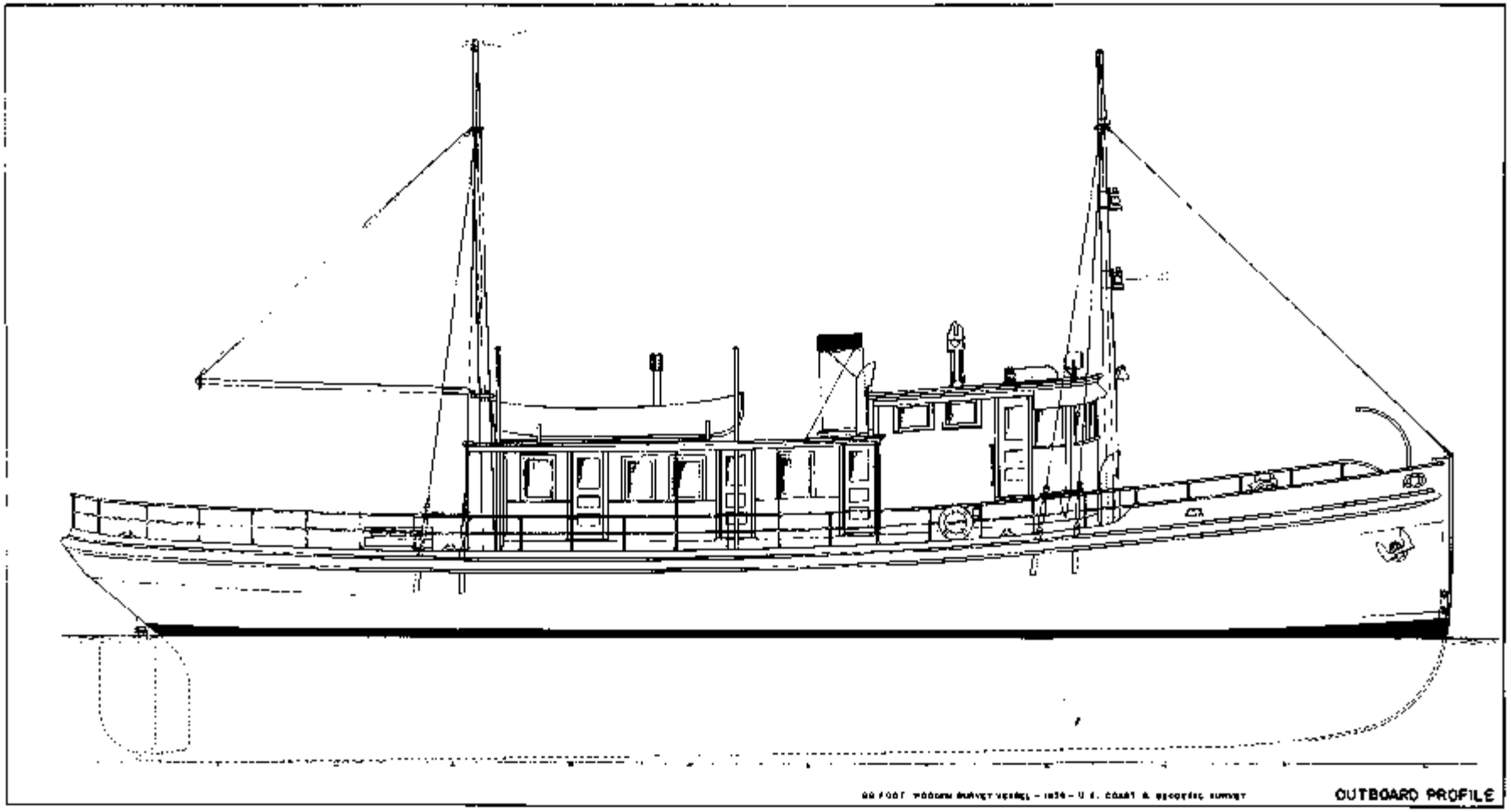
As the first field of work, the EXPLORER operated in the waters adjacent to Puerto Rico, later operating along the middle Atlantic seaboard, and spent several summer field seasons in the coastal waters and bays along the Maine coast.

On February 25, 1907, the EXPLORER left Norfolk, Virginia, under command of W. C. Dibrell, en route to the West Coast. In the wardroom at this time, among others, were G. A. Whitehead, Mate, A. L. Giacomini, 1st Watch Officer, having relieved L. M. Furman, and C. G. Quillian, Aid. The notations in the log for this date indicate that the officers were quite enthusiastic in anticipating the long trip around the Horn. It is well known that the fuel cruising radius of the EXPLORER was not long and recourse was had quite often to her sails. The following entry is noted in the smooth log as the ship passed out to sea through the Virginia Capes: "Steaming out to sea with all sails set."

The voyage from Norfolk down the east coast to South America through the Strait of Magellan and up the west coast to Seattle was somewhat routine, with its days of fine sailing weather, frequent squalls and rough seas. Supplies and coal were obtained and liberty granted at frequent ports of call. St. Lucia, British West Indies, Pernambuco, Rio de Janeiro, Montevideo and Sandy Point were visited. Sandy Point is situated at the eastern entrance to the Strait of Magellan. The EXPLORER passed through the Strait of Magellan into the Pacific on May 1, 1907. At that time, as at present, the pay of crews on the Pacific coast was higher than on the Atlantic and as the EXPLORER passed through the Strait the log shows the following entry: "On this day the pay of the crew was increased to that allowed for the ratings for crews employed on the West Coast." Continuing up the West Coast, stops were made at Coronel, Chile; Callao, Peru; Chatham Island, Galapagos; Panama; Acapulco, Mexico; Magdalena Bay, Lower California; San Diego, California; and finally Seattle, Washington, arriving on July 16, 1907. Although the voyage required 141 days, actually the distance of 14,300 miles was covered in 87 days of sailing time.

After a brief stay in Seattle for outfitting, the EXPLORER sailed for Ketchikan and began surveying operations. Each year since that time this vessel has made her annual cruise to Alaska and carried on surveying work, part of the time in Cook Inlet and Prince William Sound, but for the greater part in Southeastern Alaska. The years, however, have taken their toll and for some time it has been considered inadvisable for the vessel to operate in open, unprotected waters and for that reason she was assigned in the later years only to Southeastern Alaska.

Many officers, recalling her comfortable wardroom, will regret the EXPLORER'S retirement from service, but the promise of a modern, well equipped survey ship, able to cope with the rigors of Alaska work, will be decidedly welcome.



U. S. C & G. S. M V. "E. LESTER JONES"

88 foot Wooden Hull - Diesel Powered survey vessel now under construction at Astoria, Oregon for use in hydrographic surveys in Alaskan waters. It will have a complement of 3 officers and 12 men.

U. S. Coast & Geodetic Survey L. O. Colbert – Director
1938

THE MOTOR VESSEL "E. LESTER JONES".

A new auxiliary survey vessel is now beeing constructed for the Coast and Geodetic Survey. The contract for this construction was awarded to the Astoria Marine Construction Company of Astoria, Oregon, who submitted a bid of $99,500 and estimated 345 days as the time necessary to complete the vessel. When completed, this vessel will replace the 27-year old HELIANTHUS (37 tons) and will be assigned as a tender to one of the larger survey vessels in the extensive surveys now being made of the coastal waters of western Alaska.

The name chosen for this new vessel is that of a former Director of the Coast and Geodetic Survey, E. Lester Jones. Prior to his appointment as Director of this Bureau, he was Deputy Commissioner of the Bureau of Fisheries, and it was during this time that his interest in Alaska was aroused. As Director of the Coast and Geodetic Survey and a member of the International Boundary Commission for a period of 14 years his interest in Alaska increased. He was responsible in a large measure for the beginning of the plan of extensive survey operations which are still in progress in Alaskan waters. In recognition of his services, which were suddenly terminated by his death on April 9, 1929, the interest he had in Alaska in general and because of the fact that this vessel will be employed on Alaskan surveys almost entirely, his name has been given to it.

The E. LESTER JONES will be of wooden construction of the flush deck type and will have a length of 88 feet, a breadth of 21 feet and a draft of 8 feet. The main propelling machinery will consist of two Cooper-Bessemer, direct reversing, diesel engines of 150 horsepower each. It will have well furnished accommodations for 3 officers and 12 men and will be equipped for Alaskan work. The hull will be subdivided into five compartments by four steel watertight bulkheads.

As a special feature in the construction of this vessel all lumber being used in the framing and heavier construction will be treated by a pressure "wood preserver" process. This treatment assures the preservation of the wood in vital and inaccessible places yet does not affect its strength or holding qualities. It also affords further protection by imparting fire resisting qualities to the wood and yet is not detrimental to paint work.

When this vessel is commissioned it will fill an important and necessary role in the hydrographic surveys executed by this Bureau. Vessels of this type are sorely needed by the Coast and Geodetic Survey, particularly in the Alaska areas and the construction of the E. LESTER JONES will, it is hoped, be the first of a series of such vessels.

— Copy —

This memorandum of agreement made and completed this seventh day of July A.D. 1880 between Messrs. Goss, Sawyer & Packard, Shipbuilders of Bath, State of Maine, parties of the first part and Capt. W. H. Besse of New Bedford, State of Massachusetts party of the second part, witnesseth:

That the said parties of the first part agree to build launch, rig, & equip ready for sea a Bark of the following dimensions, —

Two hundred feet Keel — (200)
Forty one & one half feet Beam (41½)
Twenty four feet Deep — (24)

Keel, Frames, Beams, Keelson, Ceiling, Planking & Fastening to be of size material and quality to satisfy the requirements of the French Lloyds of the Class to rate 7.11. in Veritas for Fourteen years.

Vessel to have Iron windlass Emerson Patent & Iron Pumps, — Capstans, Chains, Anchors, Spars, Sails, Rigging, Boats, Outfits and Workmanship to be first class and to the satisfaction of the party of the second part. — And the parties of the first part agree that the keel for the said vessel shall be laid during the current month of July, and that then the said party of the second part shall have a lien upon said Bark and upon all the material intended for her construction and completion as security for moneys advanced and to be advanced by him as hereinafter provided. — And the said parties of the first part will keep said Bark and said material insured by policies assigned by and payable in case of loss by fire to said party of the second part for moneys advanced. — And said Bark shall be launched rigged and finally completed during the current month of November at the charge and expense of said parties of the first part. — And said parties of the first part upon the entire completion of said Bark, will transfer by Bill of Sale, Regularly or other instrument and deliver free from encumbrance lien or lawful claim, Five Eighths (⅝) of said Bark unto said party of the second part. — In consideration whereof the said party of the second part agrees to pay to said parties of the first part for said vessel at the rate of Sixty five (65) dollars per Ton Old Government Tonnage in Bonds as follows.

An expenditure of Ten thousand (10000) dollars when Keel is laid
" " " Fifteen thousand (15000) " " in Frame.
" " " Fifteen thousand (15000) " " Ceiled
" " " Twenty thousand (20000) " " Planked
Balance when ready for sea —

Goss Sawyer & Packard
W. H. Besse

The business generally that the vessel, hull, masts, spars, rigging, sails, anchors, chains, windlass, capstans, boats, outfits and workmanship be satisfactory to Bellamy —

CONSTRUCTION CONTRACT - 1880

In view of the 262 pages of specifications for the construction of the new EXPLORER, besides the many pages of contract, provisions, performance and bid bonds, it is interesting to note the simple procedure connected with the contract for the construction of a vessel of similar length in 1880. The agreement is reproduced through the courtesy of Captain F. H. Hardy, Hydrographic and Geodetic Engineer, U. S. Coast and Geodetic Survey, who sailed in this vessel with his father on many trips. Captain Hardy states that his father selected the keel and keelson on the stump, before they were cut. Another interesting feature is the rapidity with which the bark was built.

"Copy"

"This memorandum of agreement made and completed this seventh day of July AD 1880 between Messrs. Goss, Sawyer & Packard, Shipbuilders of Bath,State of Maine, parties of the first part and Capt. W. H. Besse of New Bedford, State of Massachusetts, party of the second part, - Witnesseth:

That the said parties of the first part agree to build, launch, rig, & equip ready for sea a Bark of the following dimensions:

Two hundred feet Keel (200)
Forty one and one-half feet Beam (41-1/2)
Twenty four feet deep (24)

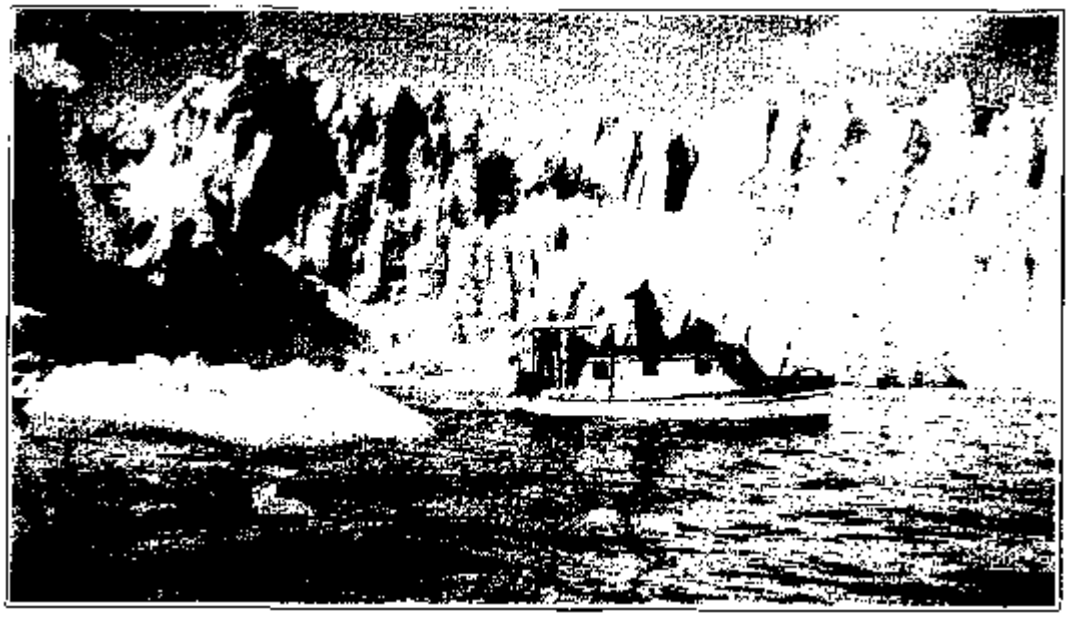
Keel, Frame, Beams, Keelson, Ceiling, Planking & Fastening to be of size material and quality to satisfy the requirements of the French Lloyds of the class to rate 3/3.1.1 in Veritas for Fourteen years.

"Vessel to have Iron Windlass Emerson Patent and Iron Pumps, - Capstans, Chains, Anchors, Spars, Sails, Rigging, Boats; Outfits and Workmanship to be first class and to the satisfaction of the party of the second Part - And the parties of the first Part agree that the keel for the said Vessel shall be laid during the current month of July, and that then the said party of the second part shall have a lien upon said Bark, and upon all the material intended for her construction and completion, as security for monies advanced and to be advanced by him as hereinafter provided-, and that said parties of the first part will keep said Bark and said material insured by policies approved by and payable in case of loss by fire to secure said party of the second part for monies advanced. And said Bark shall be launched, rigged and finally completed during the current month of November at the charge and expense of said parties of the first part- And said parties of the first part upon the entire completion of said Bark, will transfer by Bill of Sale, Registry or other instrument and deliver free from incumbrances lien & lawful claim, Five Eights (5/8) of said Bark unto said party of the second part. In consideration whereof the said party of the second part agrees to pay to said parties of the first part, for said vessel at the rate of Forty five (45) dollars per ton old Government tonnage in sums as follows:

The builders guarantee that the vessel will stand up with spars aloft and sails bent and without Ballast.

His proportion of Ten Thousand (10,000) dollars when keel is laid
" " " Fifteen thousand (15,000) dollars when in Frames
" " " Fifteen thousand (15,000) dollars when Ceiled
" " " Twenty thousand (20,000) dollars when Planked
Balance when ready for sea.

(Signed) Goss, Sawyer & Packard
W. H. Besse."



THE RESURVEY OF TAKU INLET*

George E. Morris, Jr., Junior Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Taku Inlet, to all but shallow draft river boats, is a cul-de-sac. There is no cannery or settlement along its shore; yet, each of the four major steamship lines operating a passenger service to Southeastern Alaska is vitally interested in maintaining safe navigation in the inlet. The reason is that Taku Glacier lies at the head of Taku Inlet. This glacier is one of the very few in Southeastern Alaska which is still active, and is, undoubtedly, the most accessible by water of all the glaciers. A visit to Taku Glacier is considered one of the high-lights of the Southeastern Alaska trip from the standpoint of the tourist and is prominently featured in the steamship companies' advertising.

An investigation, subsequent to a reported grounding in the late summer of 1936, disclosed that extensive shoaling had occurred off Taku Point and in the turning basin near the glacier. This, together with the commercial importance of Taku Inlet from the maritime standpoint, prompted the Coast and Geodetic Survey to give priority in the program of needed surveys to a resurvey of this area.

The U. S. Coast and Geodetic Survey Motor Vessel WESTDAHL left Seattle on April 6, 1937, arriving in Juneau six days later and began operations in Taku Inlet on April 14. Work was started in the critical areas in the vicinity of Taku Point and in front of Taku Glacier. The deep snow on the beach hampered both triangulation and topographic operations, but had the redeeming feature of presenting a distinct high water-line along the Norris Glacier moraine which, after the snow had melted, was not well defined.

Taku Glacier, being a live glacier, is an especially interesting one. But the glacial activity gave the surveying parties some thrilling moments while working near it. The glacier towers over

* Reprinted through, the courtesy of The Alaska Sportsman.

the low water beach, at its southern end and the topographic party-was able to approach close to its face while delineating the edge. At one time, the rodman had gone ahead to select a point for a plane table set-up. Stopping before the overhanging face, he called back, "The glacier's dead along here, so this will be a safe spot and you can see well from here. Anyway, if it starts to fall, you can see it in time to run". He marked the spot and returned to the table to help carry the equipment to the new set-up. A sharp crack made the group look up from collecting the equipment in time to see a huge block of ice break from the top of the glacier and fall with a thundering crash, completely obliterating his recently-pronounced "safe" set-up point.

On another occasion, the topographer was working farther away from the shore, leaving the launch engineer to take care of the dinghy. In odd moments, the engineer took moving pictures of small pieces of ice falling from the face of the glacier. While so engaged, he failed to see a much larger piece than the one he was photographing fall into the water, but the loud crash made him look in time to see a small tidal wave racing towards the boat.

The other members of the party, being at a safe vantage point, were able to see all that happened. The topographer reported that "The engineer was out of the boat and making for the beach like greased lightning as soon as he saw the tidal wave. As it struck the dinghy both wave and dinghy came racing up the beach, but he was two jumps ahead -- he broke the sprint record for men dressed in oilskins and seaboots. I'd like to have had a picture of it". The dinghy was deposited without damage nearly one hundred feet from the water line.

Not all of the interesting experiences were experienced by the topographic party, however. It was necessary to take soundings close to the face of the glacier and, while working there, a few tense moments were felt whenever we heard the ominous crack which precedes a fall of ice. Unfortunately for the photographers of the party, but fortunately for the safety of the sounding launch, only small bits sloughed off into the water during the time we were near the face of the ice cliff.

Floating ice was a constant menace and the helmsman always had to be on the alert to avoid striking the small bergs with the boat. At times, the ice was so thick that in spite of the utmost care, it was not possible to miss every piece and, before the hydrography was finished in the vicinity of the glacier, one rainy night was spent in beaching the launch and calking it around the stem.

It is only when a comparison with the original survey is made that one realizes how great the changes in Taku Glacier and Inlet really are. Since 1890 the glacier has advanced into the inlet nearly three miles. This is at the average rate of more than one-half mile every ten years. Early in May a conspicuous discoloration on the face of the glacier was located by triangulation. Ten days later the topographic party located the same spot by plane-table triangulation and found that the face of the glacier had advanced into the inlet a distance of fifty feet.

Taku Glacier is most active — that is, the ice is breaking off most — at its northern end. The greatest height of the face is slightly less than three hundred feet, but this height varies as ice breaks off and new ice is pushed to the front.

Great quantities of silt are carried down Taku River and most of it is deposited above Taku Point. In 1890 there was a depth of 54 fathoms where now sand cones, formed just in front of the glacier, bare at all stages of the tide. The greatest depth in front of the glacier is at present 27 fathoms. There is good evidence that the glacier has grounded along its entire face. The sand cones have visibly increased in size, and in August depths of less than four feet were found where depths of six fathoms were measured in May. As the glacier advances it pushes the silt ahead of it much like a giant bull-dozer.

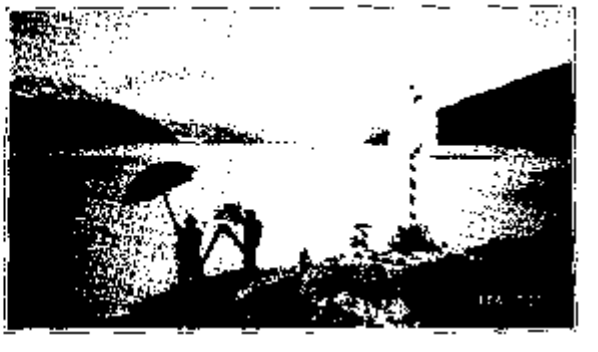
The silting at the head of the inlet, with the resulting grounding of the glacier, is no doubt the reason for the rapid forward movement of the face of the glacier. Since the weight of the advancing tongue of ice is supported, the pieces of ice breaking off are not as large as they would be if this part of the glacier was floating.

The channel between Taku Point and the Norris Glacier moraine has shoaled to some extent, but there is still a clear channel approximately one-quarter mile wide with depths of more than ten fathoms.

The Alaska Steamship Company cooperated with the party by carrying one of the EXPLORER'S hydrographic launches from Seattle to Juneau, and then returning the launch to the EXPLORER when the vessel arrived at Wrangell to begin her Alaska field season.

As soon as the critical areas off Taku Point and the glacier were sounded, a tracing of the boat sheet was made showing the depth curves in relation to the shore line. Blueprints of this were furnished the masters of the ships entering the inlet and were available and used by the first ship calling at Taku Glacier on May 17 at the start of the tourist season. As the work progressed the tracing was kept up to date until early in June, when the field work was completed in the northern end of Taku Inlet. Thus, a complete preliminary 1:10,000 scale chart, based on the boat sheet, was available to all interested navigators.

Throughout the season all the masters and navigating officers of the Southeastern Alaska ships entering the inlet expressed their appreciation of having the preliminary chart made available even before the field work was completed. By using this, all ships were able to make their scheduled calls at Taku Glacier in safety.



FAULT NOISES STUDIED
AS POSSIBLE EARTHQUAKE WARNINGS *

Wm. D. Patterson, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

During the past year sounds have been heard by listening devices deep underground at fault zones in California. The nature of the noises is still conjectural, but they are believed to be resultants of very slight movements in the earth's crust caused by internal stress of the kind that, when sufficiently large, produces an earthquake. These sounds may, in fact, be forewarnings of coming seismic movements. They are being studied continuously with a view to throwing light on this question.

"Fault-murmur hypothesis" is the theory that vibrations, presumably of sonic or supersonic range, originate in active earthquake faults. If such sounds are indications of the stress that precedes seismic movement then some interpretation that would give warning of impending earthquakes may be possible.

Geophysical prospecting parties in California repeatedly have recorded sustained vibrations which they could explain only by the fault-murmur hypothesis. The possibility of getting useful Information about these fault murmurs was discussed last year by interested engineers; in October a joint committee formed in San Francisco, arranged a cooperative program of sound studies along fault zones. Observations have continued through the winter months.

Organization

The joint committee in San Francisco represented the local section of the American Society of Civil Engineers, the Seismological Society of America, and the U. S. Coast and Geodetic Survey. Funds for necessary expenses were donated and the U. S. Coast and Geodetic Survey furnished trained personnel together with such listening apparatus as was available on the Ship GUIDE, which wintered in San Francisco Bay.

Reconnaissance began with a small field party, the objectives of which were: (1) to determine whether noises could be heard, after suitable amplification, along the faults; (2) If so, to get some indication of their volume, vibration frequency, and frequency of occurrence; and finally (3) to select suitable locations for continuous recording.

For the first several weeks the field work produced only negative results. Microphones were put down in shallow holes along the San Andreas rift, hydrophones were lowered to the bottom of lakes on faults and piezo-electric pick-ups were placed on bedrock outcroppings. It was found that shallow holes in dry earth were useless, as a grain of sand dropping on or near the sound unit made a loud crash in the ear phones and wind in nearby shrubbery or a hand touching a blade of grass near the hole caused disturbances. On the lake bottom, the sound of distant centrifugal pumps, water movement in tunnels, and even the waves lapping distant shores, assumed major proportions. No sounds were heard that could not be ascribed to known causes. In settled areas traffic disturbances blotted out other sounds.

* Reprinted through the courtesy of Engineering News-Record.

This early experience suggested the use of deep, unused wells near faults in isolated localities. Several of these were tried; they proved to be by far the most satisfactory listening posts.

One of the test listening posts (No. 1) is a well 360 feet deep with water level 30 or 40 feet below the top. In the upper 200 feet the casing is 12 inches in diameter; below that point, 8 inches. Through a hydrophone in the bottom of this well were heard the first of the faint, grinding noises with intermittent and relatively loud rumbles and crashes, which are believed to be of fault-zone origin.

Development of instruments

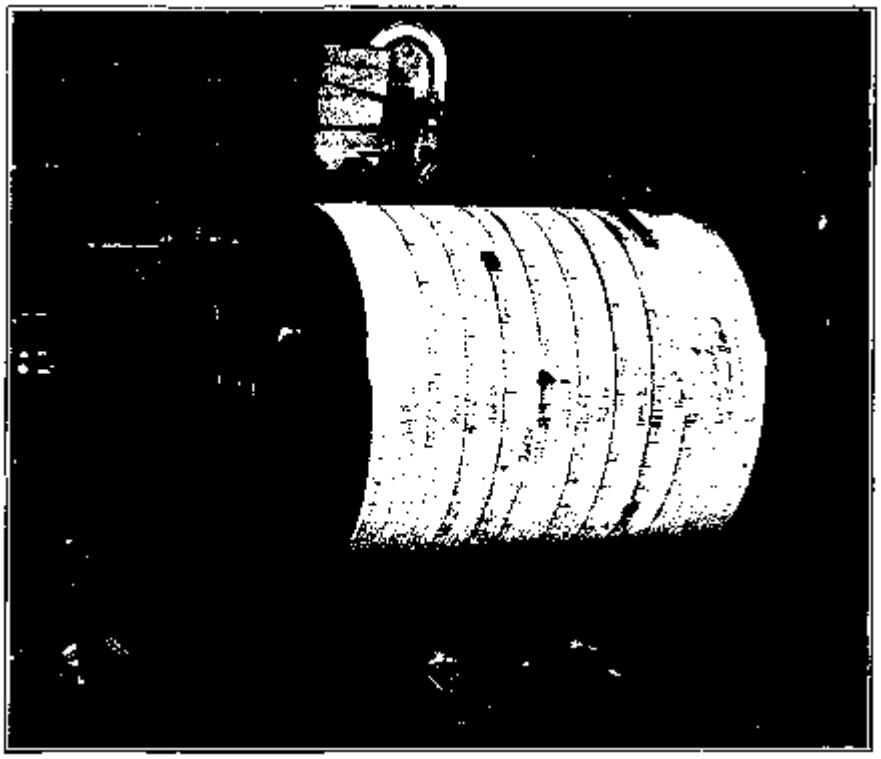
At the outset no one knew what type of listening apparatus would be most suitable. It was presumed, however, that vibrations would be in the supersonic range. Fortunately a considerable variety of equipment for sound detection was available on the GUIDE, including carbon, dynamic, magnetic and piezo-electric vibration pick-ups (microphones), some of which were in sealed cases for use under water. Although no recording equipment was available it was apparent from the start that nothing less would be adequate; only in records of variations in the noises from day to day and from week to week would it be possible to collect data useful in establishing the essential relationships. However, before going to the expense of making such apparatus it was decided to determine by test which microphone types were best.

Carbon units were unsuitable because the large amplification necessary made the carbon "hiss" objectionable. Also, carbon units produced variable reception under different conditions. Dynamic and magnetic units were satisfactory and the piezo-electric vibration pick-ups were particularly so. The sound-powered magnet type responds to wide range of frequencies (second only to the piezo-electric) and is as sensitive as any. Because it has the advantage of being much smaller than the piezo-electric, and can be used in the small watertight cases required for deep wells of small diameter, it was adopted as standard.

Alternating current amplifiers were found preferable, but direct current from storage batteries was best for a 46-decibel booster (with non-microphonic tubes) used at the well top. This booster is required to get the amplification necessary to prevent radio and other disturbances from being picked up by the shielded cables connecting well top and amplifier. The amplifier unit, housed as close to the well as possible, was finally arranged as a 120-decibel direct-coupled a.c. amplifier and recorder. Full shielding of cables and tubes is necessary to keep out surface noises.

Continuous recording

To provide a continuous recorder without incurring prohibitive expense, a portable automatic tide gage was adapted to meet requirements. This gage has a drum 6 inches in diameter and 7 inches wide operated by a spring motor timed for one turn in 48 hours, i.e., a paper movement of 13/32 inch per hour. By use of a counter-weight-operated worm screw the stylus is made to advance as it



spirals around the drum; seven complete turns are made at the rate of one turn per 48 hours. This provides a 14-day record without overlap. Standard waxed tide-gage paper is used, ruled to measure time in 10-minute intervals. Since the amplitude of stylus movements is proportional to the volume of incoming noise, variations in the sound from day to day are shown by the width of the pen's movement. Sudden bursts of energy are shown by one or more lines of maximum amplitude. Much time was spent developing details of the recorder, adapting to it the most suitable hydrophone unit and getting the assembly to work well.

Two deep wells near the Hayward fault were found to have different characteristics. Recording instruments identical in design and construction showed surprising differences in these two listening posts. To reach a recordable sound level, sounds at post No. 2 required 10 to 20 times the amplification needed at post No. 1. Oscillograph records taken at each station (using the extra amplification required at No. 2) showed the continuous noise records to be very similar in frequency and general appearance. The bursts of energy which, when heard in the ear phones, resemble crashes and rumbles, occur only at intervals of several days at post No. 1; at No. 2 they occur at two- to five-minute intervals in all records.

After several weeks of observations at both listening posts, the hydrophone at No. 1 was raised to the 200 foot level and there

operated for several days. At this depth the noise level was much lower than at the 260-foot depth in post No. 2. When the hydrophone was again lowered to the bottom of the No. 1 well (360 feet deep) the noise level was, as formerly, several times greater than at No. 2. This establishes the fact that the noises increase with depth, indicates that they are not of surface origin and tends to confirm the belief that they have their origin in earth strain. The significance of the daily and weekly variations is as yet unknown, but it may be stated that these variations have no correlation with time of day, as they probably would have were they of surface origin.

Conclusions

No earthquake has occurred on the Hayward fault since observations began and hence results are as yet inconclusive. Data are too meager to be taken as the basis for definite conclusions; additional investigations are needed. However, progress thus far indicates that stress and strain along an earthquake fault produce both continuous and intermittent noises (the latter of greater intensity) , which vary in volume from day to day and from week to week and which can be recorded continuously.

In these studies, the San Francisco joint committee already referred to, consisted of Commander R. R. Lukens, U. S. Coast and Geodetic Survey, H. M. Engle and N. A. Bowers. In addition to the contributors mentioned, Capt. R. V. Labarre, Los Angeles, not only supplied funds but gave material aid in organization. Other active cooperators were Perry Byerly, David Hendrickson, Prof. George D. Louderback, and Frank Rieber. A. M. Vincent, senior chief radio operator of the GUIDE did all instrumental work and has earned special credit for ingenious instrumental design and construction. The author had charge of the field work as a whole.

Commenting editorially on Lieutenant Commander Patterson's article, the Engineering News-Record stated:

"Mills of the Gods"

> "Subterranean noises heard and recorded in California wells close to major fault lines, most probably arising from small movements within the earth's crust, may prove to be indicators of strains and stresses similar to those whose sudden readjustment is associated with destructive earthquakes. The discovery of the noises, announced in the present issue, is therefore of great importance. While interpretations and conclusions must for the present remain speculative, it is hardly open to doubt that the noises arise from movements of some kind; something is going on within the earth's crust, whether continuous and unimportant or a precursor of more abrupt and violent happenings. Earlier observations have indicated that stress accumulates in the crust of the earth and that occasionally this stress produces large shearing or sliding movements, such as the longitudinal slip on the San Andreas rift that accompanied the destructive 1906 earth-

quake at San Francisco. It may be that the present noise observations contain advance microphone warning of some coming readjustment -- warning that might be of incalculable value, for though we cannot stop the mills of the gods, we may in some degree guard against the harm they do. Whatever it is that is going on within the earth, it is worth watching; the observational work should continue."

The above incident occurred when making the instrumental installation in the second listening post. This post was in an old well in a locked compound, which is now part of the Oakland Zoo. Senior Chief Radio Operator Vincent who is notoriously absent-minded about everything except radio, was visiting the station and unlocked the first door he saw. It happened to be the wild dog cage. Nothing serious resulted except his embarrassment and the loan of a barrel.

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Jena, Germany.

THE FIFTEENTH INTERNATIONAL GEOGRAPHICAL CONGRESS, AMSTERDAM, 1938

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

In response to an invitation from the Honorary Secretary of the Congress, Lieutenant Smith presented a paper before Section IIb - Oceanography, of the Fifteenth International Geographical Congress, entitled, "Marine Surveys of the Coast and Geodetic Survey and Their Relation to Geology and Geophysics". He was designated official delegate from the United States Government by the Secretary of State, and also represented the National Academy of Sciences and the National Research Council. A part of his official report is reproduced here.

(Editor)

GENERAL

The International Geographical Congress held at Amsterdam, Netherlands from July 18, 1938 to July 28th was the fifteenth periodical gathering of geographers from all over the world. In using the term geographer here one must conceive of it in its broadest sense -- all those persons who are interested in the related earth sciences. It is interesting to look into the origin of these meetings. Sir Charles Close, Past President of the International Geographical Union, in his address at the Anniversary General Meeting of the Society held in Cambridge on the 18th of June, 1928 said:

> "The First International Geographical Congress is associated, most appropriately, with the names of Ortelius and Mercator, and it happened in this way. Some time before 1869 a project had been set on foot to erect a statue of Abraham Ortelius in his native city of Antwerp; and, about the same time, a committee had been called into being to arrange for the erection of a statue of Gerhard Mercator in his native town of Rupelmonde. Now, it occurred to M. Charles Ruelens, Keeper of the Royal Library at Brussels, that no better way could be found of honouring these sixteenth-century geographers than by holding a general meeting of the geographers of the world, who should discuss the matters belonging to their science, at Antwerp, on the occasion of the unveiling of these statues. Now, as it happened, the statue of Ortelius was not erected, and the Franco-Prussian war prevented the Congress being held, as originally proposed, in August 1870. But the Congress was eventually held in August 1871, from the 14th to the 22nd of that month. The statue of Mercator had been already unveiled in May of that year, at Rupelmonde, so that the intended association of the Congress with the actual unveiling of the two statues did not take place. The Congress was, nevertheless, closely associated with the names of these geographers, and it is doubtful if there would have been a Congress but for the original

intention thus to honour their names. M. Ruelens, in an address delivered at Antwerp in November 1869, to a body interested in the project, said that in conversation with two learned geographers in Paris, the idea rose up in his mind to summon to the feet of Mercator and Ortelius all those who, in the two worlds, had made a name for themselves in the science of world knowledge; illustrious travellers; the creators of the great international routes; and those also whose commercial activity had established new relations among the nations.

* * * * *

"The full title of the Congress was, 'Congres des Sciences Geographiques, Cosmographiques et Commerciales,' but it was usually known as the Congres des Sciences Geographiques. It was divided, in a rather curious way, into three sections, namely, the Section of Geography, the Section of Cosmography, Navigation and Commerce, and the Section of Ethnography, which worked alternately in general assembly. Subjects were definitely set beforehand for discussion, and these subjects were placed before the Congress in the form of questions. Thus, there were 26 questions under the heading Geography; 22 under Cosmography; 36 under Navigation and Commerce; and a modest 3 for Ethnography. By studying these 87 questions we can form some idea of the matters which were then thought of greatest interest in the geographical world. What are the best ways of teaching geography? What is the best projection for use in atlases? What copies exist of Mercator's original maps? Could the Congress adopt a uniform system of orthography for maps and geographical works? What is the teaching of science with regard to Atlantis? How best to reach the poles? Could not an understanding be arrived at with regard to a standard initial meridian? How best to continue researches on the depths, temperatures, and conditions of the oceans? Where are the variations of the Gulf Stream? Is there an ice-free sea at the North Pole? Could not the Congress stimulate South Polar exploration? Should the Congress call attention to the desirability of geodetic triangulation in the south of Africa and of America? Is it desirable to encourage the decimal division of the quadrant? Is it possible to arrange for the establishment of a central geographical establishment? What is the most favourable line for cutting a canal across the American Isthmus? Does the moon exert any influence on the weather? What are the meteorological consequences of deforestation? What would be the consequences of the creation of a sea in the Sahara Desert? What is the present distribution of the races of man, and what are the tendencies for certain races to take the place of others?"

From this 'beginning International Geographical Congresses were held in Paris 1875, Venice 1881, Paris in 1889, Berne 1891 (at which the first step toward the Carte du Monde was taken in the proposal by Professor Dr. A. Penck, University of Vienna, entitled Die Herstellung einer Karte der Erde im Massstab 1:1,000,000), London 1895, Berlin 1899, Washington, Philadelphia, New York, Chicago, St. Louis 1904, (in 1904 a peripatetic congress was held visiting the several cities listed), Geneva 1908, Rome 1913, Cairo 1925, Cambridge 1928, Warsaw 1934, Amsterdam 1938.

In reading through this excellent brief by Sir Charles Close* of the various geographical congresses, one is impressed by the number of questions relating to geodesy, geophysics, and meteorology -- subjects now in the custody of the International Geodetic and Geophysical Union -- which were discussed at the meetings. Although some variety is found in the questions taken up in the different congresses under the subject of geography, the main divisions have always been Mathematical Geography, Cartography and Surveys; Physical Geography; Biological Geography; Human Geography and Ethnography; and Historical Geography.

It is also significant that the sections dealing with Mathematical Geography, Cartography and Surveys and Physical Geography have attracted the largest audiences and have had the largest numbers of publications. Many of the resolutions of the congresses were concerned with maps in some form.

Sir Charles concludes his address with these words:

> "One can hardly help feeling that the map is the essential foundation upon which geography is built.
>
> "Like all congresses, those of geography have the outstanding purpose of bringing into personal communication those who are interested in the same group of studies; that, indeed, may be looked upon as the best result of any congress. But congresses also provide a means of ventilating and bringing to general notice matters, whether practical or theoretical, that are of general interest and value to mankind. Examples of such matters are the questions, of the standard meridian, that of hour zones,and the international map of the world, the exploration of the oceans, the mapping of unknown Asia, Africa, and South America, the effect of environment of the human race - a matter with regard to which very little is yet really known - migrations, and the many problems of human geography. The list could be indefinitely extended, but the general aim is clear. By travel, by exploration, by the apparatus of maps, by detailed investigations, by the study of historical records, to learn all we can about the Earth, considered especially in its aspect as the home of man."

Amsterdam, with its many excellent museums, institutes, and points of general interest, is an admirable city for an international congress. The Netherlands was a particularly appropriate

* The Geographical Journal, Vol. IXXII, 1928, pp 100-116.

country for the meeting of the Geographical Congress, and the Colonial Institute provided a setting befitting the hosts of a country whose colonial policies have been so successful for several generations.

More than 800 members attending the Congress were given choice between several different types of entertainment, excursions, and sightseeing trips, in addition to the wide selection of technical sessions scheduled. All were so well arranged and so efficiently managed that one could select those features in which he was especially interested, or with a few exceptions, could undertake all of them. The section meetings were held in the mornings, and all the afternoons and evenings were devoted to trips, social events, or other special features of the Congress. The entire schedule was printed in tabular form and issued to each member at the opening of the Congress. This single schedule-sheet and the printed list of members were most convenient and necessary pocket-pieces of every member.

In addition to the regular and technical sessions of the Congress, there were a number of functions of outstanding interest.

A reception was given by the National Committee on the evening of July 17th, the date preceding the opening of the Congress, and the reception was followed by a dance in the Amstel Hotel. In the afternoon of the 18th His Excellency, the Minister of Education of the Netherlands, welcomed the members for Her Majesty Queen Wilhelmina, under whose high patronage the Congress was held. Sir Charles Close gave the opening address, and various delegation heads made short speeches. Dr. Isaiah Bowman, president of The Johns Hopkins University and vice president of the Congress, in his talk, acknowledged the obligations of our own nation to the ancestry, as well as the influence in literature, science and the arts of the several European countries represented. He pointed out particularly the influence of the Netherlands, reflected in the names of places in and about New York and Long Island which have resulted from the active part that country took in the early colonization of our country. His cheerful emphasis upon the things of common interest between many European countries and our own struck a chord of mutual interest quickly indicated by the sympathetic enthusiasm and spontaneous applause of his audience.

A most impressive and appropriate place for the official reception given by the Netherlands Government on the evening of July 20th was the celebrated Rijksmuseum. His Excellency, The Minister of Education, received the guests in this impressive setting, surrounded by the most treasured masterpieces of art of the Netherlands. Practically all of the galleries of the famous museum were opened to the guests, and the works of the old masters were further enhanced by appropriate and individual illumination befitting the subjects. An atmosphere typical of the Netherlands, the people, and their history pervaded the halls through which the guests from many countries mingled.

An evening of Java music and dances by native Javanese was given in the Colonial Institute. Actual museum pieces, dress, musical instruments, weapons and utensils were used in this colorful and novel entertainment.

A full day was devoted to an autobus tour of part of the Netherlands including the Zuider-Zee and the ancient town of

Vollendam. The extensive reclamation of land from the sea by the remarkable new dyke is a fascinating spectacle, especially to one who has seen the fertile wastes of the lower Mississippi and that river's delta.

A soirèe surprise and bal champêtre was given at the restored Sixteenth-century chateau of Nijenrode near Utrecht. Guests were received by President Kleiweg-Zwaan, in the role of Plancius, a sixteenth-century Dutch cosmographer. He and Madame Kleiweg-Zwaan and their court were dressed in the costume of that time, and welcomed the guests at the steps of the chateau in the evening twilight. We then wandered about the many winding passageways and rooms of the old chateau and the mellow glow of hundreds of candles illuminated the tapestries, paintings, armor, and many treasures within the walls.

Other groups walked through the acres of formal gardens by the light of torches. If the pangs of hunger generated by these exercises may have seemed to some of the Congressists too great to be appeased by the nourishment available in this instance, it should be attributed to the popularity of entertainment provided, which on this occasion attracted practically every member of the Congress. Secretary Voûte and his efficient staff are to be congratulated on handling this occasion so efficiently, as they did all features and entertainment of the Congress.

A tour through the Geodetic Institute at Delft was made in four sections, each section with a guide speaking the language specified for the group. A remarkable quantity of photogrammetric work is being carried on by this organization, both for the Netherlands and for the colonies. Apparently a large share of the work in the territories is being done without control other than that obtained by radial triangulation and astronomic stations. It raises the usual question as to whether the need for maps justifies this method preliminary to further development of the regions and accompanying adequate triangulation.

The ladies were favored with daily tours to the many places of general interest about Amsterdam. Among these were a visit to the Colonial Museum with guides, followed by tea in the Zoological Gardens; a visit to the State Museum; an excursion to the greenhouses and old windmills near Aalsmeer with luncheon at the famous Schiphol airport; an excursion to the cheese market of Alkmaar; a boat trip through the canals of Amsterdam and tea on board the Steamer Johan de Witt; a visit to the Frans Hals Museum in Haarlem; a walk through the old quarters of Amsterdam, and a tour of one of the most famous of the diamond cutting establishments.

On the evening preceding the last day of the Congress a banquet was given for the chiefs of the delegations, and a dance for all members was held in the Amstel Hotel.

The entire American delegation enjoyed the hospitality of Consul General and Mrs. Lee at a luncheon on July 23rd, and my wife and I were further entertained by Consul and Mrs. Ellis Bonnet at their home. They later took us upon an informal and instructive tour of additional places of interest in Amsterdam not provided for in the schedule of the Congress.

The papers presented at the Congress were published prior to the opening, and this greatly facilitated discussion and brought

out many valuable points which actual delivery of each paper would prohibit. In general, the language used for announcements and other addresses to the Congress was French. The work of the sections was conducted in whatever language individual speakers desired, interpretation usually being made by other members of the section when necessary. Small gold and red, white and blue enamel medals, with the registration number of the member on the attaching pin were supplied. These small medals admitted all members to the various museums, and similar exhibits in government and city buildings. In addition, a small card was sold to members at the central office in the Colonial Institute for one guilder, and the card permitted the bearer to ride upon any of the bus or tram lines in Amsterdam without additional charge during the period of the Congress. This was a great convenience, as the charges on tram lines and buses are proportional to the distances travelled. Since language difficulties were involved, it was doubly welcome. A Cook's agent had an office in the Colonial Institute where railroad, hotel, and other travel arrangements could be made, and where money could be exchanged. A central office for mail, daily tour reservations, information, and the office of the Honorary Secretary were also in the Colonial Institute. The information and mail booth was always attended by five or six young ladies, each of whom spoke at least four languages. In this booth individual mail boxes were provided, each marked with the member's number, and into these boxes were placed any mail, announcements, or publications which were issued by the Secretary. A large bulletin board was maintained near this booth, upon which any notices, announcements of facts of immediate interest to the members were posted. Announcements usually were posted in French. One photographer was always in attendance at all important functions, and the following day the photographs he had taken were displayed near the central booth for purchase by those who desired copies. A special branch post office was maintained in the Colonial Institute where packages and other mail could be posted. A full series of Netherlands stamps was kept here for those interested in obtaining copies of the various stamps. Meals could be obtained in the building in two places. On the main floor a small restaurant was operated, and in the basement one could obtain meals cafeteria style. The various rooms in the large building which were reserved for the use of the various section meetings were connected by an overhead colored ribbon, which made it easy to get about through the winding corridors and large museum rooms filled with exhibit cases.

Special Excursions

Several excursions were arranged. One into Zeeland and the region which constitutes the estuary of the Schelde occupied from July 11 to the 16th, prior to the Congress. Another, following the Congress, was made into the mining region from July 29 to August 3. A shorter trip in the region of the Polders and Dunes could be taken from July 29th until August 1. Rotterdam and its environs was the object of an excursion between July 28th and July 31st; The Glacier Region of the Netherlands required only three days, from July 29 to July 31st, and the Ancient Zuider Zee excursion could be made on July 29th and 30th.

An extended trip could be taken to the Netherland East Indies on the Steamer Johan de Witt, between August 3 and October 11.

The interesting features and purposes of each of these excursions were described in illustrated booklets published and available to the members prior to the opening of the Congress, and each excursion was conducted by a lecturer thoroughly familiar with the region.

Travel

In as much as no part of the expenses of my trip was borne by the Government, I had selected a German steamship line, partly because of curiosity, but mainly because the S. S. KÖNIGSTEIN sailed directly to Rotterdam, which port is only one and one-half hours by automobile from Amsterdam. It was noted that a part of the routine for the regular watch officers of this line required them to stand a daily radio operator's watch. Although this may be commendable in view of the present trend toward increasing use of radio aids to navigation, it is questionable whether the benefits are sufficient to merit a general policy of all junior officers participating in radio training.

Upon arriving in Rotterdam on the morning of July 13th we secured the services of an English-speaking taxicab driver, who eventually offered to drive us to Amsterdam via Schevening, Delft, and The Hague, for approximately the price of passage by train. This remarkable individual was a veritable gold mine of information and facts, most of which we later found to be of dubious accuracy. We thus arrived in Amsterdam shortly after noon, and finding all affairs relative to the Congress in readiness, we made arrangements in the afternoon for a short trip into the Rhine district of Germany as far as Heidelberg. We left Amsterdam at eight p.m. on the railroad which winds along the right bank of the Rhine past the terraced vineyards of the famous wine district, and the many medieval castles. We arrived in Heidelberg about three in the afternoon.

Although the international relations at the time were rather strained, we found all German officials most courteous and accomodating. A unique feature of travel in Germany at this time was the restriction imposed upon travellers carrying currency across the borders. A declaration of all currency carried must be made at the frontier. At the time a limit of 30 R.M. silver per person could be taken into Germany, and 10 R.M. silver per person taken out of the country. No German paper currency could be taken either way across the border. Reisechecks (German travel checks) could be purchased only outside of Germany at a considerable discount over the regular exchange rate within the country. These checks could be converted into Reichsmarks at specified banks within the country. Because of the 10 mark limit imposed upon departing travellers, it was necessary to exercise care in estimating one's expenses for the last day in Germany in order to avoid having more than the legal limit of German cash when leaving. Any excess had to be deposited at the border with the customs officials, and could be redeemed, plus a small rate of interest, during the next trip into Germany. This was the source of some amusing experiences, but we left Germany without an excess of German cash, and with a more understanding attitude toward the present problem of that country from which came the ancestors of so large a part of our own countrymen.

England

Immediately following the Congress in Amsterdam, a visit was made to England to meet the various officials of the International Geodetic and Geophysical Union in that country. The trip from Amsterdam to London was made by train to the Hook of Holland where we embarked in the evening and arrived at Harwich early the next morning. From Harwich by train to London requires about an hour and a half.

Our arrival in London on a Friday immediately preceding the August "bank holiday" made any arrangements for conferences out of the question until the next week; so advantage was taken of the week end to see parts of the British Museum, and to make a two day visit to Oxford, which is about an hour by fast train out of London. The following week, Professor E. B. Bailey, Director of the Geological Survey and Museum in London pointed out a few of the points of interest in the excellent collection of exhibits in the Museum. Among these, and in the process of construction, is a relief globe of the world six feet in diameter upon which have been placed in the conventional colors the various known geological structures. This remarkable piece rotated slowly, being driven by an electrical motor. The workmanship of the relief, and the globe in general are of the highest quality.

Regional exhibits covering local areas of England and Scotland are arranged with horizontal large scale relief models, cut away to show geological structure, and mounted upon tables in the center of small booths or alcoves. Topographic maps and enlarged photographs of the locality have been placed about the walls of the alcoves. Three floors of carefully prepared exhibits, dioramas, and displays are open to the public. The descriptive placards concisely, yet thoroughly compiled, enable the visitor to read quickly the essential facts about the items of especial interest to him. The Museum is so well arranged that one really has the benefit of a trip through the British Isles simply by a thorough study of the collection.

Following a visit to the Hydrographic Office of the Admiralty, it was my good fortune to be the guest of Admiral J. A. Edgell, the present Hydrographer, for luncheon at the historic "Senior Club" in London.

August fourth we spent as guests of Professor and Mrs. E. C. Bullard in Cambridge, where I also had the opportunity to meet Professor Bullard's colleagues, and Sir Gerald Lenox-Conyngham and Dr. Harold Jeffreys. Professor Bullard, it will be recalled, visited the Coast and Geodetic Survey in 1937 and made a trip on the OCEANOGRAPHER that summer. He and Mrs. Bullard are to be congratulated upon their twin daughters, who arrived just a few months prior to our visit.

Through the courtesy of Mr. A. Hughes, a visit was made to the famous plant of Henry Hughes and Sons at Chigwell. The various nautical instruments for which this firm has established a world-wide reputation are developed and manufactured here. Interviews with various men connected with this organization leave one with the realization that here is a healthy interest in new developments, as well as the respect for time-honored navigational instruments and methods, and a well balanced appreciation of the relative accuracy required in these instruments.

A new and convenient set of tables has just been compiled and published under the title "Hughes' Tables for Sea and Air Navigation", compiled by L. J. Comrie, M. A. Ph. D., Late Superintendent H. M. Nautical Almanac Office, 182 pages. It is believed that most users of this new publication will agree with the author in his claim that "an attempt has been made to combine the accuracy demanded by theory with the convenience demanded by the navigator." Among acknowledgements made in the preface are those for the suggestions of Lieutenant Commander P. V. H. Weems, U.S.N., (Retired), and to the Hydrographer, U. S. Navy, for the use of material from U. S. Hydrographic Office Publications Nos. 208 and 211.

Through the kindness of Brigadier M. N. MacLeod, Director General of the British Ordnance Survey Office, and Mrs. MacLeod, we spent two days with them at their home in Southampton immediately prior to our sailing for the United States. Here we also enjoyed the hospitality of Colonel and Mrs. Cheetham at their home on the edge of the New Forest. They took us for a drive through that beautiful section of England, preserved as forest land for many generations. This tract of over 92,000 acres, was the hunting ground of West Saxon Kings and derives its name from the afforestation schemes carried out by William I in 1079. Since 1877 it has been reserved as a national park. In the late afternoon, we paused for a visit with Major Sanceau who served refreshments on the lawn at the former home of the heroine of Alice in Wonderland, and then returned to the MacLeods for dinner.

With the conclusion of our trip to England came the realization of how much in common the two nations have, and how we are working out, sometimes along very different lines, our mutual problems. Among the technical problems are those of different surveying and map-making methods, -- the ones in which I was particularly interested.

In the following paragraphs I have amplified my remarks on some of the details of the work of the Section of Oceanography, and to describe a few of the outstanding features of the Cartographic Exhibit of the Congress.

SECTION IIb - OCEANOGRAPHY

Members of the Section of Oceanography discussed the papers submitted under the Questions

La circulation general dans les Oceans,
Oscillations internes dans les Oceans,
Le relief du fond de la mer, particulierement dans 1'hemisphere meridional.

An active interest was evident in this section. Dr. G. E.R. Deacon's paper "The Surface, Deep, and Bottom Currents of the Southern Ocean" pointed out some interesting observations relating to the boundaries between Antarctic surface waters and sub-tropical waters, and suggested a probable system of vertical circulation in the South Atlantic. The approximate geographic boundaries of the slope caused by the warm, highly saline water climbing from depths of 1500 meters or more to within 150 or 100 meters of the surface are outlined.

In the paper "Circulation of the Sea Water in the Vicinity of

Simoda Bay, Sizuoka, Japan", Nobuhiko Obara describes the results of studies to determine the local movements of sea water in Simoda Bay. Extensive temperature, salinity, and current velocity observations were used.

Dr. P. M. Van Riel in his paper "The Influence of the Bottom Configuration on the Properties of the Sea Water in the Abyssal Layers" described by the use of a colored plate and diagram the movements of deep ocean waters in the East Indies between the Philippine Islands and Australia and briefly reviewed the various observations made on the subject.

Other papers discussed were:

Vallaux, Prof. Camille (Finistere), La circulation de profondeur dans les grands oceans. Avec 4 figures

Wust, Prof. Dr. Georg (Berlin) , Das Problem des antarktischen Bodenstroms im Weltmeere. Mit 1 Figur

Ejeldstad, Jonas Ekman (Bergen), Interne Wellen

Jolly, H. L. P. (Southampton), A supposed landsubsidence in the South of England. With 2 figures

Lek, D. L. (Brussel), Interne Wellen in den Niederländischostindischen Gewässern. Mit 3 Figuren

Pettersson, Prof. Hans(Göteborg), Internal waves in Scandinavian waters. With 4 figures

Greve, Lt. Commander Sv. de (Copenhagen), Echo-Soundings -- The Dana Expedition

Kuenen, Dr. Ph. H. Groningen), Submarine slopes of volcanoes and coral reefs in the East Indian Archipelago. With 6 figures

Leahy, L. R., The configuration of the bottom of the South Pacific. With 1 map

Pinke, F., Accurate determination of depth and bottom-configuration. With 14 figures

Seymour Sewell, R. B. and John D. H. Wiseman (London), The relief of the ocean floor in the southern hemisphere.

Smith, Paul A., Marine surveys of the United States Coast and Geodetic Survey and their relation to geology and geophysics. With 10 figures

Umbgrove, J. H. E. (Delft), On the time of origin of the submarine relief in the last Indies. With 4 figures

Vaughau, Thomas Wayland (Washington), Recent additions to knowledge of the bottom configuration of the southern oceans.

In commenting upon Commander Pinke's paper on "Accurate Determination of Depth and Bottom Configuration", I made the following remarks:

"This comprehensive treatment of the somewhat controversial subject of slope corrections to echo soundings by Commander Pinke is "based upon the assumption that the echo always is reflected from the normal surface, that is to say from the spot on the ocean bottom nearest the vessel. While this assumption, on the basis of purely theoretical considerations for sonic oscillators may be valid, I question whether we have enough factual evidence in the form of observations to justify the application of the theory to actual soundings. I am wondering if Commander Pinke does not have some comparisons between reliable vertical casts and echo soundings. The word reliable is used, not as a reflection upon the skill of the observers, but because it is always questionable whether any vertical cast soundings taken in very deep water are really vertical.

"This subject has been given considerable study by our own hydrographers and cartographers, and while we have sufficient information to justify slope corrections in certain regions where very steep slopes are found, and where the surveys had been plotted on fairly large scales, the final conclusions have been that, as yet, we do not have sufficient data in general to justify the application of slope corrections on the smaller scale surveys. This applies to the Coastal Slope Charts, surveys for which were made on the same scale as the charts, namely, 1:120,000.

"If, for example, one should attempt to apply the comparatively insignificant slope corrections in the region of the Hudson Submarine Valley, it can be seen that for a line of soundings running parallel to the axis of the main valley, and about halfway up the side of the valley, the slope corrections as derived solely from the profile would be decidedly erroneous. To get the proper corrections all of the soundings must first be plotted and contoured to see the regional characteristics of the bottom in the vicinity of the profile.

"Echo sounding has certain very definite limitations in deep water which Commander Pinke has described so well by the use of diagrams. These limitations must be recognized. While the method is not perfect, I think all who have had some experience with echo sounding will agree that it is a most satisfactory and rapid means for adding to our all too meagre knowledge of the ocean bottom.

"It should be noted that the author stresses the necessity for a preliminary, or a provisional chart, as well as a provisional profile. Unless the characteristics of the region are known, one would not be justified, for example, in deriving the profile of Figure 10 from the echo sounding profile of Figure 9, for, conceivably the profile of Figure 9 might actually exist! Another factor in favor of the publication of echo soundings uncorrected for slope, (but corrected for temperature and salinity) is the use of the soundings by mariners for navigational purposes. It is desirable to have the apparent features charted, that is, the shapes as given by the echo soundings uncorrected for slope.

"The judicious use of Commander Pinke's method, having due regard for the regional topographic characteristics, should provide some interesting results. It is recommended, however, that for the present, echo soundings he published as noted, corrected for temperature and salinity, but not corrected for slope. This will enable the individual student to judge the probable type of physiography after considering the general area, and to apply slope corrections when they obviously become of significant magnitude."

The four Geological Society of America Coastal Slope Charts with contours by A. C. Veatch were displayed in the section and considerable time was devoted to discussion of the charts and the work of the Coast and Geodetic Survey as outlined in my paper.

In commenting upon the Coastal Slope Charts Dr. Georg Wüst of the Institut für Meereskunde said:

"Man kan diese Karte nur mit grösster Bewunderung anschauen. Man muss unseren amerikanischen Kollegen gratulieren. Von solcher Arbeit hatte man vor 10 Jahren noch nichts geahnt. Ich bin davon überzeugt, dass in einem Jahrzehnte jedes Schiff ein Echolot haben wird und dass wir hierdurch zum Teil die astronomische Ortsbestimmung verbessern".

The daily procedure followed in the Section of Oceanography is to be commended. A brief summary or review of each paper was given by the author or other member previously designated by the Chairman of the Section, and the discussion followed. The publication of the Comptes Rendus of the Congress prior to the opening was a most commendable action. It enabled members to prepare concise questions after reading the papers, conserved much of the time usually taken in delivering the paper for discussion, and it enabled those members who read other languages but are unaccustomed to the spoken version, to enter the discussion of the papers printed in foreign languages.

The increasing importance of oceanography in all earth sciences was reflected in the attendance at the meetings of this section. Most of the members took active part in the discussion of papers.

The Coastal Slope Charts aroused something of a sensation, and were the subject of many compliments in the section, as well as a resolution to the Union commending the recent work of the Coast and Geodetic Survey and urging other nations to take up similar coastal surveys.

CARTOGRAPHIC EXHIBIT

In the spacious halls of the Colonial Institute of Amsterdam the large cartographic exhibit was displayed. The United States of America, Great Britain, Germany, Italy, France, Belgium, Hungary, Norway, Netherlands, Poland, Switzerland, Czechoslovakia, and Yugoslavia were represented. In several instances, various mapping or charting agencies of one country were separately designated by smaller subtitles in the main section of the exhibit embraced by one country. For example, in the section devoted to the United States of America, the following organizations were designated separately: The Coast and Geodetic Survey, Geological Survey, Hydrographic Office, Army Engineers, U. S. Lake Survey, Soil Conser-

vation Service, Bureau of Chemistry and Soils, Forest Service, Bureau of Agricultural Economics, Weather Bureau, Bureau of Public Roads, Bureau of the Census, and Department of State, Office of the Geographer.

The Minister of Education of the Netherlands opened the exhibit on the first day of the Congress with a short address of welcome and thanks to the many organizations participating in the exhibit.

A few outstanding features of the exhibit were:

1. The British Ordnance Special Purpose Maps including (a) the "one-inch" (one inch to the mile scale) maps for tourists with hill shading and contours in mounted folder form, (b) the "Period Maps", for example, Britain in the Dark Ages, XVII Century Britain, and Neolithic Wessex. These historical maps have forest areas, trails, roads, settlements and other information restored from archeological and geological studies. They constitute a real contribution to history, and they give to a student of history a pictorial guide which makes the history of England have a real meaning. (c) The Ordnance aeronautical charts have several unique features, one being the use of deep blue for the water areas of harbors, such as Southampton. The blue tint is very dark near the shore, and shades rapidly to very light blue seaward. This emphasizes the water areas in a region where the demarcation between the land and water may otherwise appear indistinct or indefinite.

2. The German Fishereikarte of the Barents Sea published on a scale of 1:700,000 in three sections has gray shaded submarine contours and red and blue current arrows, and tables along the margins for conversion of fathoms to meters, and vice versa. This chart is published by Oberkommander der Kriegsmarine, Nautische Abteilung Tirpitzufer, Berlin, who, at present is Kapitän zur See von Kurze, and who was in attendance at the Congress. This tends toward a contoured chart of a comparatively sparsely sounded region, although I could not ascertain how thoroughly the region had been sounded, and the contouring is most highly generalized, even more so than that on the Georges Bank Fishing Charts published by the Coast and Geodetic Survey. It is, however, another indication of the necessity for a satisfactory cartographic presentation to the nautical world of the detailed surveys now being made by different nations, and in which the Coast and Geodetic Survey has pioneered.

3. The well arranged exhibit of the Coast and Geodetic Survey, so completely described by printed placards, attracted many people and incited much favorable comment and many questions relating to reproduction methods. Included with it were two copies of the proofs of the Coastal Slope Charts over which was placed a subtitle reading "Geological Society of America, Coastal Slope Charts". A typewritten note describing the arrangement and form of publication was posted with them. Many requests were made verbally for copies of these charts, to which I answered that it was expected that they would be ready for issue by the Geological Society of America as soon as the work was completed, probably this winter.

4. The publication of the Netherlands, Hydrografische Opnemen 1938, Uitgegeven door de Arfdeeling Hydrografie van het Ministerie van Defensie. 's - Gravenhage - Algemeene Landsdrukkerij, was on exhibit. The ink sketch by Mr. MacEwen, of our Chart Division,

showing a base measuring party, and which was reproduced in several of our Field Engineers Bulletins has been copied, but the member's hats and costumes have been altered to officers' caps for observers and tropical native costumes for the tape stretchers (p. 10). A description of radio-acoustic ranging with three sketches, from our publication, including the sono-radio buoy, occupies pages 53 - 57. An extensive section on wire drag work acknowledges the source material as Commander Hawleys Wire Drag Manual (p. 76), Other references to work of the Coast and Geodetic Survey will be found. This publication was prepared under the direction of J. L. H. Luymes.

5. A base chart of the Atlantic Ocean, 1:5,000,000 (Grundkarte der ozeanischen Lotungen 1:5 Millionen, Sheet SII2) by Theodor Stocks Wissenschaftliche Ergebnisse der Deutschen Atlantischen Expedition auf dem Forschungs und Vermessungsschif "Meteor" 1925-1927, Vol. 3, Part I, Morphologie des Atlantischen Ozeans, Part 4, Berlin and Leipzig, 1937 was exhibited and explained in person to the writer by Dr. Stocks. On this chart have been compiled all the available reliable soundings, and by an appropriate code of style of letters and figures the following information is shown wire or echo sounding, corrected or uncorrected sounding, names of ships making the soundings, whether or not bottom was reached, dates of soundings, relative accuracy of position determination. This chart is in black and white only, without contours, but a transparent overlay sheet to the same scale has the contours, outlined where sufficient information is available, and this sheet is printed in red. This series is to be highly commended as furnishing an accurate base for the addition of future work, and the style is such that the sounding data are not confused nor obliterated by the interpretation of the overlay sheet. The first sheet is on an equal area projection, 65.49 centimeters by 87.17 centimeters (neat line). (See also a review by T. Wayland Vaughan, Geographical Review, July 1938, p. 497).

The following Members from the United States of America attended the Congress:

Colonel C. H.Birdseye. Delegate of the United States Government
National Academy of Sciences
National Research Council

Dr. Isaiah Bowman, President, The Johns Hopkins University
Delegate of the United States Government
National Academy of Sciences
American Geographical Society

Lieutenant Commander R.G. Hillenkoetter, USN.,
Delegate of the United States Government

Mr. C.B. Hitchcock, Delegate of the United States Government
American Geographical society

Dr. G.C. Martin, Delegate of the United States Government

Mr. O.M. Miller, Delegate of the American Geographical society

Captain J.R. Noyes, USA. Delegate of the United States Government

Professor R.J. Russell, Delegate of the United States Government
National Academy of Sciences
National Research Council

Mrs. Sophia Saucerman, Delegate of the United States Government

Lieutenant Paul A.Smith, USC&GS.
Delegate of the United States Government
National Research Council
National Academy of Sciences

Dr. Anna M.Wellnitz.

Sir Charles Close addressing the opening session of the International Geographical Congress

Seated left to right: Secretary General E. J. Voûte, Gen. Winterbotham, Prof. Mecking, Prof. Keliweg de Zwaan, Prof. Bowman, S.Exc. Le Ministre Slotemaker de Bruine, Prof, de Martonne, Prof. Rommer, Prof. Panzer, Prof. Boerman.

Minister of Instruction of the Netherlands, S.Exc. M.J.R. Slotemaker de Bruine, at the opening of the Cartographic Exhibit, Kolonial Museum, Amsterdam.

TRIANGULATION IN NARROW INLETS

Riley J. Sipe, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

During the 1936 field season an unusual problem was encountered in extending second-order control through Hammersley Inlet to the head of Oakland Bay, Washington. Since the configuration of the shore line was such that it could not be traversed, it was necessary to use triangulation.

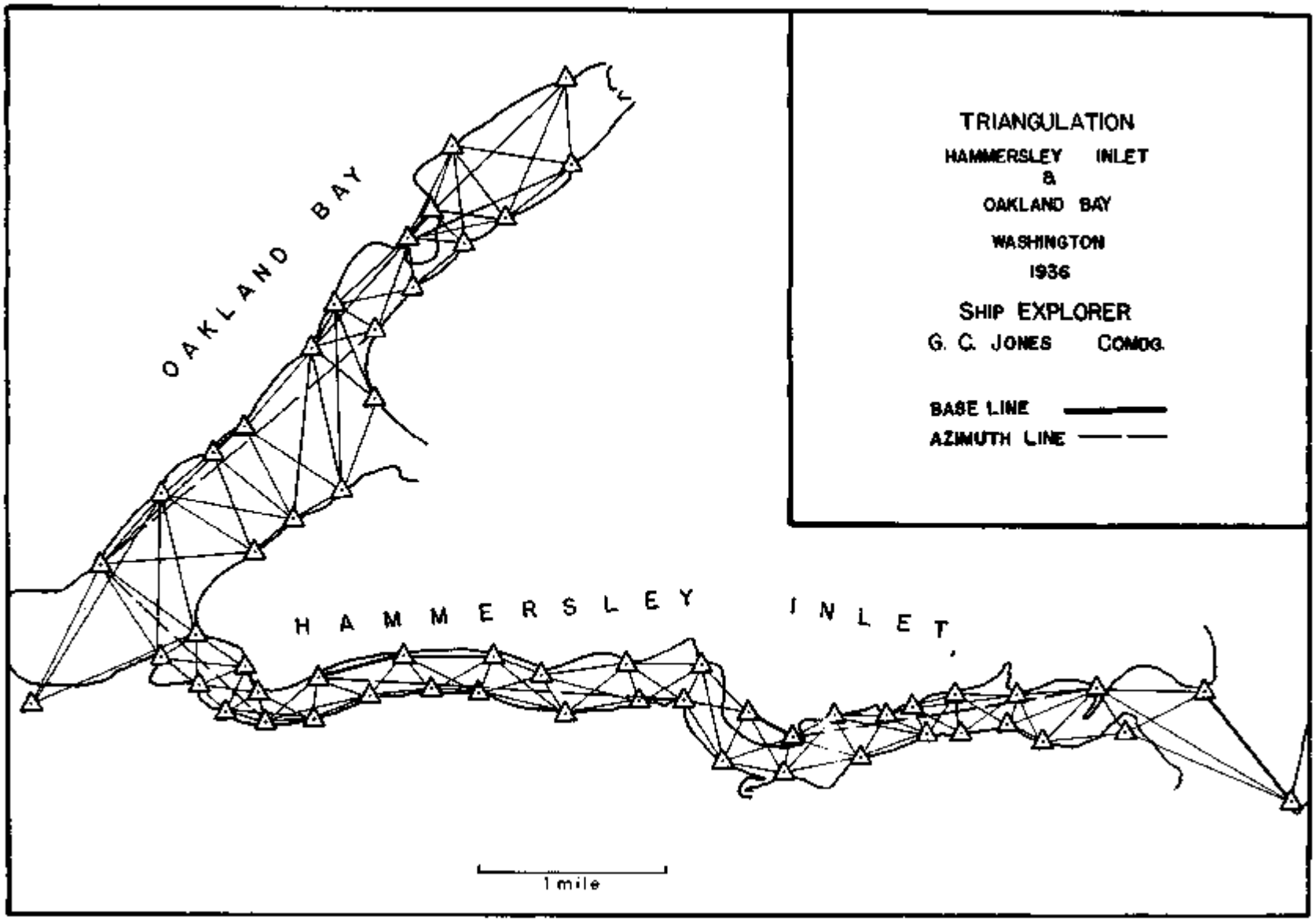
Hammersley Inlet is five and one-half miles long and has a least width of about 250 meters. The total area covered by the scheme through the Inlet to the head of the Bay was approximately five square miles. To obtain good figures it was necessary to establish 58 stations spaced closely together. The resulting short lines, the shortest of which was approximately 275 meters, necessitated extraordinary care in signal building and observing to obtain the required accuracy without the use of special equipment. Good azimuth was maintained throughout the scheme by observing long azimuths between stations separated by about five quadrilaterals.

Due to the heavily wooded nature of the area, together with the vertical bluffs of varying heights, stations often had to be established on soft slides and in swampy places, at or below high water. In order that the instrument, a second-order Parkhurst theodolite, which was used with a regular tripod, might be stable while observing, 2" x 4" stakes were driven for each of the tripod legs. These stakes varied from ten inches to three feet in length, depending on the type of soil and were driven vertically. At some of the stations, it was necessary to build observing platforms.

The signals consisted of broom handles painted in alternate black and white bands about eight inches wide. Only perfectly straight handles were used, and small nails, which fitted snugly into the holes in the triangulation marks, were accurately centered in the bottom. Four guys of number 14 gage wire were fastened to the top. Before observing on the signal poles they were checked for plumbness, using a well adjusted 30-inch carpenter's level, and to see that the nail in the bottom was in the hole in the station mark. Because of the short length of the lines there was no phase and it was found that either the black or white part of the poles showed clearly regardless of the direction of the light. In observing the longer azimuth lines good results were obtained by using small signal lamps except on very bright days. Prevalence of haze prevented these longer lines being observed on the broomstick signal poles.

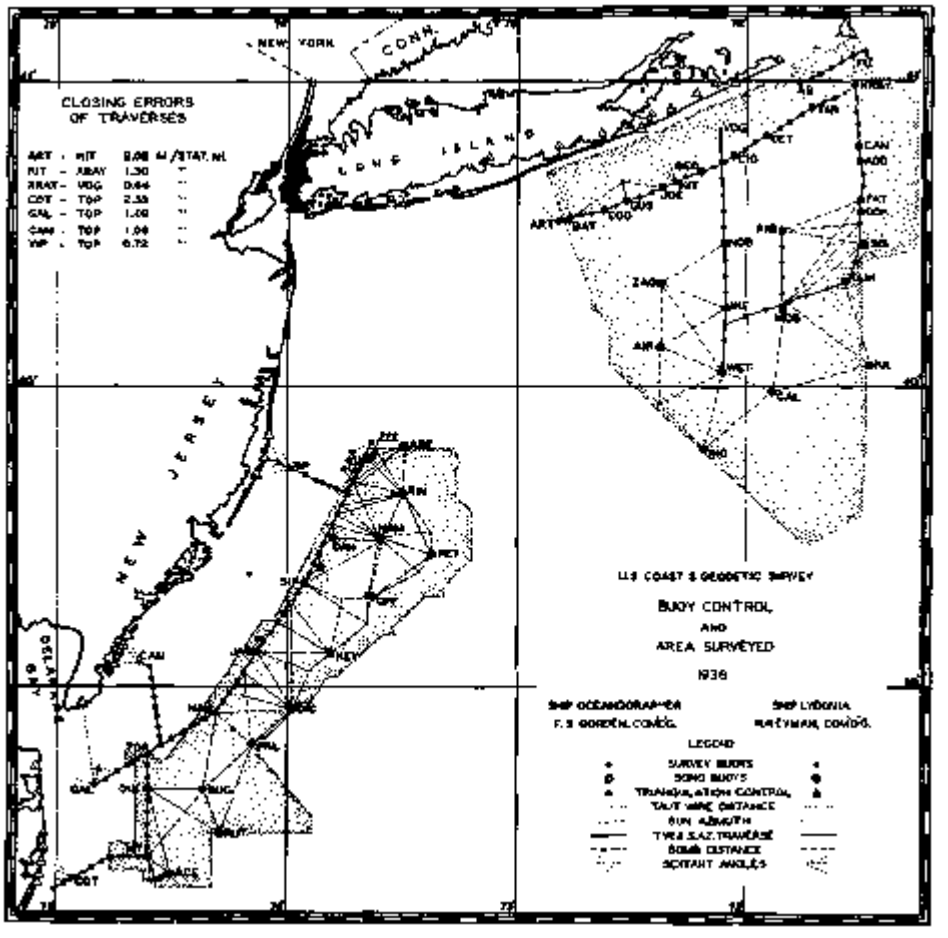
To obtain the desired second-order accuracy it was necessary to plumb the instrument and the signals with great care in order that the positions of the pole and instruments would be identical. The importance of this can be better shown by noting the fact, "An error of one second in arc will be caused by an error of 0.10 inch over a length of line of 1760 feet".

The observers followed regular second-order procedure and always closed on the initial station. Eight positions on the circle were used for all observations. When abstracting the results, the rejection limit was five seconds from the mean. In order to procure the desired accuracy it was necessary to make observations either during overcast weather, or else early in the morning before heat waves caused disturbances. The average closure for the 109 triangles was 2"01.


TRIANGULATION
HAMMERSLEY INLET
&
OAKLAND BAY
WASHINGTON
1936
SHIP EXPLORER
G. C. JONES COMDG.
BASE LINE
AZIMUTH LINE
OAKLAND BAY
HAMMERSLEY INLET
1 mile

For ordinary observations, when an observer was working alone, reading both micrometers and recording, the average time for a direct and reverse pointing was 2.9 minutes. An observer and a recorder could observe the same line in 1.2 minutes and by the addition of a micrometer reader the time was reduced to 0.9 minute per line observed. The addition of a micrometer reader not only decreases the eyestrain for the observer but also increases the speed of the observations.

Strict compliance with the requirements for second-order horizontal control supplemented by the measurements of the long azimuths was rewarded by excellent results. A report of the office adjustment of the scheme states in part "A single example will illustrate the general excellence of the work. At Hammersley Inlet an adjustment was made between the base "ASH-BROM", through the base "NICK-RAID", and on up to the base "BAY-SHORE", involving two length equations and two azimuth lines. The maximum correction obtained to any one direction was 1"7, and the mean correction to the 129 directions was 0"5."



TAUT-WIRE, SUN-AZIMUTH TRAVERSES

Frank S. Borden, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Three seasons' experience on the Atlantic and Gulf Coasts during which more than 1200 miles of taut-wire, sun-azimuth traverses were run by the writer has shown by the thirty-odd loop closures that an accuracy of at least one part in 1000 can be expected in this class of work. The traverses run during the past season (1938) by the Ship OCEANOGRAPHER are shown on the sketch opposite.

During the three seasons referred to, traverse buoys have been anchored, or as we say, "planted" in depths ranging from 5 to 42 fathoms, usually with a two to one scope and using three railroad car couplers for a single anchor. The spacing of buoys in the traverses has ranged from 2-1/2 to 6-1/2 miles. The shorter intervals are used where visual fix hydrography is contemplated, or where, because of prevailing haze, there is a probability of low visibility at the time the azimuth observations are made. Higher accuracy and a considerable saving in time result from taking the azimuth observations at the same time the taut-wire measurement is made, so it is well to allow a visibility factor of safety when establishing buoys for any section of a traverse, the general azimuth of which will permit simultaneous distance and azimuth measurements. It takes but little extra time to plant and pick up a few extra buoys, but missing an azimuth because of low visibility upsets the general plan of procedure, delays availability of a limited number of buoys for new traverse, and impairs the excellent coordination of buoy positions that is obtained when both azimuth observations and distance measurements are made during one full speed run of the ship. In general, the distance between buoys is increased when clear weather prevails; when visual fix hydrography is not contemplated; where the primary purpose is to extend the control scheme; and where the general azimuth of a traverse section is so near east and west that it appears unlikely the azimuths and distances can be obtained simultaneously. Also, on traverse sections in deep water, where long anchor cables are required, it is often necessary to increase the spacing more than would be desirable if there were an unlimited supply of anchor equipment available.

When planning a traverse control scheme, it is well to avoid planting a row of buoys in an east-west direction in so far as practicable. Unless one is fortunate enough to find another vessel on the horizon on which to split angles, the chances are, due to the steepness of the inclined angle, that satisfactory azimuths cannot be obtained throughout the taut-wire line or even on a subsequent full speed run along the line of buoys. Generally the determination of azimuths on east and west lines becomes a tedious operation, and may require a supplemental target buoy some distance off the traverse line for splitting the inclined angles. In general, the nearer the azimuth of a row of buoys is to the meridian the better are the chances of carrying azimuths through the entire section on one run of the ship.

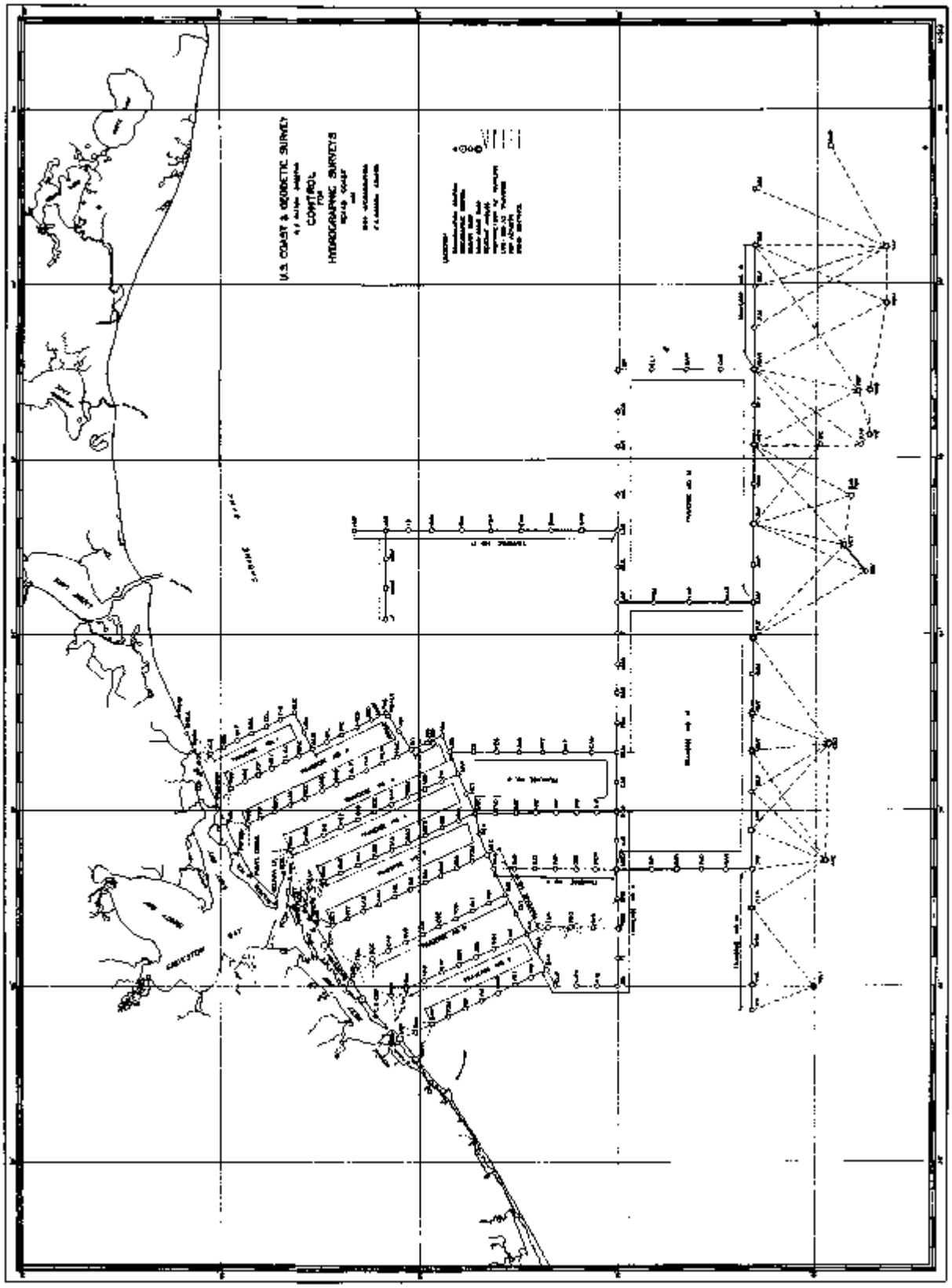
The question has arisen as to whether an attempt should be made to correct buoy positions on traverses for the scope of the anchor cable. During the past season this was not done, and the loop closures showed an average error in the traverses of 1.3 me-

ters per mile (0.8 meter per kilometer). Experience shows that the several adjacent buoys of a traverse section usually are veering to their anchors in nearly the same directions, and with practically the same intensity of current, and the effect of scope differential between buoys in coastal shelf waters is negligible. During the previous season in the Gulf of Mexico where conditions were more favorable for this class of work, the corrections were made and the average error was 1.0 meter per mile (0.6 meter per kilometer). Provided the method is employed, wherever possible, of observing azimuths when the taut-wiring is done, I am of the opinion that corrections for scope are unwarranted, when plotting on scales of 1:40,000 or smaller, except in localities where it is apparent that a radical change in the current occurs while a section of the traverse is being measured. This statement, of course, does not apply to the starting buoy or to the tie-in buoy. Each of these should be related to its respective anchor and the positions of the anchors considered as the two fixed ends of the traverse. In locating these buoys, the method of range intersections, in which fixes are taken with the buoy in range with each of three or four shore signals, is recommended.

Experience also indicates that errors considerably larger than those caused by the uncertainty of buoy scope are apt to result from blunders and errors made in obtaining, recording and computing the traverse data. Only a trained organization and one in which each member exercises the greatest care can expect to obtain and record accurately all of the distance, azimuth and sounding data required for computing the traverse and plotting the sounding line, and obtain this information within the period of time it takes for the ship to make the run at about 10 knots speed. For this reason certain supplemental data that may be helpful in isolating blunders or eliminating uncertainties should be obtained. To my knowledge, mistakes of one degree have been spotted on two occasions by having available the gyro compass bearings taken of each buoy range as the traverse was measured. On another occasion, an appreciable error in distance was discovered by having available the log distances as a cheek to the taut-wire distances.

To avoid dragging the anchor at the end of the taut wire after the traverse is started, and to assure uniform conditions over the traverse the anchor should be dropped at least one-half and preferably three-fourths of a mile before reaching the first buoy. On the OCEANOGRAPHER, a 70-pound sounding shot is used as the anchor. This is dropped with the vessel proceeding along the range of the first pair of buoys at slow speed. The speed should be increased gradually and it is a safe precaution not to attempt to attain full speed until the second buoy is reached. If the traverse line is also a sounding line, log readings should be recorded at sufficient intervals to insure that increasing the speed does not result in improper spacing of soundings. With the OCEANOGRAPHER, the speed was generally increased to about 7 knots by the time the first buoy was reached and then increased to 9 or 10 knots at the time of passing the second buoy. While it appears that the taut-wire device will stand a speed of about 12 knots, a speed of about 10 knots gives much smoother operating conditions and reduces strain on the wire and anchor. Pilothouse control of the engines is a decided advantage for making a uniform increase in speed.

Taut-wire sheave readings at buoys should be made by two officers and the reduction of revolutions to meters carefully checked and initialed. After the readings have been made, at least one of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these officers becomes available to assist with sun-azimuth observations, which are taken as soon as the ship is placed on the next range ahead or astern as the case may be. The stand-by signals from the bridge, which also serve to inform the officers aft at the taut-wire apparatus on which side a buoy will be passed are made with the ship's whistle, and are the same as used for passing vessels except that the signals are made shorter. In case there are other ships in the vicinity, this information is sent to the taut-wire observers by messenger.

Compass bearings of each buoy range should be observed both when planting buoys and when observing the sun-azimuths. The bearings are helpful, not only for picking up errors but they also afford an excellent means of checking the compass by a comparison with the corresponding sun-azimuths. Such comparisons have indicated that bearings on a gyro repeater can be obtained with an accuracy of one or two tenths of a degree. This, however, cannot be considered a measure of the absolute accuracy of the gyro compass because of the oscillations set up in the gyro compass when making turns. Gyro compass bearings taken when the ship is running the traverse are usually more reliable than those taken when planting the buoys because in the former, a uniform speed is maintained with only small variations in course.

In addition to recording log readings at each buoy, the distance the ship passes abeam of the buoy as well as the direction of the current should be recorded. This latter is obtained by taking a bearing on the target buoy when it comes on range with the relieving or watch buoy. Much of this information may not be used but some of it is certain to be found useful at a later date.

At least three observations should be made of the inclined and vertical angles for each sun-azimuth, and special care should be taken to check the degrees of the inclined angle reading. The angles are generally observed in rapid succession in order to obtain them all before the ship moves off the range or the sun goes behind a cloud or under the horizon, and it is quite possible that a mistake in the degrees may be carried through the entire series.

A radio time comparison should be obtained on the day the traverse is measured and, needless to say, particular care is required on the part of the recorder to mark the times correctly and record the corresponding angles. As previously stated, the inclined and vertical angles are generally obtained in rapid succession and unless a recorder experienced in this class of work is available he should have assistance until he becomes experienced. It is essential that the angles and all other data be called out to the recorder distinctly and uniformly but not too rapidly.

When contemplating both distance and azimuth measurements on one run of the ship, the buoys should be anchored so as to avoid large differences in the azimuths of adjacent buoy ranges. If this occurs, it will not be possible to obtain the sun-azimuths while making the run without having an appreciable curve in the taut-wire line between buoys because of the wide swing necessary to put the ship on range with the next pair of buoys in time to make the series of azimuth observations. When planting a row of buoys, it is well to watch carefully the bearing of the last buoy planted, and to con the ship so that it will be on the desired azimuth when the log distance to the proposed position of the next buoy has been run, rather than to attempt to maneuver the ship after the approxi-

mate position has been reached. By watching the hack hearing of a buoy as well as its relationship to its own relieving buoy, a fair estimate can be made of the strength of the current setting across the course. Allowance can then be made for the drift of the ship during the time it takes to plant the buoy as well as for the buoy scope when it swings to its anchor.

In planting buoys, the buoy itself is first put in the water and the ship is then backed away until the cable has been straightened out before the anchor is dropped. For this reason, it is not desirable to plant a buoy, particularly a sono-radio buoy, with the vessel headed directly into the current since the cable may foul the anchor, or the hydrophone foul the anchor cable, while the target buoy is assuming its natural position with relation to the anchor. For want of better information when planting a buoy, and in regions where wind currents prevail, one can usually assume that the current is setting approximately 20° to the right of the wind.

When running a traverse, the buoys should be passed on the side opposite that from which the current is setting, as indicated by the relationship between the target and relieving buoys. This is not only safer but it makes it possible to pass close to the buoy and thus avoid any appreciable departure from the range. When passing the next to the last buoy a bearing should be taken on the buoy ahead and the ship conned so as to maintain this bearing until the last buoy is reached.

The question has arisen as to how sharp a turn can be made at a buoy without appreciable error in the distance measurement due to straightening out of the wire. It has been observed on two occasions that the resistance of the water to the side pull of taut-wire, when changing course sharply at a buoy, is much greater than expected and it is my opinion that, in so far as the side pull of the wire is concerned, very little, if any error in distance results from making turns as large as 18°. Sometimes it is practicable to pass a buoy on the outside of a sharp turn which insures that if the wire does pull sidewise to any great extent, it will be stopped by the buoy cable. Of course, this should not be done in the case of sono-radio buoys as the taut-wire may foul the hydrophone cable.

Several methods of determination of buoy positions have been used during the three-year period referred to. The graphical method of plotting on aluminum sheets was not used during 1938 on this party except for the location of tie-in buoys. Of the several methods of computing traverses, the standard method used in computing geodetic positions on a shore traverse was used during the past season and is, in my opinion, the most satisfactory. Computations are made independently by two officers on form No. 596 (Position Computation, Traverse) and the closing error is distributed back through the traverse in proportion to the distance run.

Occasionally the moon or a planet has been used to advantage for azimuths when the sun has not been available. On September 9, 1938, only one set of observations could be obtained on the sun before it went below the horizon. However, both the moon and Jupiter were showing in favorable positions and were used. The resulting azimuths of the buoy range as determined from the sun, moon and Jupiter differed by less than 4 minutes. The question has arisen in connection with the use of the moon on this class of work as to whether the correction for horizontal parallax should be applied.

Since the observer, the center of the moon and the center of the earth are in the same vertical plane, it is apparent that the distance of the observer from the center of the earth would have no effect on the azimuth of the moon. Consequently the correction for horizontal parallax need not be considered in the computation of azimuths based on angles taken between buoy ranges and the moon.

With an experienced organization the personnel normally available on each watch when engaged on other classes of work is adequate for running a taut-wire, sun-azimuth traverse except that an additional man is required to operate the taut-wire machine. The organization then consists of three officers, one recorder, one quartermaster, helmsman and a petty officer at the taut-wire apparatus. If sounding the traverse line also it is well to have an additional recorder.

The officer in charge of the watch places the ship on the first range and, when at the proper distance from the first buoy and with the ship at slow speed, signals one short blast of the whistle to drop the taut-wire anchor. He then cons the ship on the range, gradually increasing the speed, obtains current direction at the buoys, distances passed from the buoys, keeps up the abstract and in addition is in full charge of all operations. Generally he also measures the inclined angle.

The other two officers divide their time between the taut-wire machine and the bridge. They record and check the taut-wire sheave readings and compute and check the distances in meters between buoys. On the bridge they enter and copy check the distances on the abstract, measure vertical angles, observe gyro compass bearings of ranges, determine and enter positions of the sun-azimuths and, if time is available, start the azimuth computations.

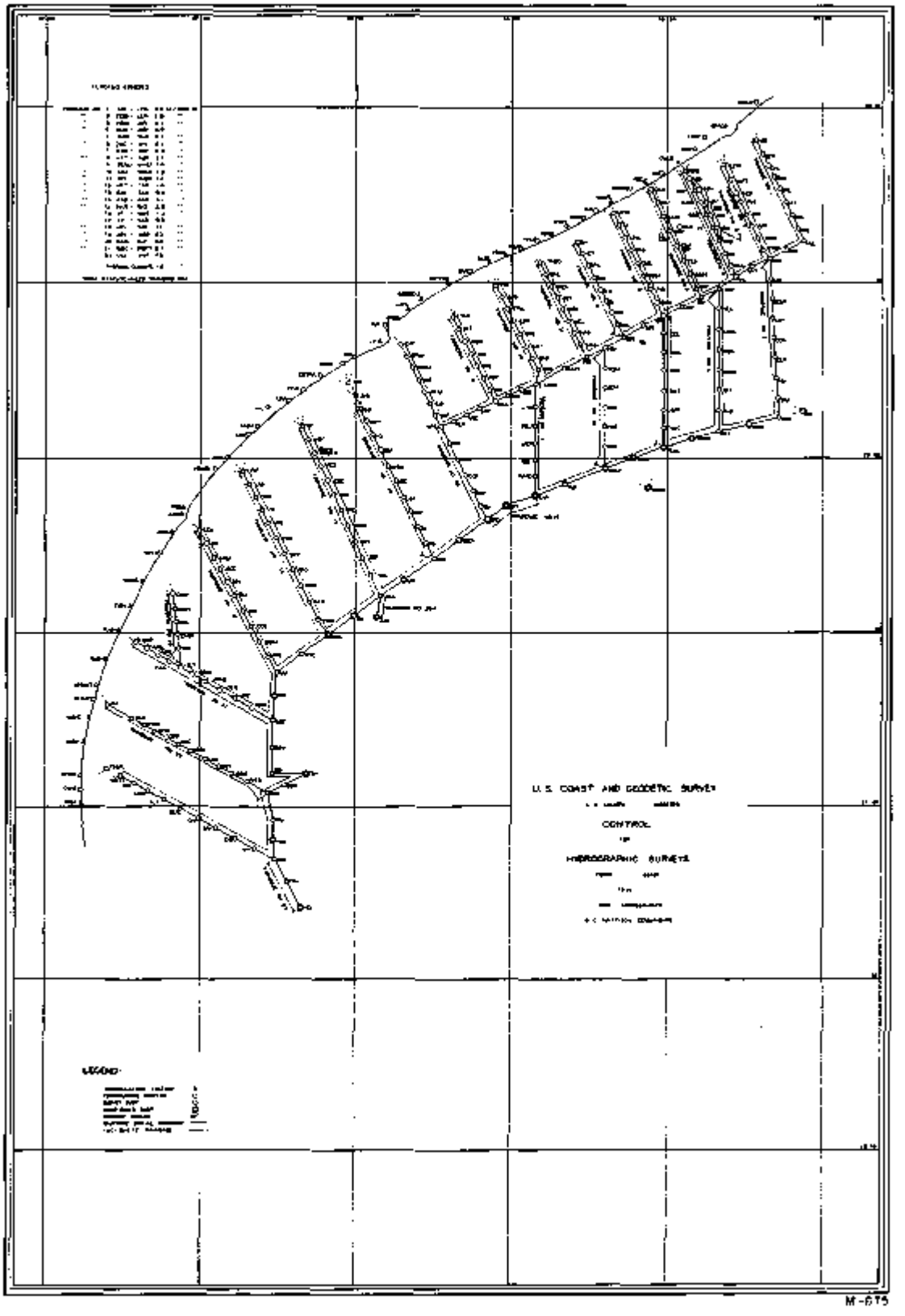
If soundings are not taken on the traverse line, the recorder enters the times and angles on the azimuth form and records the electric log reading at each buoy. If soundings are taken the recorder devotes his entire time to the fathometer and sounding record and additional help is needed for recording the azimuth data.

DISCUSSION

G. C. Mattison, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Commander Borden's observation, "Only a trained organization and one in which each member exercises the greatest of care can expect to obtain and record accurately all of the data,_____", is a very important one, and a very good reason why all the recommendations regarding precautionary measures should be strictly followed. On the Ship HYDROGRAPHER, we have repeatedly made use of supplemental observations to identify the probable location of errors in observations, records, or computations. Everything in connection with taut-wire sun-azimuth traverses has to be done in a minimum of time in order to insure efficient operation of the surveying unit. Supplemental observations are of extreme value in quickly locating possible errors.

Commander Borden has had considerable experience with this type of work, and is well qualified to recommend simplification of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methods. However, we believe that observations should be made to locate the anchor positions, especially where current action is apt to give erroneous surface indications. In new territory or with a new party, everything should be done to insure complete information. Experience will indicate possible short cuts.

G. L. Anderson, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

The methods described in Commander Borden's article, which I read with great interest, were used on the Ship HYDROGRAPHER during the past season with the following few exceptions.

Buoy positions were corrected for the scope of the anchor cable, determined by observing two depression angles at each buoy; one to the target of the survey buoy and the other to a marker buoy secured to the anchor. Each angle was observed when the object was passed abeam. The marker buoy used was a five-gallon gasoline can secured to the anchor with a length of seizing wire equal to the depth plus about nine feet and marked a point on the surface of the water vertically over the anchor, or nearly so. The distance between the survey buoy and the marker buoy normal to the traverse line, as given by the two vertical or depression angles, is a direct measure of the eccentricity normal to the azimuth at each buoy. In correcting an azimuth, the eccentricities in meters at the two buoys were combined to give one reduction, using the formula:

$$\frac{\text{eccentricity (meters)}}{\text{length of line (meters)}} = \text{tangent eccentricity (minutes)}$$

Since these eccentric angles are small, one can make use of the fact that the natural tangent of a small angle divided by the natural tangent of one minute equals the angle in minutes. To make the eccentric reduction on a slide rule, divide the eccentric distance in meters by the length of the course in meters, then divide by the tangent of one minute (0.00029). The result is the eccentric angle. The same result can be obtained by one setting of a slide rule using the reciprocal of the tangent of one minute. Little time is required to measure and compute the eccentrics and the observation can be made by the regular bridge watch.

In addition to measuring the distance passed abeam of the marker and the survey buoys, the direction of the current was noted. It was not always so, that the direction between the survey buoy and the relieving buoy indicated the true direction of the current, as frequently the effect of wind on the target of the survey buoy would be greater than that of the current on the submerged portions of the two. In my opinion, the use of the marker buoy gives the best method of relating the buoy to the anchor and the scope of the anchor cable should always be considered in extensive buoy control systems such as are used in surveys of the Gulf of Mexico.

In locating the inshore buoys from which the traverses were started, three sextant angles were observed at the instant of dropping the buoy anchor, at the same time noting the distance and direction between the observers and the place on the ship where the anchor was released. The ship was moving very slowly astern at the

time of observation. The buoy position was determined from the two strongest angles, using the third angle as a check, and plotted on an aluminum mounted topographic sheet, with a projection of 1:40,000 scale. One sheet was used to plot all inshore buoys during the season. The projection was constructed for the locality of the first buoy and, for each subsequent buoy, the parallels of latitude were renumbered and a new set of meridians constructed. Tie-in buoys were plotted using the same set of parallels but constructing different meridians for each buoy.

Intermediate taut-wire sheave and log readings were recorded every six minutes and at all changes in speed for spacing soundings along the traverse and to aid in detecting any errors.

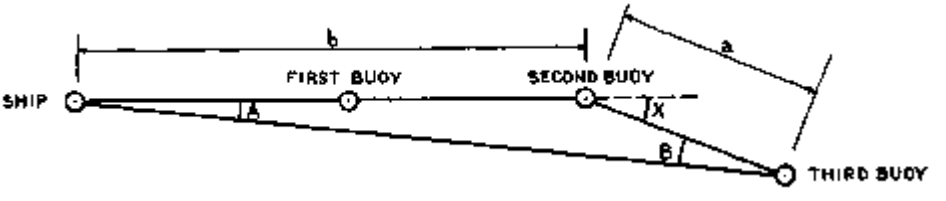
The geographic positions of all buoys in a traverse loop were computed on one form using the method described on page 53, Field Engineers Bulletin No. 11 for December, 1937. This method was followed throughout except for determining the error of closure. During the past season this was done by first computing the positions of all buoys, using azimuths and distances, and then obtaining the difference in the position of the last buoy as carried through the traverse and the position of the same buoy as scaled from the aluminum sheet. This closing error was then distributed through the traverse and the positions corrected accordingly.

For the 1938 season's hydrography, 259 buoys were located by taut-wire sun-azimuth traverses. In my opinion the work of computing the positions of these buoys was reduced a considerable amount by using this method rather than resorting to graphic determination or by using form No. 596 (Position Computation, Traverse) for each buoy.

Glenn W. Moore, Aid
U. S. Coast and Geodetic Survey

When it is impossible or inconvenient to observe sun-azimuths at the time a taut-wire traverse is measured, due to the sun being obscured or for other reasons, considerable time can be saved by measuring the horizontal angles at the buoys. Then, with one azimuth of the traverse obtained by sun observation, the others can be computed.

On a fairly straight line of buoys the angle at the second buoy either forward or aft of the ship can be arrived at very easily. While taut-wiring, maneuver the ship on to the range of the first and second buoys, and observe the angle "A" between the range and third buoy. The log or taut-wire sheave readings give the distances "a" and "b".



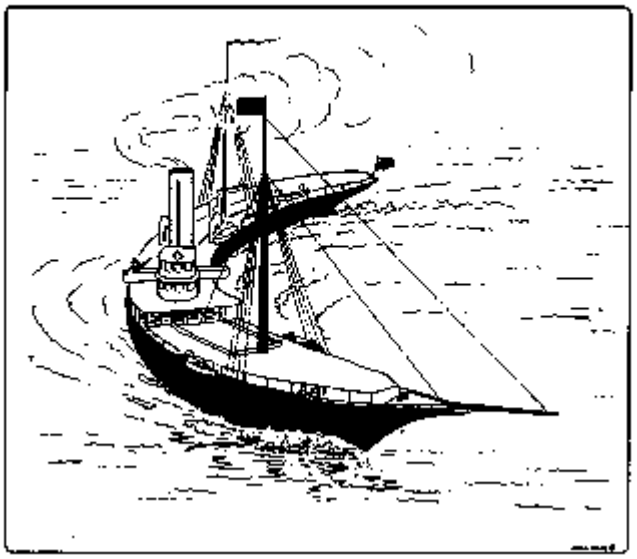
In the figure,

A is the observed angle at the ship expressed in minutes,
B is the angle at the third buoy - ship to second buoy in minutes,
X is the deflection angle at the second buoy in minutes,
b is the distance from the ship to the second buoy in miles or meters, and
a is the distance from the second to third buoy in miles or meters.

$$\frac{\text{Sin } B}{b} = \frac{\text{Sin } A}{a} \quad \text{or dividing by Sin } 1', \quad \frac{B}{b} = \frac{A}{a} \quad \text{or } B = \frac{A \times b}{a}$$

$$\text{Since deflection angle } (X) = A + B, \text{ then } X = A + \frac{A \times b}{a}$$

Since the formula is dependent on the smallness of angles A and B, an appreciable error is introduced when A exceeds eight degrees. The computation can be made quickly on a slide rule. Log distances are sufficiently accurate. The method should not be used for determining the azimuths on an entire line of buoys, because all errors are accumulative, whereas in observed sun-azimuths they are not. The results of a series of comparisons between angles measured as above and actual sun-azimuth differences indicate that an angle can be arrived at in this manner with a probable error of not more than two minutes.



The genial former editor of the Bulletin, Commander F. S. Borden, now commanding the Ship OCEANOGRAPHER, reports that he makes a right angle turn at the end of a sounding line in less than a tenth of a mile. We wonder if the OCEANOGRAPHER looks something like this.

THE NEW ENGLAND HURRICANE

On September twenty-first a hurricane of unprecedented violence swept the waterfront areas from New York to Cape Cod, with an estimated damage of half a billion dollars and a toll of more than 500 lives. By skillful seamanship and unrelenting effort on the part of officers and men, appreciable damage to vessels of the Coast and Geodetic Survey was averted and the personnel of these vessels were able to render material assistance to the stricken communities.

The center of the storm, which was moving northward with the unusual speed of about 40 miles per hour, passed inland at Fire Island Inlet, toward the western end of Long Island. Winds near the center of the disturbance were estimated at 100 miles per hour, causing the highest tides on record in some localities. As a result of wind and sea action, a number of new inlets were cut in the barrier beach of Long Island, one at Shinnecock Bay measuring 300 feet in width and 18-1/2 feet in depth.

The OCEANOGRAPHER, berthed at the New York Navy Yard, delayed sailing upon receipt of advice of the storm's approach, but otherwise experienced little inconvenience, as wind velocities in that area were considerably more moderate than those in the dangerous semicircle to the eastward.

The LYDONIA was less fortunate. On approach of the storm the vessel ran from the working grounds to New London and tied up, bow out, along the west side of the State pier. A graphic description of conditions during the storm is given in the report of the commanding officer, Lieutenant Commander R. P. Eyman:

"As the barometer continued to fall rapidly all preparations were made to moor the ship as securely as possible and lashings were made fast over a number of piles of lumber on the inner end of the dock to protect us from flying lumber. The wind still held to the southeast, which, as we lay at our berth, was nearly ahead. As the wind increased in force the engines were started ahead to relieve the strain on our mooring lines and a close watch was kept to regulate the revolutions to maintain a constant strain.

"After 3:00 p.m. the velocity of the wind increased rapidly. Huge seas made up in the river and swept into the slip causing a violent surging on our lines, which, however, was greatly eased by the engines turning ahead. Sand and pebbles from across the river were picked up and showered on us in an almost constant stream with the rain and spray. Two boats moored to the same pier ahead of us broke adrift and were carried down to us; all efforts to get lines to them failed and they were washed to the head of the slip and carried high ashore by the breaking seas - no one was injured, we later learned. Other ships at neighboring docks broke adrift and were carried ashore.

"The water rose rapidly until it covered the deck of the dock to a depth of one and a half to two feet. The wind hauled slightly to our starboard bow and held the ship against the dock with some pounding. Before the height of the storm was reached the anemometer registered a wind velocity of an even 100 miles per hour and then was carried away. About 4:45 p.m. the velocity of the wind decreased rapidly and by 6:00 p.m. it was not more than 35 or 40 miles per hour. The engines were stopped and the ship rode com-

fortably to her dock moorings with no unusual strain. With the decrease in the wind the water subsided rapidly and soon cleared the deck of the dock".

Danger to the vessel, however, was not ended with the passing of the storm. A fire of major proportions broke out in the city and threatened to raze the entire water front.

"Between 5:30 and 6:00 p.m.", continues the commanding officer's report, "a fire broke out downstream from us along and in back of the water front. Thick smoke and flying sparks filled the air about us. It appeared as if the fire was spreading rapidly and headed in our direction. Fire hose was laid and a watch was kept on all portions of the ship to arrest danger of fire from sparks. This watch was maintained throughout the night although it appeared that the spread of the fire had been checked about 11:00 p.m."

The following morning, with weather conditions again normal, the LYDONIA was instructed to remain at New London to render assistance in handling communications, local facilities having been destroyed. By afternoon other agencies had taken over this work and the LYDONIA sailed for the working grounds.

At the mouth of the Thames River in Long Island Sound, a disabled motorboat with five men aboard was found drifting rapidly out into the Sound. The LYDONIA took the boat in tow and returned with it to New London, proceeding thence to the working grounds without further incident.

The LYDONIA was one of the few vessels in her vicinity to escape material damage or indeed total loss, her casualties consisting mainly of a dented hull plate and, most curiously, the complete frosting of pilothouse windows from wind driven sand and gravel. Personal injuries were slight and were limited to those received by one man while tending mooring lines.

At Woods Hole, Massachusetts, where the Motor Vessel GILBERT was tied up, damage was particularly great, although wind velocities there did not exceed about 80 miles per hour. Lieutenant Charles M. Thomas, in command of the GILBERT, vividly reports the progress of the storm:

"The morning before the hurricane hit, the barometer was fairly steady, and the center of the storm was reported to be off Cape Hatteras. That afternoon the barometer started dropping very rapidly, for a while at the rate of a tenth of an inch per hour.

"In view of the approaching bad weather, we had secured the GILBERT along the north side of the U. S. Coast Guard dock with sixteen 5-1/2 inch lines. From the way the wind and sea were increasing their intensity I decided that these lines were not strong enough to hold the vessel to the leeward side of the dock. To prevent her fetching up on the beach the starboard anchor was dropped and the port anchor chain unshackled and led across the dock to a dolphin. While this was being done the bow line parted, and a short while later one hawser of the after spring parted. In addition to the bow anchor chain, a new hawser was led across the dock to a dolphin farther ahead. We also replaced two of the other bow lines, already parted.

"At this time the tide was rising rapidly, the top of the dock

already being awash. Raging waters were surging across the narrow neck of land connecting Penzance Point with the mainland forming almost a waterfall as the higher water from Buzzards Bay came flooding over into Great Harbor during the period of extreme high tide. At least 500 feet of the highway in this vicinity was wrecked. Three men from the U. S. Coast Guard patrol boat GENERAL GREEN lost their lives while doing rescue work in that vicinity. Our engineer was standing by, which he continued doing throughout the night, ready at any time to go ahead on his engine in case the dock collapsed and we had to depend on our anchor to keep from being blown ashore. Much wreckage of various descriptions, including many boats, was being washed up on the beach around the north side of Great Harbor.

"After the boatswain and his party had placed our instruments safely out of reach of the rapidly rising water, they procured a boat and went to the aid of a woman stranded on top of an automobile at the corner of West and Milfield Streets. They then returned as near as possible to the GILBERT, and finding everything secure they went to answer an emergency call to aid two men marooned on a telephone pole, where the water was flooding through Bar Neck from Buzzards Bay, on the Penzance Road.

"By the time of their arrival, one of the men had been swept away by the raging overflow of water from the Bay into Woods Hole Harbor, which had a velocity of approximately 9 knots. After many unsuccessful attempts had been made by others with inadequate line, our boatswain procured a strong line from a nearby house, which was carried by a civilian out across the swiftly flowing water and made fast to the pole, making it possible for the remaining man to get safely ashore before collapsing from exhaustion".

On returning to their offshore working grounds the day after the storm, the OCEANOGRAPHER and LYDONIA were able to recover all sono-radio buoys, and all but 3 of the ordinary survey buoys. The superstructures had been carried away and one magnetophone was lost; otherwise the buoys were intact. As the time for closing the season's work was at hand, no effort was made to reestablish the control system of buoys. Incompleted areas in the hydrography were filled in with the control available and the vessels proceeded to Norfolk without further mishap.

The New England hurricane recalls to mind the experience of the old HYDROGRAPHER in the hurricane of September 9 and 10, 1919. This vessel, then under command of Lieutenant Commander G. C. Mattison, was anchored in Key West Harbor undergoing repairs to the main engine. As the low pressure cylinder was dismantled when the hurricane struck, the vessel dragged, fouling the cable of the Coast Guard Cutter TUSCARORA. To avert the latter vessel's dragging, owing to the increased strain, all hands on the HYDROGRAPHER were ordered to board the TUSCARORA as the two vessels came together. When everyone except himself was transferred, Mate 0. M. Straube, at considerable personal risk, slipped the ship's cables and then jumped aboard the TUSCARORA. The HYDROGRAPHER was blown across the channel and grounded on the shoals west of Key West. The personnel of the HYDROGRAPHER later succeeded in floating the vessel by using its own power to cut away the sand.

CALIBRATION OF TAUT-WIRE APPARATUS

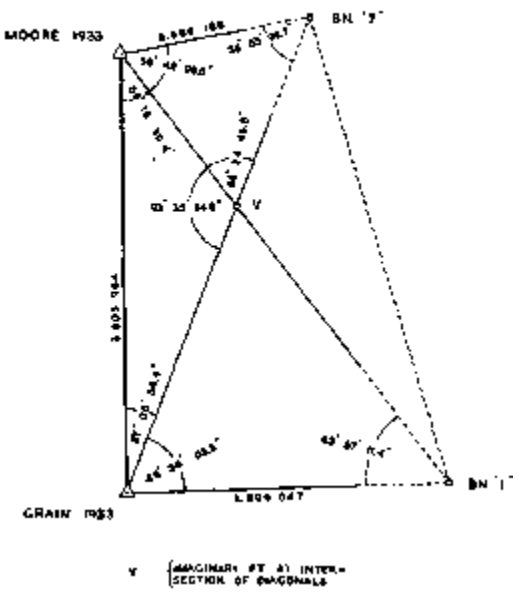
Leroy P. Raynor, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

The accompanying illustration shows the method used in calibrating the registering sheave of the Ship HYDROGRAPHER'S taut-wire apparatus in 1937; a method which is believed to be the most accurate and satisfactory of any heretofore used. The previous calibration of the sheave was made in 1935, over the one-mile speed course in the Gulf of Mexico near the Southwest Pass of the Mississippi River. Since that period, about 1,000 miles of wire had been used in measuring taut-wire traverses and the 1937 calibration was undertaken to ascertain if this extensive use of the registering sheave had changed the conversion factor.

The proximity of the HYDROGRAPHER'S working grounds during the 1937 field season to the Houston Ship Channel was particularly fortunate in that a section of this Channel, marked by four pairs of firmly built beacons, provided a straight course of four miles and simulated the actual conditions of a taut-wire traverse between two or more survey buoys.

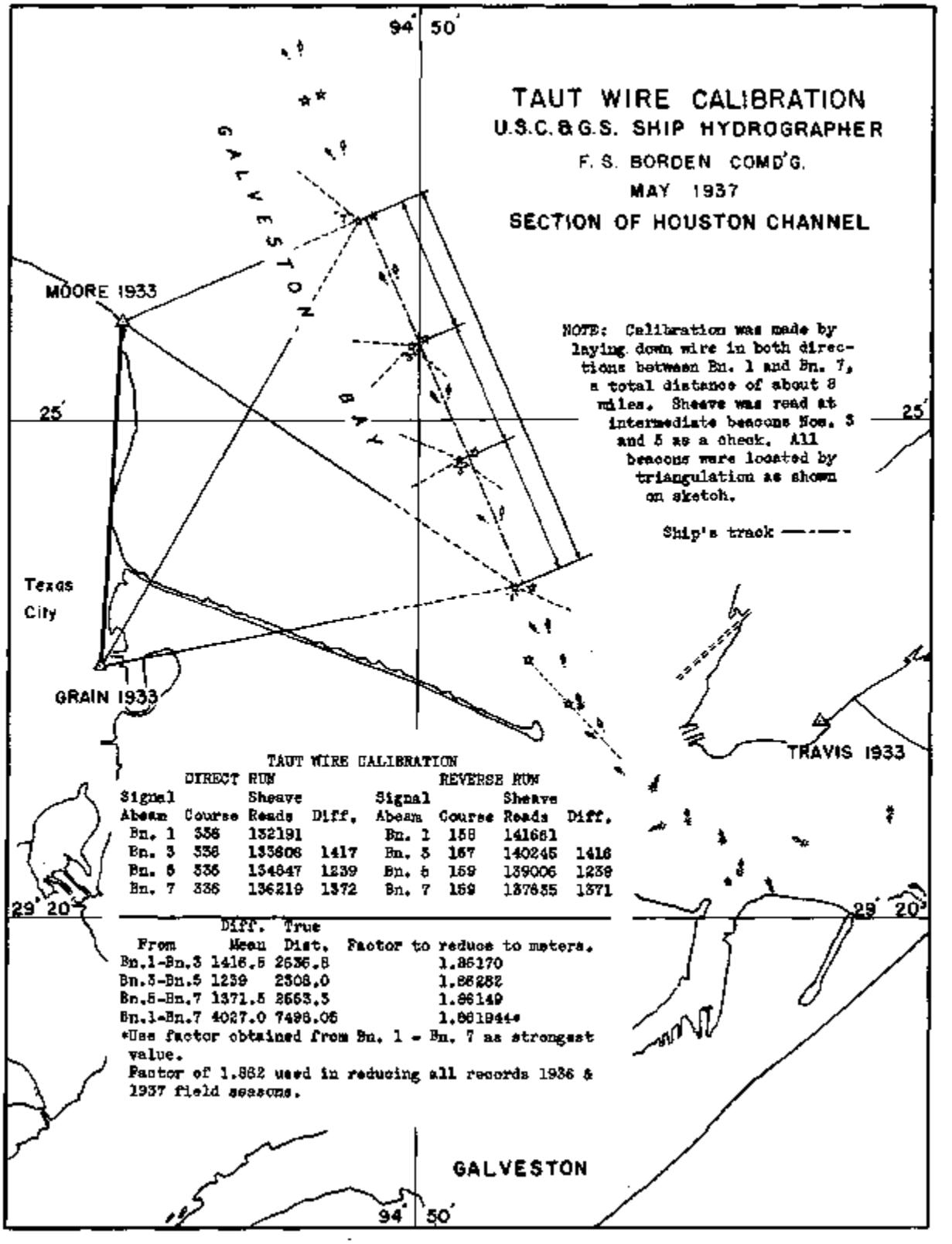
The four beacons Nos. 1, 3, 5 and 7, located on the east side of the channel, were used as reference points. Since their positions had been determined by second order triangulation in 1933, the distances between adjacent beacons, as well as the distance between the two end beacons, were obtained by inverse position computations. The latter distance was checked by solving the quadrilateral Grain-Moore-Beacon 1 - Beacon 7 from the adjusted triangles, as shown on the sketch.

SKETCH SHOWING DATA OBTAINED FROM ADJUSTED TRIANGULATION.



In the operations for calibration, the wire, secured to a 75-pound weight, was lowered to the bottom about 3/4 mile from the first beacon, and the engines started. Speed was uniformly increased so that standard sounding speed was obtained prior to passing abeam of the first beacon. This speed was maintained throughout the test while a tension of 38 to 40 pounds, as indicated on the dynamometer of the apparatus, was kept on the wire and the ship conned carefully on a straight course.

When each beacon was abeam of the taut-wire apparatus, the registering sheave was read and recorded. A run was made in each direction and the total distance of each run of four miles agreed, in terms of the sheave readings, within two revolutions or approximately 3.6 meters in 7,500 which is better than one part in 2,000.



TAUT WIRE CALIBRATION

DIRECT RUN				REVERSE RUN			
Signal Abeam	Course	Sheave Reads	Diff.	Signal Abeam	Course	Sheave Reads	Diff.
Bn. 1	336	132191		Bn. 1	158	141661	
Bn. 3	336	133608	1417	Bn. 3	157	140245	1416
Bn. 5	336	134847	1239	Bn. 5	159	139006	1239
Bn. 7	336	136219	1372	Bn. 7	159	137635	1371

From	Diff. Mean	True Dist.	Factor to reduce to meters.
Bn.1-Bn.3	1416.5	2636.8	1.86170
Bn.3-Bn.5	1239	2308.0	1.86282
Bn.5-Bn.7	1371.5	2553.3	1.86149
Bn.1-Bn.7	4027.0	7496.06	1.8619444

*Use factor obtained from Bn. 1 - Bn. 7 as strongest value.

Factor of 1.862 used in reducing all records 1936 & 1937 field seasons.

These readings between the end beacons were used in computing the conversion factor, the readings on the intermediate beacons serving only as checks.

It is interesting to note, in the result, the slight difference between the 1935 and the 1937 calibrations, the factors being 1.86163 and 1.86194 respectively. Since the factor is used to the third decimal only, 1.862 serves for both calibrations. However, the method used in 1937 is considered the more accurate and is recommended whenever similar control is available.

SPEED PLOTTING ON RADIO ACOUSTIC RANGING

At the beginning of radio acoustic ranging by the Coast and Geodetic Survey in 1924, distances between the RAR stations and the surveying vessel, as determined by the time of travel of the bomb explosion, were plotted on the hydrographic sheet with a beam compass. It was natural that this awkward procedure would inspire improved methods of plotting. Distance arcs at regular intervals are now drawn on the hydrographic sheets and on this page and the few following pages, are described methods whereby these arcs are utilized to facilitate the plotting of distances.

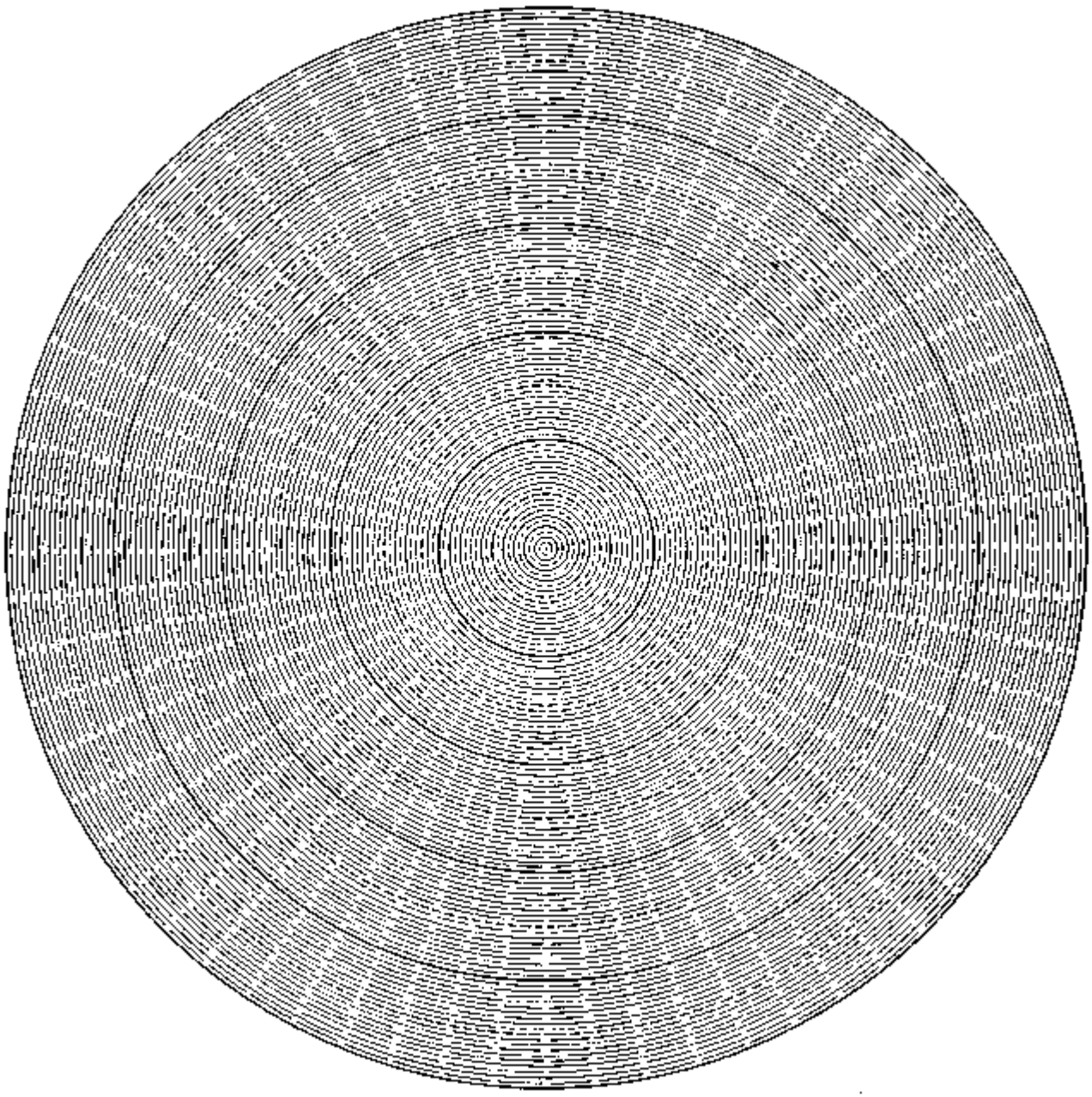
(Editor)

Herman Odessey, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

The drawing shown on the opposite page illustrates a device that can be used instead of dividers for plotting the residuals between distance circles drawn on the radio acoustic ranging hydrographic sheet. The series of concentric circles are spaced 50 meters apart for the scale of 1:60,000 and 100 meters apart for the scale of 1:120,000 and range respectively from zero to 5,000 and from zero to 10,000 meters.

In practice, the drawing either is made or reproduced photographically on clear celluloid of low distortion. The residual or remaining distance beyond the last regularly spaced distance circle is plotted by placing this distance, as read from the concentric circles, tangent to the distance circle, estimating between 50 or 100 meters. The center of the device then marks the correct distance. If the scale is well made, the accuracy in laying down a residual is limited only by the plotter's ability to estimate accurately fractions of the interval between the concentric circles. An error in estimating these fractions of l/l0 the interval between circles corresponds to an error of only five meters or 0.003 second in time of travel of the RAR sound wave, for a scale of 1:60,000.

The device also furnishes a ready means of measuring and compensating for the distortion of the hydrographic sheet between distance circles. Also, when a position is determined by only two RAR distances, the device may be manipulated like a 3-arm protractor.



R.A.R. PLOTTING DEVICE

1:60,000 & 1:120,000

Each residual is placed tangent to its respective distance circle and the center marks the position. Considerable saving of time in plotting results from use of this device without loss of accuracy.

W. F. Malnate, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Gone with the wind are the old laborious processes of plotting RAR lines on the Ship GUIDE. No longer does the plotting officer proceed to the plotting room armed with his slide rule and reams of paper. Instead, very simple innovations, employing old tools, have been utilized.

Bomb returns are plotted on the hydrographic sheet by means of a french curve and bow compass. By laying a french curve along the distance or time arc, (whichever is being used), nearest to the approximate position of the ship at the time of firing the bomb, the arc of the bomb return may be easily plotted parallel to the distance or time arc by keeping the point of the compass bearing against the edge of the french curve. A bow compass is used instead of dividers so that a single operation only, is required both to measure the distance and mark the arc at which the intersection of returns will occur. By this method, the arcs of the bomb returns can be plotted almost as quickly as the distances are scaled from the chronograph tapes, and it is not necessary to have the complete returns from all the stations before starting to plot the position.

For plotting the intermediate positions and computing log factors, etc., a speed diagram has been utilized which obviates any slide rule work. A diagram is made for the scale of the survey and the speeds of the vessel engaged in the hydrography. An inspection of the diagram accompanying this article shows the abscissas to be the log factors and the ordinates the various speeds of the vessel. With this diagram the log factor of any run can be solved graphically by knowing the distance made good over the ground, or, knowing the log factor, the distance made good over the ground can be scaled and plotted. The graphic determination of the intermediate distances between bombs, particularly when the log factor is varying because of currents, is readily solved by use of the diagram.

TIDES, MAGNETICS AND RACING

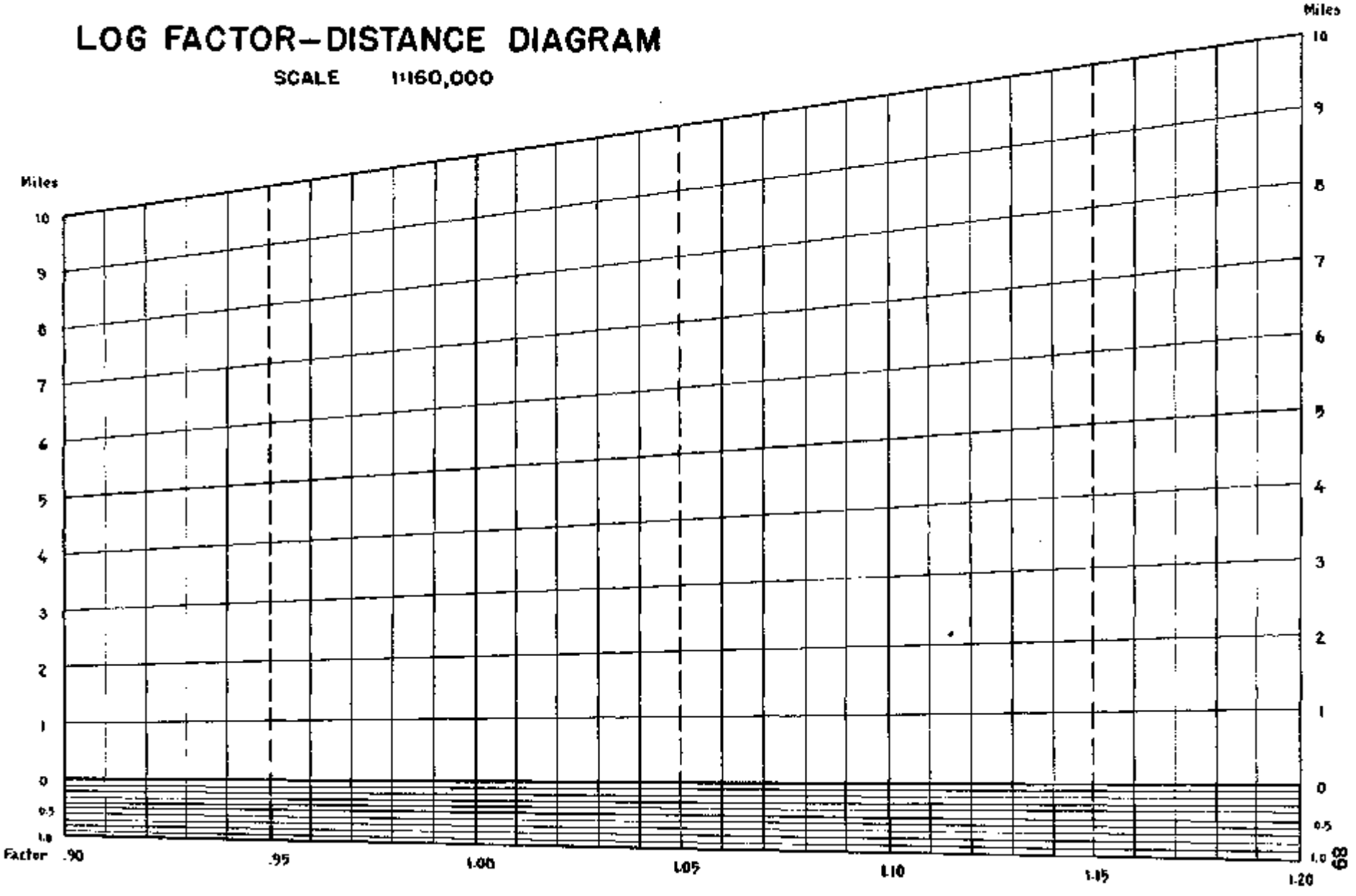
A recent request from Sulphur Springs, Arkansas for information may be of interest to our readers:

"Please send me the following information:

(1) The daily or weekly schedule of tides for this locality.
(2) A moon table and planet and zodiac signs. (My calendar and almanac give them different.)
(3) When the gravity center or magnetic center is rising and setting in this locality.
(4) Where does one buy sweepstake tickets.
(5) And a horse racing magazine and charts. I thank you."

LOG FACTOR–DISTANCE DIAGRAM

SCALE 1:160,000



THE UNITED STATES COAST PILOTS

Anthony J. Marbois, Assistant Nautical Scientist
U. S. Coast and Geodetic Survey

Marine navigation is the science or art of conducting various types of vessels over the navigable waters of the globe from one place to another. To accomplish this safely and with economy it is essential to know the position and surroundings of the vessel at all times, if possible.

The most important part of navigation and that requiring the most experience and good judgment is "coastwise navigation", which consists of navigating a vessel approaching land, along coasts, and in channels and harbors. Here the depths of water and the vicinity of latent dangers require that a constant watch be kept on the vessel's course and frequent changes of direction are necessary. This part of navigating is properly named "piloting". When far out at sea an error in position may be rectified by later astronomic observations, but an error in position while "piloting" a vessel often results in a costly grounding or disaster and possible loss of life. It is to help and to guide mariners through the difficulties of navigating where it is dangerous and special knowledge is required that the Coast Pilots are planned and published.

While nautical charts are without doubt the most valuable contribution to safe navigation, the Coast Pilots certainly are next, for they contain a vast amount of information and data which cannot be shown graphically on the charts. Before Coast Pilots were issued in book form by the Coast and Geodetic Survey, sailing directions were printed on the charts themselves, but only a small fraction of the information contained in a modern Coast Pilot could be made available by this method.

All the principal maritime nations of the world publish sailing directions and information of the same character for the use of mariners, and foreign Pilots of the waters of the United States and possessions consist mostly of translations of the text of the United States Coast Pilots.

The Coast Pilot needs no introduction to seafaring men, for it is in such constant use that it has often been named the Mariner's Bible. But it is comparatively unknown to the landsman and few realize the wealth of information contained in the thirteen Coast Pilot volumes published by the U. S. Coast and Geodetic Survey to cover the coastal waters of the United States and possessions.

The "American Coast Pilot", known as Blunt's Coast Pilot, describing the waters of the Atlantic Coast, was the first Coast Pilot volume published in America. It appeared first in 1796, and was published by Edmund M. Blunt of Newburyport, Massachusetts, then a printer by profession who also dealt in nautical instruments and publications. The first edition was appreciated so much and was in such great demand that a second edition was published in 1798. This early work was compiled from notes of pilots and shipmasters but subsequent editions also included data collected by special survey expeditions financed by Blunt himself. Mariners of this period disclosed information of this kind with great reluctance, for they considered their professional knowledge of the secrets of the sea too valuable a business asset to be published.

Two sons of Blunt, both of them hydrographers of note, continued as a private enterprise the work of revising the American Coast Pilot. The twenty-first and last edition was published in 1867. Coast Pilot information, however, can be collected only imperfectly and at great cost by private enterprise. Consequently the maritime public was insistent that this task be performed by the federal government and the Coast Survey, which had been engaged in charting the coasts of the United States since 1816, undertook the preparation of an Atlantic Coast Pilot, which was published about the time of the last edition of the Blunt publication. This was 14 years after the first official edition of Davidson's Directory of the Pacific Coast. At the present time all private publications containing piloting information relative to the coasts of the United States and possessions, are compilations from Government publications and are generally based on the work of the U. S. Coast and Geodetic Survey.

Before the acquisition of California by the United States comparatively little was known of the hydrography and geography of the Pacific Coast, except by the few navigators trading along its seaboard and the daring otter hunters familiar with every cove, rock, and headland.

The first accurate detailed information of the West Coast was contained in the Coast Pilot Notes of William Pope McArthur, an officer of the U. S. Coast and Geodetic Survey, who, in a short but brilliant career, showed unusual qualities of leadership and accomplished much under adverse conditions. McArthur was ordered to the West Coast by the Superintendent of the Coast Survey in the fall of 1848. This period witnessed one of the most spectacular expansions in shipping ever known, due essentially to the development of gold mining near San Francisco, and marks the time of the first definite action of the Coast Survey toward making surveys of the Pacific Coast. (1) In 1849, McArthur made an estimate of the increase in the combined population of San Francisco, Sacramento, and Stockton. From scarcely 100 people in these three settlements the number rose to about 175,000 in the short space of 18 months. McArthur died of illness in December, 1850, near Panama Harbor while returning to the East Coast. About the same time Professor George Davidson, then a young man, was sent from Washington to the Pacific Coast and began collecting Coast Pilot information while engaged in the control surveys of the coast, surveys which were made under serious difficulties. For a period of more than 50 years the biography of George Davidson might almost be considered the history of the activities of the Coast Survey along the Pacific Coast from the Mexican Border to the Arctic. In 1854, Davidson began to write, outside of his working hours and in addition to his other duties, his Coast Pilot Notes, or Directions, which were published in one of the contemporary daily journals of San Francisco. (2)

The first official publication of a Pilot for the West Coast consisted of Davidson's Notes included in the Coast Survey Report

(1) There was no justification for surveys of the Pacific coast at an earlier date. Although the northern limits of the Oregon Territory were settled in 1846, it was not formally claimed by the United States until 1848. The conclusion of the Mexican War in 1848 resulted in the cession of California, The United States had no Pacific coast before 1848.

(Editor)

(2) It is said that the Superintendent of the Coast Survey at first refused to publish this information officially for fear that some of it might he erroneous.

(Editor)

for the year 1858. The first Pacific Coast Pilot information issued separately by the Coast Survey in books especially designed for the purpose was made in 1862. These volumes were the first of this character published by the Coast Survey and antedated its Atlantic Coast Pilot. (3) The new Pilot, a revision of the Coast Pilot Notes in the 1858 Report, was named "The Directory of the Pacific Coast of the United States". In 1867, Davidson submitted "The Directory of Alaska", and, in 1869, his "Coast Pilot of California, Oregon and Washington Territory" was published.

"The Davidson's Coast Pilot of California, Oregon and Washington", edition of 1889, is the most elaborate of them all and has been referred to as "a monumental work standing unequaled as a work of reference for the mariner, for the historian and for the geographer".

More about McArthur and George Davidson may be found in Captain Thos. J. Maher's most interesting article, "The Coast Survey on the Pacific Coast", in the Field Engineers Bulletin of December, 1934.

Twelve Coast Pilot volumes and one Inside Route Pilot (New York to Key West) are now published by the United States Coast and Geodetic Survey. They describe the coastal waters of the United States and possessions, and the Intracoastal Waterway along the Atlantic and Gulf Coasts. Each volume covers a certain section of the coast as, for example, the United States Coast Pilot, Section B, from "Cape Cod to Sandy Hook". There are two volumes each for the waters of Alaska and the Philippine Islands.

The information in the Pilots is suitable for small boats as well as large vessels. This consists of a description of shore features to aid in the identification of isolated portions, such as outlying islets, when the shore is obscured from view. It includes information about local conditions, and the dangers to be avoided when navigating in close quarters, in or out of ports, in narrow channels, up rivers, or along the coast. Where it is particularly dangerous and difficult to navigate, the necessity for caution is stressed and more details are given. Port and anchorage regulations are given and the locations and nature of anchorages are described. Information regarding wharves, quarantine, customs, repairs, marine railways, supplies, communications, hospitals, and inland transportation facilities permits operating companies to plan their schedules intelligently and aids mariners to conduct their business without undue loss of time. Most information of this kind cannot well be printed on the charts, but in the index and geographic sequence of the Pilot's text it is readily accessible.

Included in the information in the Coast Pilot are meteorological tables, showing temperature, barometric pressure, and prevailing winds, tabulated by months; descriptions of ice conditions; tidal and current data; values of the variation of the compass; the use and methods of correction of radio bearings; the use of charts; bridge regulations for drawbridges; rules of the road; instructions to mariners in case of shipwreck, etc.

A simple outline of the services of interest to mariners rendered by various agencies combines in simple and intelligible form

(3) Although. 66 years after the first "American Coast Pilot" for the Atlantic Coast, it was published actually only 14 years after there was a West Coast.

(Editor)

information that is otherwise available only in complex forms scattered through many national and international publications. For instance, in a few pages the mariner is informed of the various radio services available pertaining to weather, navigational warnings, direction finding, time signals, medical advice via radio, etc.; also of the procedure for radio distress traffic; and the shipmaster is reminded of certain of his responsibilities in connection with the radio equipment, operators, communication and the reporting of dangers to navigation.

Sailing directions are given for the more difficult sections and information regarding depths and widths of channels, and clearances of bridges is readily found, so that in most of the navigable waters covered by the Pilot, with the help of the system of aids to navigation established by the U. S. Lighthouse Service, strangers may cruise with ease and safety.

Recommended routes, sailing directions, and controlling depths are based on charts compiled from accurate instrumental surveys, or, in inadequately surveyed waters, on the experience of navigators familiar with the waters concerned. In parts of Alaska, for example, large areas are still unsurveyed, and the charts of such areas are still based on early Russian exploratory and reconnaissance surveys. In such localities the Coast Pilot is often more valuable than the chart itself, for it gives the courses and distances actually made good by ships that have safely navigated the area. In such inadequately surveyed areas a shipmaster's best chance of safety is to follow as carefully as possible the beaten track.

Though the Pilot is a reliable source of information, the possibility of changes occurring after the information has been obtained must be taken into consideration. Changes, both man-made and natural, are constantly occurring, and a volume soon requires corrections. To keep the Pilots up-to-date, the U. S. Coast and Geodetic Survey issues a supplement to each volume about once a year, and each annual supplement is all inclusive canceling preceding supplements if there have been any. The supplement contains the more important changes. It is printed on one side of the paper only, and is so arranged that the various items can be clipped and pasted in their proper places in the Pilot volume. The navigator should also correct his Pilot from information published in the weekly Notice to Mariners, issued jointly by the U. S. Coast and Geodetic Survey and the U. S. Lighthouse Service of the Department of Commerce.

The revision of each U. S. Coast Pilot is undertaken about once every six years and a new edition is prepared. A field examination of the area and an office examination of available data is made by someone who knows the needs of the mariner and how the Pilot is used by him. In the office all the latest field surveys and reports of the surveying parties for this area are examined for new information and latest data. In addition to the hydrographic and topographic surveys, there are blueprints, charts and descriptive reports, as well as hundreds of notes and notices which may contain pertinent information. The compiler must select certain data, reject others, and prepare that accepted in such form that the text of the Pilot will be readily understood by thousands of men of varying education and mental ability. Quite frequently incorrect information is received and it is necessary to verify statements before accepting them for publication.

An extensive field examination of the region covered by the Pilot is then made. Every part of the coast and the adjacent waters included in the volume are visited; the information collected in the office is verified; pilots, navigators, and many persons and organizations with local knowledge are interviewed in order to obtain information from all available sources. Interviews with fishermen have disclosed many uncharted shoals, especially in inadequately surveyed areas. Fish frequent shoals and rocky banks and knowledge of the locations of such spots is handed down from father to son. Due to his long familiarity with the waters in which he fishes, a fisherman can easily locate himself over such shoals without the help of charts. Once in a while some fishermen are met who regard such knowledge as their own private property and object to having it made available to others.

In collecting and selecting the data for the Pilot consideration is always given to the needs of the navigator at night or in daytime and in all sorts of weather, whatever the type of his vessel or its draft, size, power, and maneuverability. Extreme care as to the accuracy of all information, either general or detailed, is exercised to avoid ambiguous statements that might lead mariners using the Pilot, with or without charts, into danger. Incidentally, another obligation for accuracy, is the fact that the Pilot is regarded as authoritative and sometimes is used in lawsuits.

The final preparation of the Pilot consists in arranging the accepted data in a most readily accessible form and proper geographical sequence; and the final editing of the manuscript before transmittal to the printer. After final changes and corrections have been made to the page proof, cross references in the text and the index are prepared.

These are the Coast Pilots which for many years have aided the mariner to guide his vessel safely into port and along the coasts of the United States and its possessions. They are sold by the United States Government at the cost of printing and binding only and each volume sold is accompanied by its latest supplement.

SPEAKING OF WEATHER!

Alibis, like comparisons, are generally odious, but sometimes a young chief of party who has not yet proven himself may have to stress the handicaps which have ruined his season's results. The following is quoted from the season's report of 1912 of a chief of party operating in Prince William Sound, Alaska:

"Bad weather conditions still continued upon arrival in Port Wells. According to the report of the Weather Bureau observer at Cordova, there were two clear days in June, twenty partly cloudy and eight cloudy, with six inches of rainfall; July, three clear days, thirteen partly cloudy, with five inches of rainfall; August, no clear days, thirteen partly cloudy, eighteen cloudy, with twenty-three inches of rainfall, and September, no clear days, eight partly cloudy and twenty-two cloudy, with *FIFTY INCHES* of rainfall."

LIGHT-STAR SIGHTS

Frederick B. T. Siems, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

A departure from the usual practice in hydrographic surveying led to the conception and development of the light-star method of employing a light and two stars for position finding at sea. The occasion was the survey of Cordell Bank off the coast of California in 1929, when poor visibility prevented the use of a sufficient number of survey buoys for fixing the position by means of the three point problem.

As an alternative, observations comprising a sun azimuth, coupled with the single angle between two of the buoys that were visible, provided the means of locating the survey vessel while engaged in sounding. At night, Point Reyes Light, Farallon Island Light, and the star Sirius were employed in a like manner for obtaining data to locate the buoys. The relation in azimuth between the sun and one of the buoys was obtained from the observed inclined angle between them and the observed altitude of the sun. To obtain the relation between the star and Point Reyes Light, the inclined angle between them was observed; but the altitude of the star was computed, as there were no other means of obtaining it.

It should be noted that a comparatively high degree of accuracy can be obtained in an azimuth to a horizon light derived from a near-horizon star when the inclined angle between them is in the neighborhood of 90°. Under such conditions, the altitude of the near-horizon star need be known only approximately as observed by bubble sextant, or as taken approximately from (H. O. 214) tables. If the inclined angle is 90°, the altitude need not be known at all.

The practicability of using astronomically observed azimuths in navigational sights will now be considered. If, at sea, it were possible to cause a horizon light to appear in the vertical circle passing through a near-zenith star, then the observed altitude (the angle between the star and light); the astronomically observed azimuth to the light derived from a near horizon star; and the time of these observations taken simultaneously would provide the means of fixing the position of a vessel. In the astronomical triangle there would be three known parts, namely: the azimuth angle, the codeclination of the near-zenith star, and the zenith distance. Hence, the latitude and difference in longitude would be derived.

A near-zenith star is specified in the above arrangement for the reason that an astronomically observed azimuth at sea is limited in accuracy to a degree which will produce favorable results *ONLY WHEN THE ZENITH DISTANCE IS SMALL.*

A light-star sight is analagous to the assumed sight considered above, in that a horizon light, a near-zenith star and a near-horizon star are employed; the light, however, need not appear in the vertical circle passing through the near-zenith star. The observed angle between the light and the near-zenith star, the astronomically observed azimuth to the light derived from the near-horizon star, and the time of these observations, taken simultaneously, provide the means for establishing a line of position. This line of position is a great circle having its pole at the point in the horizon created by the light. If the sight is taken as specified

in Case I, described hereinafter, no previous knowledge of the observer's position is required in the solution; a position in the great circle line of position and the direction of the line at that point are derived, as in great circle sailing, to establish a section of the great circle in the proximity of the observer. In Case III, a dead reckoning or assumed position is used in the solution.

The light is observed at a distance of about 4 miles as determined by range finder or by log; when placed on a vessel, it is made to appear in the plane of the horizon of the observer, precluding the necessity of applying corrections for dip and refraction to the two observed angles common to the light. (See notes on refraction and on dip at conclusion of article.) It may be mentioned here, that the refraction of the line of sight to a near-zenith star is small and may be neglected; also, that the horizontal line of sight is removed some distance from the surface of the water and probably is not liable to error caused by the occasionally abnormal refraction encountered when sighting the visible horizon.

In the ordinary altitude sight, an angle is observed between a star or limb of a heavenly body and the line of the visible horizon. In light-star sights, the important angles are observed between a light and a star; in other words, between two distinct points, a factor conducive to greater accuracy. It is realized that the vertical movement of vessels in a seaway would affect adversely the latter observations, particularly the angle between the near-zenith star and the light. At a distance of 4 miles, a 3-1/2 foot upward displacement of one of the vessels, and a downward displacement of the same amount of the other vessel, occurring at the same time, would cause an error of 1 minute in the observed angle or 1 mile in the resulting line of position. The error from this source may be reduced by taking more than one set of observations, or by increasing the distance between the observer and the light.

If necessary, the observer's vessel or the vessel carrying the light may be maneuvered into position, prior to the observations, so as to bring the inclined angle between the light and the near-horizon star in the neighborhood of 90°. If the angle between the light and the near-zenith star is observed when the inclined angle is exactly 90°, a special solution is made, as demonstrated in Case I.

The solution of the problem in Case I is unique in that no prior knowledge of the vessel's position is required. The line of position, as a section of a great circle, is found definitely without any reference to a dead reckoning or assumed position, and the latter are not required for azimuth determination.

If the light is on a buoy, correction for dip and refraction is applied to the observed angle between the lighted buoy and the near-zenith star. Referring to Case I, the inclined angle between the near-horizon star and the point in the horizon vertically above the lighted buoy is 90° when the angle between the star and lighted buoy is observed as 90° increased by the inclined component of the dip.

Case I.— A *LINE OF POSITION* at sea may be found from the following elements:

1. The angle between a near-zenith star

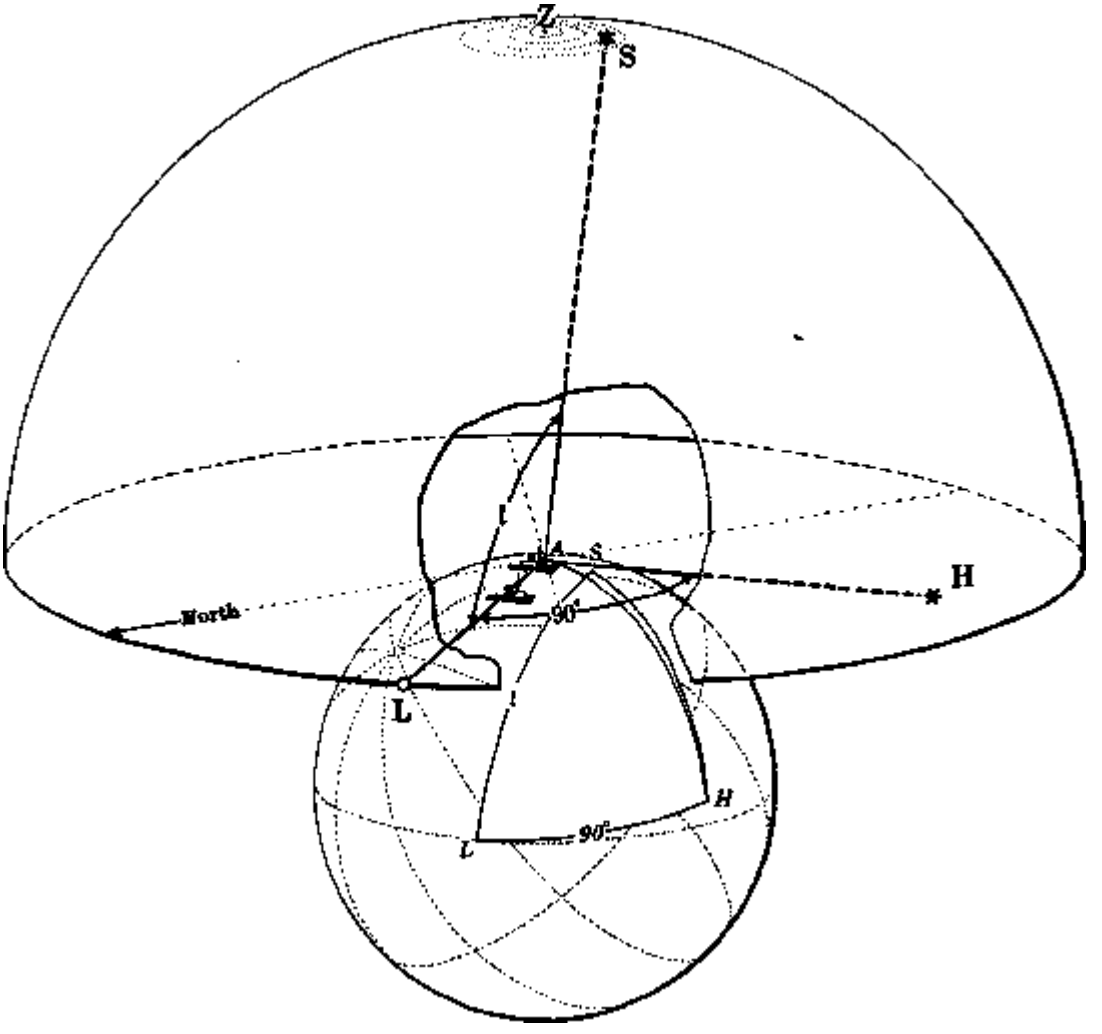


Figure 1. Using a light and two stars for position finding at sea. A point L in the horizon is created by a light placed on a distant vessel. The angle Z between L and a near-zenith star S is observed when the light appears 90° angularly distant from a near-horizon star H. The zenith Z of the observer A is also 90° distant from L; and the great circle passing through A and the terrestrial position *H* at the time of observation is a line of position.

and a light placed so as to appear in the plane of the horizon of the observer, the angle being taken when the light appears 90° angularly distant from a near-horizon star.

2. The time of observation.

In making the observation, it is proposed that two vessels steam abreast of one another in the same direction approximately away or toward the near-horizon star selected for the sight. (See Figure 1.)

The speed of the observer's vessel is varied to bring or keep the light 90° angularly distant from the near-horizon star; at the occurrence of this event, the angle between the near-zenith star and the light is observed, and the time is noted.

It may be found desirable to take a series of sights and use the mean as a single observation; however, it should be noted that the angle between a light and a star is one between two definite points. If taken during calm weather, with a precise sextant, a single observation will probably furnish the degree of accuracy desired.

The spherical triangles and line of position used in the discussion of Case I are shown projected on the plane of the horizon in Figure 2. The parts of the triangles and line are lettered and defined as follows:

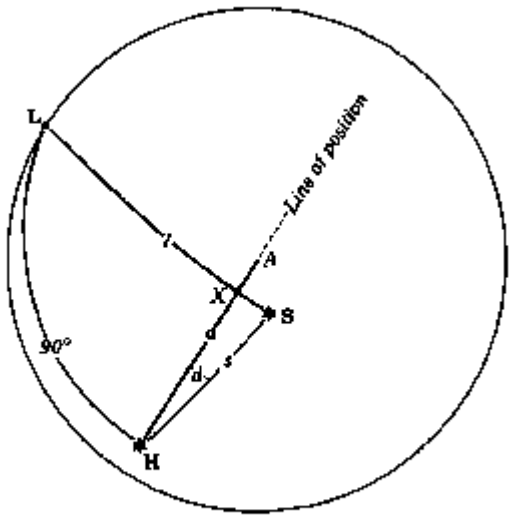


Figure 2.

S, the near-zenith star.
H, the near-horizon star.
L, the light projected on the celestial horizon.
l, the measure of the angle between the star S and the light.
s, the angular distance between the stars S and H.
AH, the great circle having its pole at L; it passes through the star H and the zenith, and is a *LINE OF POSITION* .
a the approximate zenith distance of the star H, estimated or obtained roughly by bubble sextant.
A, a point in the line of position distant *a* from the star H.
d, the difference in azimuth between the azimuth of H to S- (azHS) and the azimuth of H to A (azHA).

The angular distance s and the azimuth azHS are computed from

the celestial coordinates of the stars H and S. These computations may he made in advance of the observations and the computed elements may be used in connection with sights repeated on successive nights.

The angle d is computed from known elements in the spherical triangle HXS. The arcs intersecting at X form right angles, and XS = $l \sim 90^{\circ}$. Therefore,

$$\csc d = \frac{\sec l}{\csc s} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (1)$$

$$azHA = azHS \sim d \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (2)$$

Projecting the celestial position of the star H on the terrestrial sphere for the time of observation, the position A, distant a and in direction azHA from H, is found from the latitude and longitude of H; also the azimuth of A to H (azAH) is found. This establishes a section of the line of position in the proximity of the observer. The formulas required are derived below.

In Figure 3, the star H and the point A (which is in the line of position and near the zenith) are shown projected on the horizon in relation to the pole P. The arc p (AY) is drawn perpendicular to the meridian of H. The arc K is the angular distance from the equinoctial to Y. The angle tAH is the difference in longitude between A and H, (Long. A ~ Long. H)

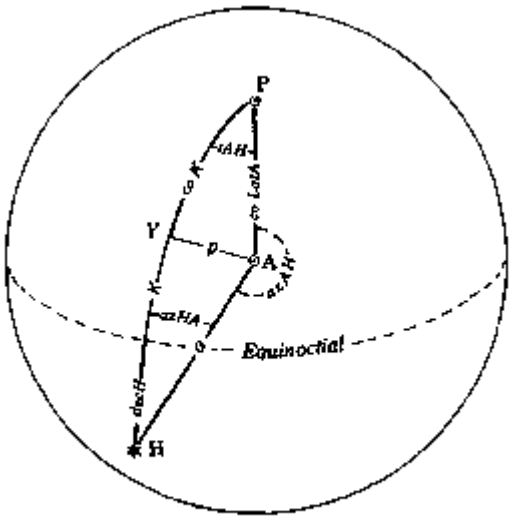


Figure 3

In the right spherical triangle HYA,

$$\csc p = \csc a \;\; \csc azHA \quad . \; . \; . \; . \; . \; . \; . \; . \; (3)$$

$$\sec (K \sim decH) = \frac{\sec a}{\sec p} \quad . \; . \; . \; . \; . \; . \; . \; . \; (4)$$

In the right spherical triangle PYA,

$$\csc Lat. A = \sec p \csc K \quad . \; . \; . \; . \; . \; . \; . \; (5)$$

$$\csc tAH = \frac{\csc p}{\sec Lat. A} \quad . \; . \; . \; . \; . \; . \; . \; . \; (6)$$

In the spherical triangle PAH

$$\csc azAH = \frac{\sec decH \csc tAH}{\csc a} \quad . \; . \; . \; . \; . \; (7)$$

Establishing the line of position at A may he considered a problem in great circle sailing: the initial position and course are given, and the position and course at a given distance from the initial position are found.

Problem 1.—At $23^h\ 50^m\ 02^s$ GCT on August 13, 1935, the star Vega was observed 94° 21' from a light appearing in the plane of the horizon; also at that time the light was 90° to the right of the star Antares. The approximate zenith distance of the star Antares by bubble sextant was 74°.

Preliminary computations to determine s and azHS, using method by Agston:

R.A.H.	16^h	25^m	$26^s.9$	Antares (near horizon star)			decH	26°	17:6	(S)	
R.A.S.	18	34	47.3	Vega (near-zenith star)			decS	38	43.5	(N)	
tSH	2	09	18.4								
tSH	32°	19:6	A	27185							
decS	38	43.5	B	+ 10792	A	20371					
			A	37967	B	− 4153	B	4153	A	37967	
k	43	30.0	. . . . .		A	16218					
decH	26	17.6									
k ~ decH	69	47.6	. . . . .				B	+ 46167			
s	71	42.3	. . . . .				B	50320	A	− 2253	
azHS	26	03.9	. . . . .						A	35714	

Solution of problem 1, using formulas 1 to 7:

Date August 13, 1935											
GST		$23^h\ 50^m\ 02^s$			t	94°	21'	B	112005		
Sid T 0 GCT	21	22	00.8		s	71	42.3	A	− 3853		
		3	54.9		d	4	34.9	A	109752		
GST	21	15	57.7								
R.A.H.	16	25	28.9	azHS ~	26	03.9					
LongH	4	50	28.8	azHA	21	29.0					
LongH	72° 3712										
a	74°	00'	A	1716	B	55966					
azHA	21	29.0	A	+ 43624							
			A	45340	B	− 2873	B	2873	A	45340	
K ~ decH	72	52.4	. . . . .		B	53093					
decH	26	17.6	. . . . .								B 4742
K	46	34.8	. . . . .				A	+ 13867			
*Lat A	42°	49.8	. . . . .				A	16760	B	− 13482	
tAH	28	41.3	. . . . .						A	31673	A + 31673
											36615
Long H ~ 72	37.8										
*Long A	43°	5519									
a	74	00	. . . . .								A − 1716
*azAH	153°	24'	. . . . .								A 34899

* Line of position sought.

The line of position may be determined in the following different manner: Compute the azimuth at the near-horizon star to a dead reckoning or assumed position near the observer and compare this azimuth with the azimuth of the line of position (formulas 1 and 2). The difference between the two azimuths in minutes multiplied by the sine of the estimated zenith distance of the near-horizon star will give the distance in nautical miles between the assumed or dead reckoning position and the line of position. The distance is applied in a direction either away or toward the light as would be indicated by a simple sketch of the two azimuth lines drawn in relation to each other and with respect to the direction of the light from the observer.

Case II.-- A *POINT OF POSITION* at sea may be found from the elements enumerated in Case I together with the following additional elements, all simultaneously observed:

1. The angle between the near-zenith star and a second light appearing in the plane of the horizon.

2. The horizontal angle between the two lights.

The second light would be placed on a third vessel steaming ahead or astern of the observer's vessel, all three vessels proceeding in the same direction.

The spherical triangles used in the discussion of Case II are shown projected on the plane of the horizon in Figure 4. The parts of the triangles are lettered and defined as follows:

S, H, L, l, and s, as defined in connection with Case I.

R, the second light projected on the celestial horizon.

m, the horizontal angle between the two lights.

r, the measure of the angle between the star S and the second light.

Z, the zenith or position of the observer.

z, (ZX~XH), the zenith distance of H.

θ, the measure of the arc ZX.

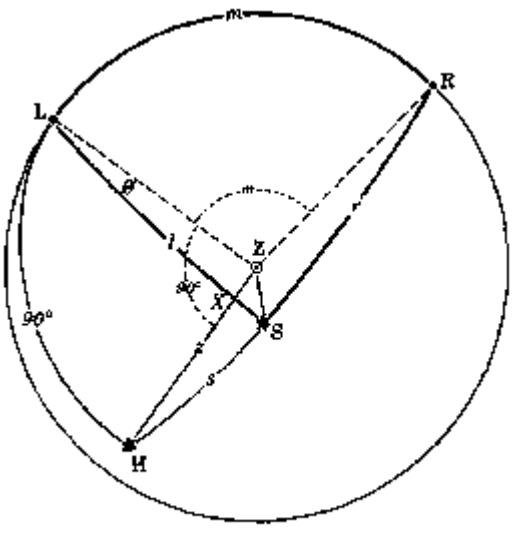


Figure 4

In the spherical triangle IRS, the three sides l, m, and r are known, and the angle at L is equal to 90° ~ θ or 90° ~ ZX. The arc ZX is expressed in terms of l, m and r as follows:

$$\csc ZX = \frac{\sec (r + V)}{\csc l \ \csc m \ \sec V}$$

in which V is found from

$$\cot V = \frac{\sec l \ \sec m}{\csc r} \quad . \ . \ . \ . \ . \ (8)$$

In the right spherical triangle HXS

$$\sec XH = \frac{\sec s}{\csc l} \quad . \ . \ . \ . \ . \ . \ . \ . \ (9)$$

$$z = ZX \sim XH \quad . \ . \ . \ . \ . \ . \ . \ . \ (10)$$

The azimuth at H to Z (azHZ) is found as azHA is found from formulas 1 and 2.

The latitude and longitude of the observer (Z) are found from formulas 3, 4, 5 and 6, which are made applicable by writing z for a, azHZ for azHA, tZH for tAH, and Lat. Z for Lat. A.

Problem 2.-- In addition to the observations made in problem 1, the star Vega was observed 91° 30' from a second light appearing in the plane of the horizon; and the lights were observed 99° 24' apart, the sec-light being to the right of the first.

Solution of problem 2, using formulas 8 to 10 and 3 to 6:

s	71°	42.5	. . . . .				B	50319		
l	94	21	B	112005	A	125	A	- 125		
m	99	24	B	+ 78694	A	+ 587				
				190699						
r	91	30	A	- 15						
V		42.6	cot	1.90684	B	+ 3				
r + V	92	12.6	B	141364						
			B	- 716	B	715				
ZX	8	14.8	A	140649						
XH ~	71	39.0					B	50194		
z	73	53.8	A	1738	B	55694				
azHZ	21	29.0	A	+ 45624						
			A	45862	B	- 2870	B	2870	A	45862
K~decH	72	45.8	. . . . .		B	52824				
decH ~	26	17.6								
K	46	28.2	. . . . .				A	+ 13966		
*LatZ	42	44.2	. . . . .				A	16836	B	- 13403
tZH	28	37.5	. . . . .						A	31959
LongH ~	72	37.2								
*LongZ	43	59.7								

* Position sought

Case III.— A *LINE OF POSITION* at sea may be found from the following elements:

1. The near-vertical angle between a near-zenith star and a light appearing in the plane of the horizon of the observer.
2. The observed azimuth to the light.
3. The time of observation.

It is necessary that the star be very close to the zenith (within about 1-1/2°) if merely an approximate azimuth, as by compass, is observed. A star having a declination within about 1° of the dead reckoning latitude is selected. The time of observation is planned to approximate the star's meridian passage, the predicted GST of which is the sum of the right ascension of the star and the longitude of the dead reckoning.

If the star is more than 1-1/2° from the zenith, an astronomically observed azimuth to the light is employed. It is assumed that a near-horizon star (less than 25° in altitude) is available, and that the position of the observer's vessel with respect to the light is such as to cause the angle between the light and the near-horizon star to be in the neighborhood of 90°. The azimuth to the light is derived from the formula:

$$azZL = azZH \sim \sec^{-1}\left(\frac{\sec i}{\sec h}\right) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (11)$$

in which azZL is the azimuth to the light; azZH, the azimuth to the near horizon star obtained from azimuth tables; i, the inclined angle between the light (appearing in the plane of the horizon) and the near-horizon star; and h the bubble sextant altitude of the near-horizon star.

The member of equation 11 expressed as $\sec^{-1}\left(\frac{\sec i}{\sec h}\right)$ is the difference in azimuth between the light and the near-horizon star, and is otherwise expressed by the formula:

$$\sec C = \frac{\sec i}{\sec h} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (11a)$$

in which C is the difference in azimuth. Referring to Figure 9, if L represents the light in the plane of the horizon LE, and H, the near-horizon star, it will be seen that C, i, and h are the sides of the right spherical triangle LEH. A discrepancy of about 20 minutes in observing h will produce an error of less than 1 minute in C, when i is between 85° and 95°, and h is not greater than 25°.

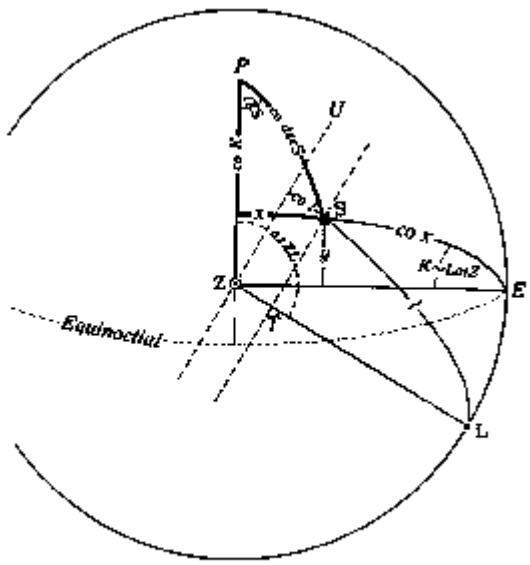


Figure 5.

In Figure 5 the zenith Z, a near-zenith star S, a light in the plane of observer's horizon projected on the celestial horizon at L, the meridian PZ, the prime vertical ZE, the measure of the angle t between the star and the light, etc., are shown projected on the plane of the horizon.

The arc x from S is drawn perpendicular to PZ, and the arc y from S is drawn perpendicular to ZE.

TS is the small circle distant t from L, and ZU is the great circle line of position having its pole at L. The two circles projected on the plane of the horizon are parallel lines perpendicular to ZL.

$$\csc x = \sec \text{decS} \csc \text{tZS} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (12)$$

$$\csc K = \frac{\csc \text{decS}}{\sec x} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (13)$$

$$\csc y = \csc (K \sim \text{LatZ}) \sec x \quad . \; . \; . \; . \; . \; . \; . \quad (14)$$

The linear distances between the two parallel lines TS and ZU, between S and the plane PZ, and between S and the plane ZE, are respectively cos t , sin x, and sin y; the radius of the earth being considered as unity which constant disappears in the formula:

$$\cos t = \sin x \sin \text{azZL} \sim \sin y \cos \text{azZL} \quad . \; . \; (15)$$

By calculating a hypothetical angle t based on the dead reckoning latitude and longitude, the observed azimuth, and the time of observation, the distance between the dead reckoning position and the line of position is found by taking the difference between the calculated angle t and the observed angle t . The distance is applied from the dead reckoning position in a direction toward the light when the observed angle is greater than the calculated angle and in an opposite direction when the observed angle is less than the calculated angle.

Problem 3.-- Assume the terrestrial coordinates of a near-zenith star (S) to be 40° N., in latitude (declination) and 30° W., in longitude at the time of observing the near vertical angle 88° 55' between the star and a light appearing in the plane of observer's horizon; the azimuth 120° from the observer to the light; and the dead reckoning position (A) being latitude 41° N., and longitude 31° W.

Solution of problem 3, using formulas 12, 13, 14 and 15:

decS	40°	00'	B	11575	A	19193						
tAS	1	00	A + 175814									
x	0	46	A	187389	B	- 4	B	4	A	187389		
K	40	00	. . . . .		A	19169						
Lat A	41	00										
K — Lat A	1	00	. . . . .				A + 175814					
y	1	00	. . . . .				A	175818			A	175814
azZL	120°	00	. . . . .						A	+ 6247	B	+ 30108
										1.93836		
sin x sin azZL			.01158	. . . . .				Log	8.06364			
												2.05917
sin y cos azZL			.00873	. . . . .							Log	7.94083

calculated t 88° 50' cos.02031

observed t 88 55

5 miles from dead reckoning position toward light.

The problem may be solved graphically in the following simple manner: Plot the dead reckoning position A and the geographic position S of the star for the time of observation, using a polyconic projection of suitable scale as in Figure 6. Draw the line AL 120° in azimuth from A. Through S draw ST perpendicular to AL. Establish the point U in AL by making it 90° 00' - 88° 55' (65 miles) distant from T. The line UZ, through U and perpendicular to AL, is the required line of position.

Scaling the distance AT in Figure 6, it is found to be 1° 10' and this corresponds with the complement of the calculated angle t (90° 00' - 88° 50') hypothetically observed at A. Also the distance between A and the line of position UZ as scaled corresponds to the computed distance.

Referring to Figure 6, ZU' is a line of position resulting from assumed observations made simultaneously with those of problem 3, as follows: (1) near-vertical angle 90° 39' between the star S and a second light appearing in the plane of the horizon; (2) horizontal angle 105° between the first and second lights, the latter being to the left of the first light. The intersection of the two lines of position establishes the point of position at Z.

A linear scale with degree and minute marks, graduated from 90° in both directions may be used in the simple manner indicated in Figure 6, for laying down the distances TU and T'U'.

Graphical representations or sketches should be made in connection with all light-star sights to serve as a guide in determining the proper signs to be used in the computations.

Notes on Refraction

The line of sight to a near-zenith star within 10° of the

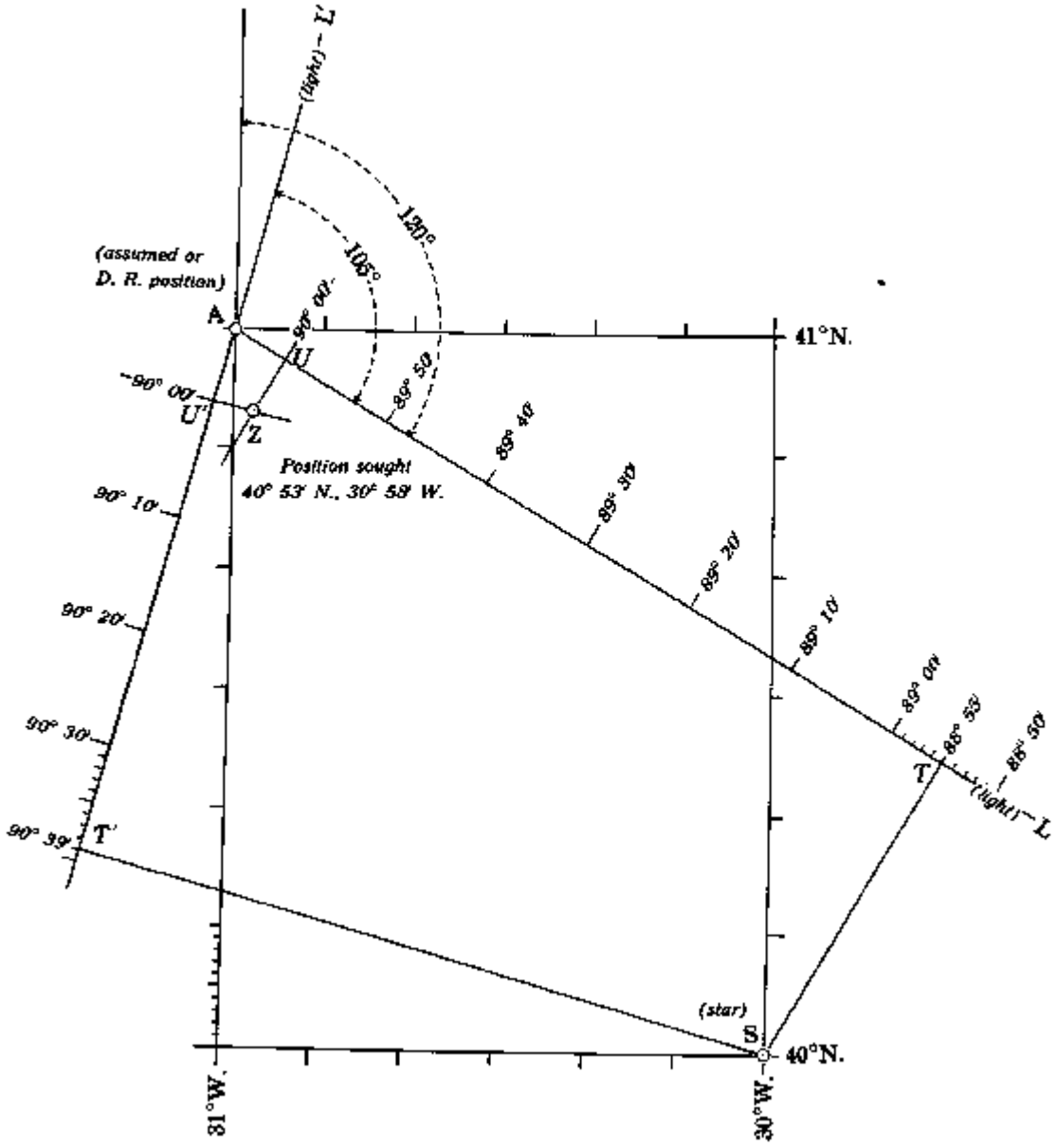

(assumed or
D. R. position)
A
90° 00'
U
90° 00'
U'
Z
Position sought
40° 53' N., 30° 58' W.
90° 10'
90° 20'
90° 30'
90° 39'
T'
L' (light)
120°
105°
89° 50'
89° 40'
89° 30'
89° 20'
89° 10'
89° 00'
88° 53'
88° 50'
T
L (light)
41°N.
(star)
S
40°N.
31°W.
30°W.

Figure 6.

zenith is refracted less than 0.1 minute of arc, and no correction for this refraction is applied.

Referring to Case I, the displacement of the near-horizon star, caused by refraction, is in the vertical plane of the line of position (Figure 2). In other words, no change in the azimuth of the star is occasioned by refraction. Therefore, when the light appears 90° from the visible position of the star, it is also-90° from the true position of the star.

Referring to Case III, formulas 11 and 11a, the displacement of the near-horizon star, caused by refraction, is in the vertical circle passing through the star, and no change in azimuth is occasioned. Therefore, the observed angles i and h, referred to the visible position of the near-horizon star, may be used directly in formula 11a to obtain C.

The formula for mean refraction of a line of sight near sea level and approximating the horizontal is:

$$R = .075\ D \quad \ldots\ldots\ldots\ldots\ldots (16)$$

in which D is the distance in nautical miles between the observer and the object sighted, and R is the angle of refraction formed by the initial direction of the line of sight and the direct line from the observer to the object. This formula is the result of an investigation of formulas given by Bowditch for dip of the sea horizon, dip short of the horizon and distance of visibility of objects. It may be shown that they are based on angles of refraction which closely approximate .075 D.

A light distant D nautical miles from an observer and elevated e feet above sea level is in the true plane of the horizon of the observer when the light is elevated:

$$e + 0.884\ D^2 \text{ feet} \quad \ldots\ldots\ldots\ldots (17)$$

The light is observed to appear in the plane of the horizon when the above elevation (17) is reduced by the refraction element:

$$\sin 1' \cdot R \cdot D \cdot 6080 \text{ or } 0.133\ D^2 \text{ feet} \quad \ldots\ldots (18)$$

Combining (17) and (18) the formula for the elevation of a light to be observed as appearing in the plane of the horizon is:

$$E = e + \tfrac{3}{4}\ D^2 \quad \ldots\ldots\ldots\ldots\ldots (19)$$

in which E is the height of the light in feet above sea level; e, the height of the observer in feet above sea level; and D, the distance in nautical miles between the observer and the light.

A determination of refraction may be made by two observers reciprocally and simultaneously observing a near-zenith star in angular distance with respect to one another, a light being placed at each observer. In Figure 7, let l and l' represent the angles observed at lights L and L' between a near-zenith star S and the lights L' and L respectively. Assuming that both angles contain the same angle of refraction R, then

$$R = 90^\circ - \frac{l + l'}{2} \quad \ldots\ldots\ldots\ldots (20)$$

The formula for the elevation of a light to be observed as appearing in the plane of the observer, using the angle of refraction R as determined in equation 20, is

$$E = e + 0.884\ D^2 - \sin 1' R \cdot D \cdot 6080$$

$$\text{or}\quad E = e + D\ (0.88\ D - 1.77\ R) \quad \ldots\ldots (21)$$

in which E is the height of the light in feet above sea level; e, the height of the observer in feet above sea level; D, the distance in nautical miles between the observer and the light; and R the angle of refraction in minutes.

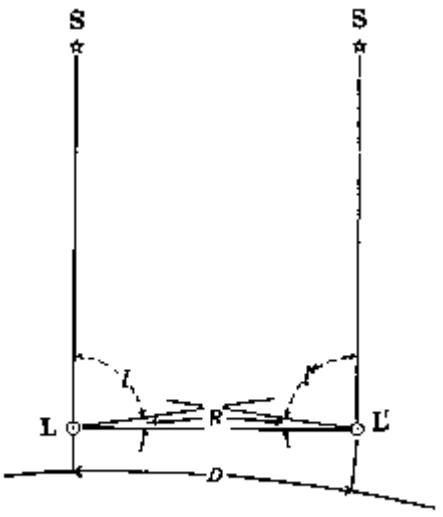


Figure 7.

Simultaneous reciprocal observations may be incorporated in the light-star sights. For example, assume in Case I, that the light and observer in the distant vessel are in the true plane of the horizon of the light and observer in the position-seeking vessel, expressed as follows:

$$E' = e + 0.88\ D^2 \quad \ldots\ldots (22)$$

in which E' is the elevation in feet of the light and observer in the distant vessel; e, the elevation in feet of the light and observer in the position-seeking vessel; and D, the distance in nautical miles between the two vessels. Then the near-vertical angle corrected for refraction is:

$$\frac{180^\circ + l - l'}{2}$$

in which. l and l' are the simultaneous reciprocally near-vertical angles observed respectively in the position-seeking and distant vessels.

In the above modification of Case I, that is, placing the distant light in the true plane of the horizon, the initial direction of the line of sight to the light is not in the plane but is inclined slightly above it in the amount of the refraction. Theoretically, an angle less than 90° between the light and the near-horizon star will establish L (Figure 2) as the pole of the line of position. This, however, is an unnecessary refinement, and 90° instead of the theoretical angle will establish the line of position with sufficient accuracy through the near-horizon star.

Notes on Dip

The preceding discussions dealt with a light in the plane of the horizon or with the initial direction of the line of sight in that plane. Consider now that a lighted buoy is used instead of an

elevated light and that observations are made after the vessel steams a known distance away from the buoy.

By applying correction for dip and refraction, as in an altitude sight, a near vertical angle between the lighted buoy and a star is referred to a point in the plane of the horizon vertically above the lighted buoy. Correction for inclination to the vertical need not be considered, since the greatest error from this source would be less than 2% of the dip with the star within 10° of the zenith.

Referring to Case I, the angle between the lighted buoy and near-horizon star that would establish L (the projection on the celestial horizon of the point in the plane of the horizon vertically above the lighted buoy) as the pole of the line of position through the star H (Figure 2) is:

$$90° + d \sin h \qquad (23)$$

in which d is the dip and h the estimated altitude of the star H.

Referring to Case III, formula 11, the correction to the observed inclined angle between the lighted buoy and the near-horizon star, considered as the inclined component of dip, is:

$$- \frac{d \sin h}{\sin i} \qquad (24)$$

in which d is the dip in minutes; h, the altitude of the star by bubble sextant and i, the inclined angle as observed. The corrected inclined angle thus obtained is used as i in formula 11 and is the inclined angle referred to a point in the plane of the horizon vertically above the lighted buoy.

In formula 24, $\frac{\sin h}{\sin i}$ may be considered as a percentage of the dip, and this percentage may be obtained by inspection from graphs in Figure 8 for a given inclined angle (i) and altitude (h).

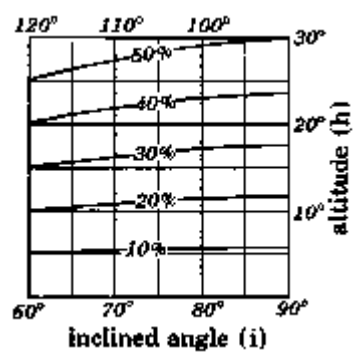


Figure 8.

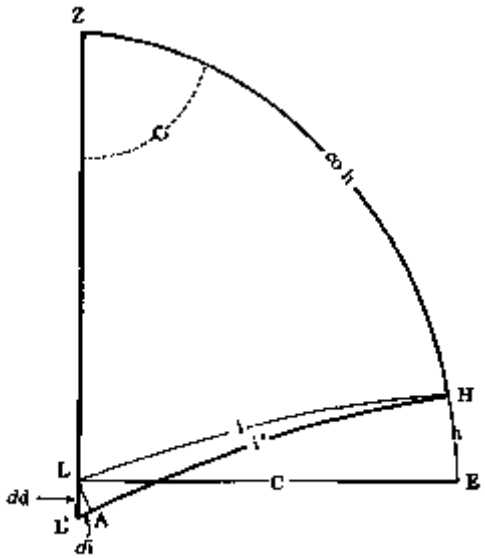


Figure 9.

Derivation of Formulas 23 and 24.-- In Figure 9, let LE represent the plane of the horizon; Z, the zenith; H, a near-horizon star, the altitude of which is h; L', a light, the dip of which is d or LL'; L, the point in the plane of the horizon vertically above the light; i', the inclined angle between the light and the star, and i, the corresponding inclined angle corrected for dip. The dip correction for the inclined angle is represented by L'A, (i' - i).

The ratio of the inclined component of the dip with respect to the vertical dip is considered equivalent to the ratio of the corresponding differentials.

In the spherical triangle ZHL',

$$\frac{di}{dd} = \cos ZLH = \sin HLE = \frac{\sin h}{\sin i}$$

$$\text{therefore,} \quad di = \frac{\sin h \, dd}{\sin i}$$

Substituting increments for differentials,

Inclined component of dip $\frac{d \sin h}{\sin i}$

When the inclined angle is 90°, the component reduces to

d sin h.

HARNESSING EARTH'S FORCES WITH PWA FUNDS

Otis W. Swainson, Hydrographic and Geodetic Engineer
Assistant Chief, Division of Terrestrial Magnetism and Seismology
U. S. Coast and Geodetic Survey

Did you ever have the satisfaction and worry of spending a bonus or other unexpected small sum of money? There were so many things you needed, such as a new automobile or fur coat for your wife. However, the money had to be spread out to replace the worn-out carpet, the shiny suit of clothes, and to modernize the kitchen.

Such was the case with a PWA grant of $29,500 made to the Division of Terrestrial Magnetism and Seismology. A non-magnetic ship, new quarters and houses for the observatories, and additional personnel were needed. These, of course, could not be secured but many repairs and improvements to the magnetic observatories, and new equipment for some of the seismological stations were gratefully made possible.

The allotment was divided as follows: Cheltenham, Maryland, $10,000; Tucson, Arizona, $8,500; Bozeman, Montana, $2,000; Chicago, Illinois, $2,000; and California, $7,000.

In the drought of 1930 the surface well which was the only water supply for the Cheltenham Magnetic Observatory went dry. Anyone who has tasted this well water would say the drought was a blessing. However, it left the observatory without fire protection and without water needed in the processing of the records. Later another well was dug to avoid the repetition of this serious occurrence. It was dug at a lower elevation on the grounds, and while water was obtained, it was contaminated by seepage from nearby hog-pens on adjacent property.

The PWA grant made it possible to drill an artesian well to a depth of 392 feet. An electric pump, pressure tank, and automatic pressure regulator were installed. The well provides good water for domestic use and an ample supply for the observatory and fire protection.

The only known non-magnetic stove in the United States is used at Cheltenham. Heretofore it has consisted of a "barrel" stove made of sheet copper and brick-lined. The copper never lasted very long. With a portion of the PWA funds a new stove was designed and ordered. It is similar to the stoves commonly seen in country stores and around which the "old timers" would sit, reared back on the two hind legs of their chairs, discussing politics and settling all the controversies in the universe. The new non-magnetic stove was cast of special bronze which has a melting point equal to that of cast iron. Brass polish instead of stove blackening will be necessary to keep it shining. A similar stove is used at the magnetic observatory at Agincourt, Canada.

Many valuable instruments were kept in the small wooden storehouse at Cheltenham. The danger of fire had been a worry for many years. A new brick fireproof storehouse was constructed with the PWA funds.

Termites had been causing serious trouble. Several years ago the thick insulated walls of the building used for absolute obser-

vations at Cheltenham were found to be nothing but sieves. The termites had bored millions of air passages, thus completely destroying the insulation and weakening the structure. The lower portion of the building was removed and rebuilt. It was made termite proof by carrying the concrete foundation eight inches above the ground and inserting between the top of the foundation and the building a copper sheet extending three inches beyond the sides of the foundation and at a downward angle of 45 degrees. It is believed that the termites will be unable to travel up over this copper strip. They are still active in the vicinity. Recently they demolished a nearby electric power pole. The PWA funds permitted the termite proofing of the remaining buildings at Cheltenham.

At Tucson an inspection of the building housing the variation measurement instruments was made by removing the sawdust insulation and some of the foundation. The building was found to be in such bad condition from termites and dry rot that the cost required for repairing was not warranted. The balance of the funds allotted to Tucson was used to excavate and build the foundation for a new building. All sand and gravel for the concrete had to be tested to be sure it was non-magnetic. It is not easy to find absolutely non-magnetic concrete material.

A new office building and a fence to enclose the entire grounds were built. New office furniture and equipment were secured. Fortunately this furniture did not have to be without screws, nails, and tacks as it must be at Cheltenham where the piers for absolute observation instruments are in the same building as the office.

New seismometers were purchased to modernize the stations maintained in cooperation with the University of Chicago, Chicago, Illinois, and Montana State College at Bozeman, Montana. These seismometers are of the improved Milne-Shaw type.

The seismometer at Chicago is on a pier 60 feet high standing in a pit. The top of the pier moves slightly with a change in temperature. This tilt caused the recording light beam to move off the paper. The new seismometer will automatically compensate for the tilt.

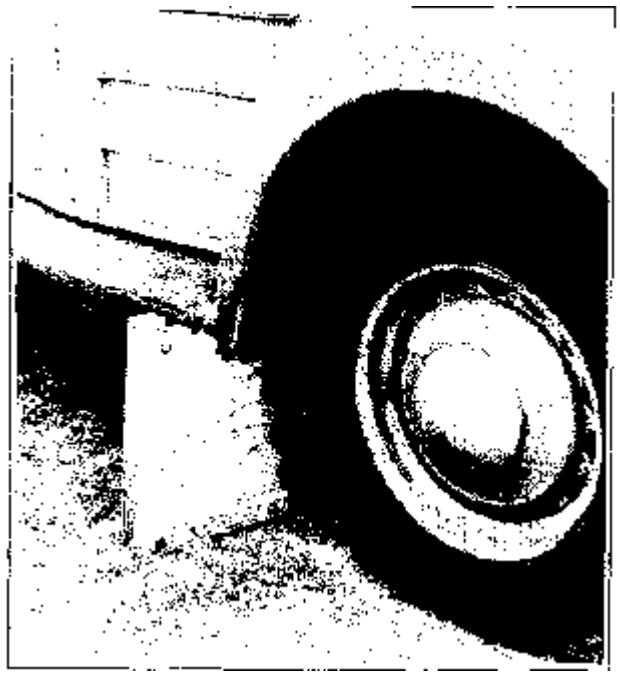
With the funds allotted for use in California a new, improved and larger shaking machine was built to induce vibrations in the ground or buildings in order to determine the dominant vibration periods. A knowledge of these natural vibration periods is of assistance to the architect and engineer in designing structures to withstand earthquakes. This machine weighs about 500 pounds but will produce 6,000 pounds of vibration force. Unless care is used, the plaster in some types of buildings might be cracked by the induced vibrations.

In addition to the improvements and purchases mentioned, the $29,500 will secure three trucks for the California seismological field survey and one each for Tucson and Cheltenham Observatories; also recording apparatus, and a number of minor instruments and modernizing parts.

The PWA grant to the Division of Terrestrial Magnetism and Seismology will serve innumerable scientific and engineering activities and organizations. It may be the means of saving thousands of lives and millions of dollars' worth of property.

PLANE TABLE OH TRUCK

In surveying Columbia Basin flat lands the Reclamation Bureau engineers have found usefulness in mounting a plane table on the roof of the station wagon that transports the survey party. The survey party is a part of the Grand Coulee project. The editor is indebted to F. A. Banks, Construction Engineer, Coulee Dam, Wash., for the illustrations.



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FATHOMETER DIAL SPEED REGULATION

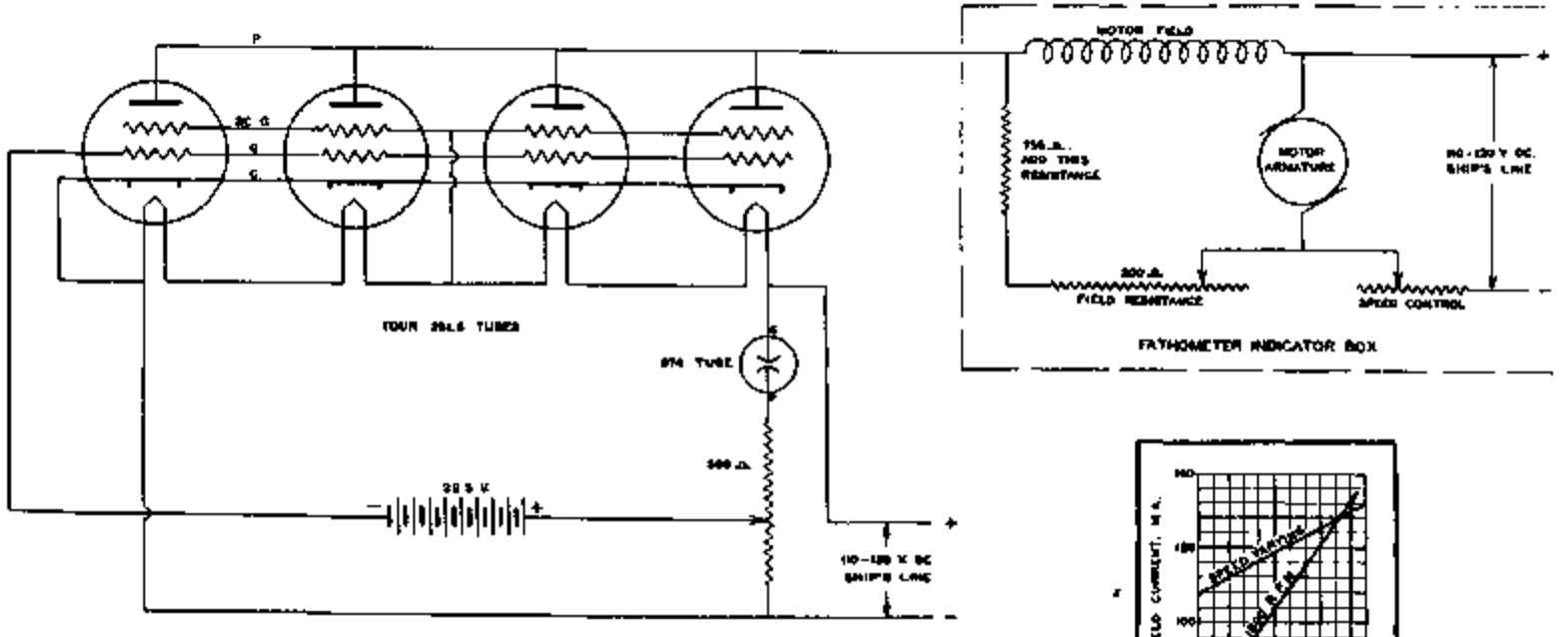
F. H. Hardy, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Maintenance of constant dial speed, which is so essential for accurate Fathometer soundings, has been a problem on the Ship GUIDE. The original governor, with which the 312 Type Fathometer is equipped gave unsatisfactory service and was removed on advice from the Washington office. While the mechanical governor of the turbogenerator provides for major voltage changes, apparently there is a small lag in time, and minor voltage fluctuations appreciably affecting the motor speed are frequent. Pitching and rolling of the ship also appear to affect the voltage, even though all jets of the turbine are open. Despite a readjustment of the governor, these variations could not be controlled and consequently, it was necessary to maintain a continuous manual adjustment of the Fathometer rheostat, a laborious procedure which considerably distracts the operator from close observance of the depths being recorded.

To avoid this necessity, several methods were tried to maintain automatically the Fathometer motor at the proper speed of 1800 r.p.m. (Type 312 Fathometer). First, a graph was drawn, illustrated in the insert on Figure 1, showing the variations that must be made to the motor field current for changes in the ship's line voltage. It was found that this could be secured by a system of thermionic tubes, with a resistance of 750-ohms added in the motor field circuit (Figure 1). The circuit was mounted as an isolated unit except for the 750-ohm resistance. This proved to be effective in balancing the small changes in the line voltage but it made no provision for the mechanical changes, such as friction, torque, and inertia, which were found to affect the dial speed considerably.

Regulation by tuning fork was then investigated. While there are several methods of synchronizing motor and fork speeds, the circuit shown in Figure 2 offers extreme simplicity combined with a minimum addition of apparatus. The 60-cycle tuning fork from an obsolete Sonic Depth-finder was connected to the Fathometer motor as indicated in the diagram, and only a 200-ohm resistance in the field circuit and the slip rings constructed from the former Fathometer governor were added. The installation was exceedingly simple; provided for the mechanical variations; and gave good regulation under normal voltage changes; but was not as positive as the method finally adopted.

This method was evolved by utilizing the fork-controlled motor from the Sonic Depth-finder. The motor was connected exactly as originally used for maintaining a constant turntable speed (see insert diagram, Figure 3). This arrangement held the motor at its speed of 1800 r.p.m. for variations in line voltage up to approximately five volts. The large size of the motor (3/4 H.P. with 500 V.A. 60-cycle collector rings), however, prevented its substitution for the regular Fathometer motor. Accordingly, rather than purchase a new alternating current motor, chopper slip-rings were added to the converter. This will be explained in a subsequent paragraph. The circuit did not prove entirely satisfactory since it provided no regulation for the larger voltage fluctuations which occurred with line overload. These fluctuations were especially troublesome when the wire sounding machine was being used for obtaining comparisons between vertical casts and Fathometer soundings. The load on the fork contacts also caused sparking which shortened their period of serviceability and also caused considerable interference to radio reception.



SPEED REGULATION
WITH
THERMIONIC TUBES

Figure I

After some experimenting with the apparatus on hand the circuit with the buffer unit shown in Figure 3 was adopted as the most suitable. This circuit gave positive control for line voltage variations up to approximately ten volts, which is seldom exceeded.

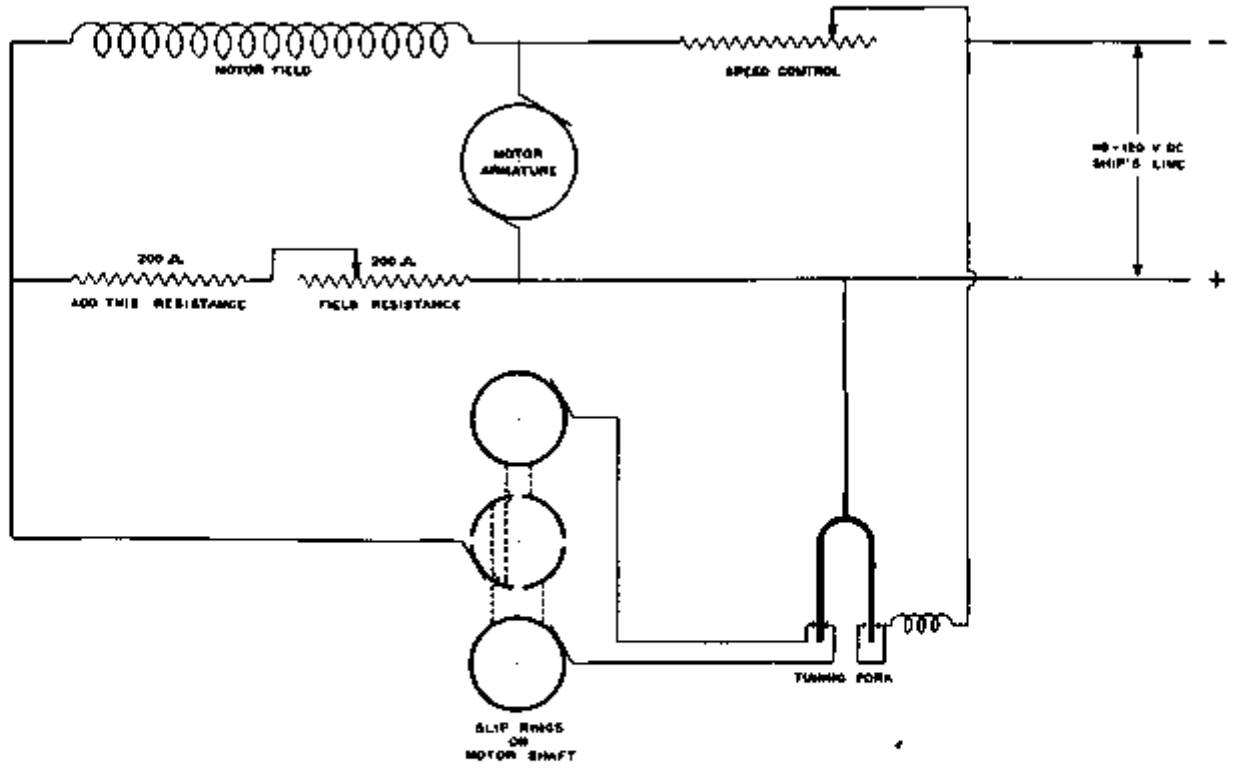
A slight change in the tuning fork unit was made and the condensers changed to proper capacity to resonate at 60 cycles. The amplitude of the fork was reduced by the 500-ohm resistance in series with the driving coil, and a 10-watt tungsten filament lamp was substituted for the 5-watt carbon one previously used. The 100-watt carbon filament lamp formerly used in the motor field circuit was replaced by a 25-watt tungsten filament lamp.

The buffer unit which relieves the load on the fork contacts is composed of two transformers and two electronic tubes, either type 2A3 or FG-17 (Thyratron), and can be mounted in a container.

Since the present Fathometer is equipped with a D. C. motor with 30-cycle collector rings for tachometer indication of speed, it was necessary to reduce the controlled 60-cycle A. C. to this frequency. This was accomplished by chopper slip-rings attached to the end of the converter shaft (Figure 3). The pulsating 30-cycle A. C. (see insert graph, Figure 3) was then run through a transformer and a 100-watt tungsten lamp to isolate the circuit and to safeguard against short circuits. The addition of a capacitive-inductive reactance (to resonate with transformer at 30 cycles) resulted in a pure sine wave of 30 cycles. This was lead to the Fathometer where it was connected across the 30-cycle terminals (leading to the tachometer) to run the motor as a synchronous 30-cycle A. C. motor. It was necessary to add a suitable resistance in the tachometer circuit to produce sufficient amplitude of vibration of the reeds. A DPDT switch was located near the Fathometer so that regulation could be applied after the Fathometer motor has been started by direct current in the conventional manner. Although direct current is used constantly so as to distribute the load between the D. C. and A. C. brushes, the motor will function normally on alternating current alone when once started.

The chopper unit and reactance can be dispensed with when the present Fathometer D. C. motor is replaced by a synchronous 60-cycle motor. If this is done, it will then be necessary only to plug in at any place on the ship's controlled 60-cycle line.

While this method of speed regulation may not be ideal, it does "fill the bill" on the Ship GUIDE with practically no additional expenditure since the obsolete Sonic Depth-finder apparatus is utilized. It is simple to install, requiring no alterations whatsoever in the electrical circuit of the Fathometer. The reliability of the fork and motor has been established from their performance with the Sonic Depth-finder. Instantaneous inter-second fluctuations in speed are avoided because of the inertia created by the heavy converter armature. This was verified by superimposing the commercial (shore) 60-cycle A. C. upon the converter 30-cycle A. C. wave (3/4 KVA load applied intermittently while testing) simultaneously on the screen of an oscillograph. This inertia is sufficient to maintain the speed should the fork contacts become sufficiently corroded and pitted to cause frequent misfiring. Such a condition would rarely occur in this circuit where the fork contacts are so lightly loaded. Simplicity of design provides a full kilowatt of power controlled with only three tubes. It gives flexibility; the frequency range of the fork may be set, within limits, to suit requirements. Calibration of Fathometers is therefore not



SPEED REGULATION
WITH
TUNING FORK

Figure 2

necessarily confined to 820 fms./sec. such as used on the GUIDE. Calibration of the tachometer can be accurately accomplished on shipboard, thereby obviating the necessity of shipment to the office. A controlled 60-cycle alternating current may have other uses aboard ship. It makes possible the use of standard 60-cycle electric clocks, since compensation of time signal differences can be made by fork adjustment as well as preventing gain or loss in time, thereby assuring an accurate 60-cycle frequency. The RAR chronograph motor may be replaced by a 60-cycle synchronous motor to give constant tape speed. Commercial instruments and timing devices (as oscillograph, beat-frequency oscillators, telechron switching devices, crystal calibration, etc.) which may be required in the future can be used on shipboard without re-design. Also, more than one Fathometer may be controlled from the same source.

The frequency of the tuning fork, although made of a metal with low coefficient of expansion, is affected somewhat by the ambient temperature changes, as well as the variable friction of contact points. The combined error introduced is insignificant as far as speed control of the Fathometer is concerned. Hourly readings in a 24-hour test, with normal temperature changes, gave an error of less than .03 of one per cent, or ± one second per hour. However, should electric clocks on shipboard prove a greater convenience than expected, the error should be decreased by placing the fork in a thermostatically controlled case, and substituting inductive drive for the contacts now used. This would necessitate the addition of two magnetic headpieces or loudspeakers, and an additional tube. Preliminary tests with these additions show the error in time should not exceed plus or minus one second per day. Further test will be made with this method of inductive coupling.

Undoubtedly, in the future, many of the present Fathometer installations will be replaced by modern equipment, incorporating improved speed regulation, graphic recording, super-sonic oscillators, etc. However, the controlled 60-cycle method of speed regulation can be easily adapted to any installations with poor regulation by simply replacing the small indicating motor with a 60-cycle synchronous motor.

LIST OF APPARATUS FOR FORK CONTROLLED CONVERTER.

From obsolete Sonic Depth-finder:

(1) Converter, 3/4 H.P. with 500 VA 60-cycle collector rings.

(2) Rheostat, starting, 2-ohm.

(3) Tuning fork, 60-cycle.

(4) Transformer, Thordarson, 1/2 KVA, Pri. 100 V., Sec. 230 Y., with center taps (shown as T3 on Figure 3).

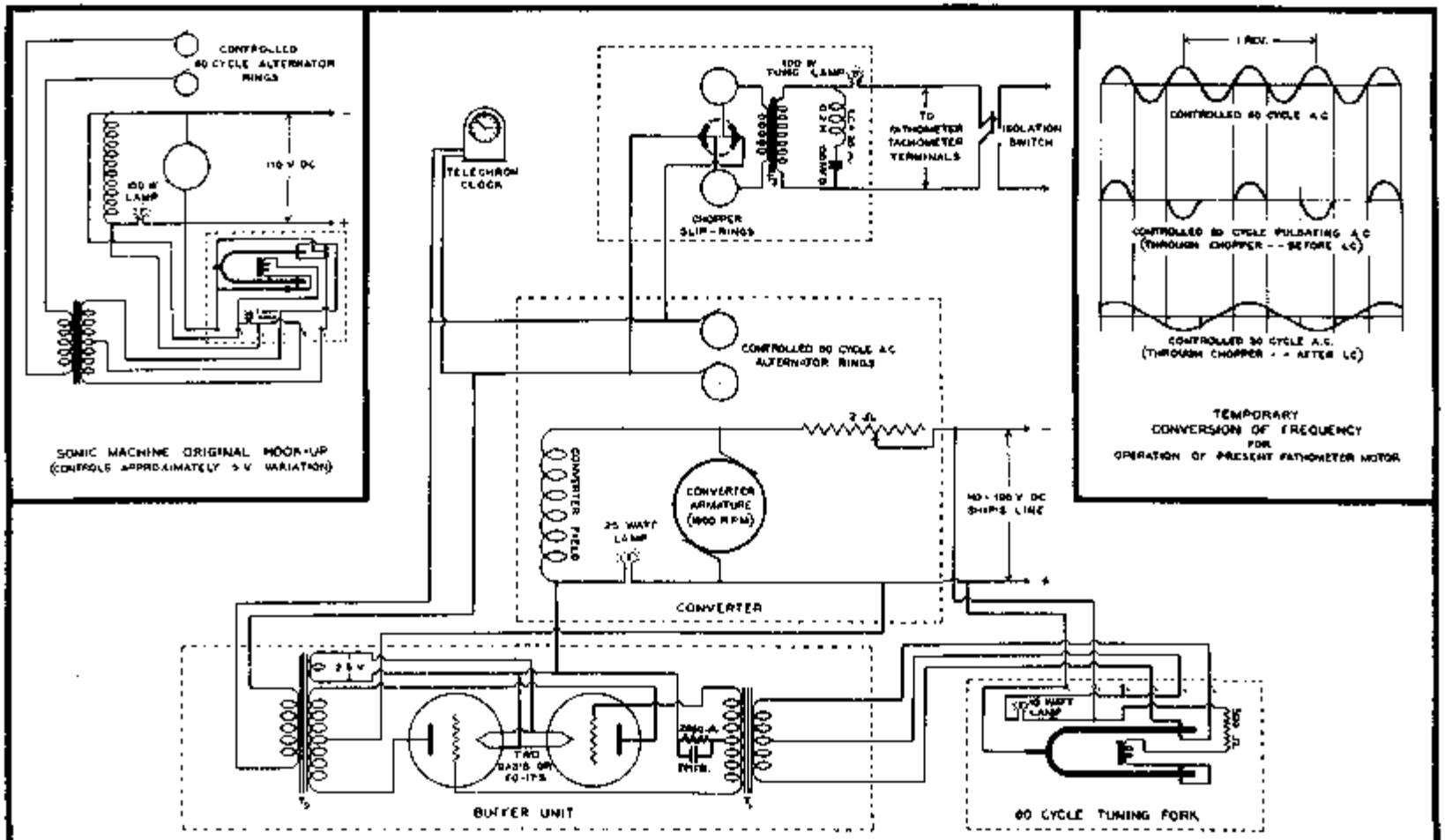
Purchased:

(5) Transformer, Gardiner, No. 2519 P, variable ratio (shown as T1 on Figure 3). Secondary tuned to form pure 60-cycle wave. Primary matches the fork, as well as the plate of additional tube when inductive coupling is substituted for the contacts. . . . . $ 1.25

(6) Transformer, Gardiner, type 5084, low voltage power supply (shown as T2 on Figure 3). Pri. 110 V. and Sec. 250 V. at 1 ampere, with separate 2-1/2 volt 20 amp. filament windings, series operated if the FG 27 tubes are substituted for the FG 17 tubes as a direct converter. . . . . $ 4.00

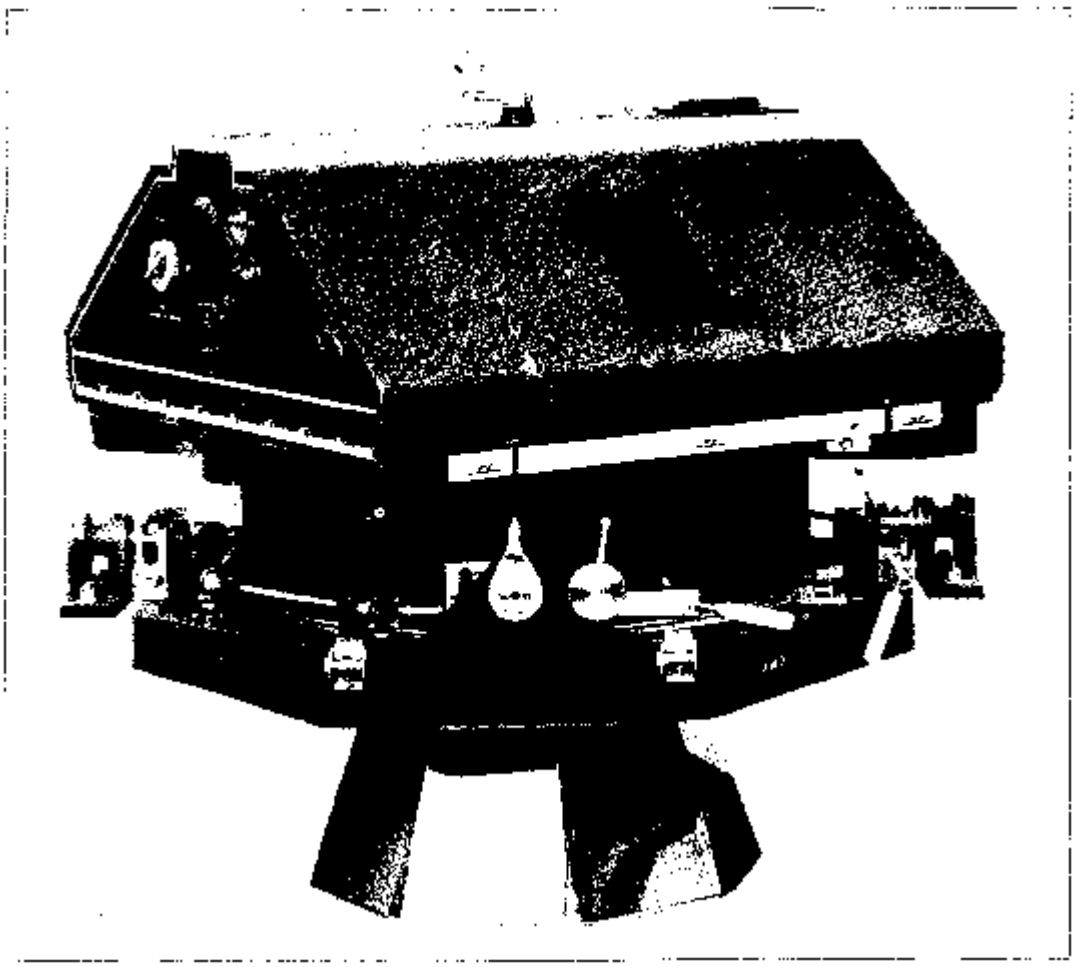
(7) Standard radio stock, resistances, condensers, sockets, wire, switches, etc.....$ 3.40

Total $ 8.65



SPEED REGULATION
BY
FORK CONTROLLED CONVERTER

Figure 3



THE NINE-LENS AIR CAMERA IN USE

B. G. Jones, Cartographic Engineer
U. S. Coast and Geodetic Survey

A discussion of the development of multiple lens cameras, and the general design of the U. S. Coast and Geodetic Survey nine-lens camera are given in detail in the article by Lieutenant Commander O.S. Reading which was published in Field Engineers Bulletin No. 9, December 1935. At that time the camera was in progress of manufacture by the Fairchild Aerial Camera Corporation of New York. The camera and transforming printer were delivered by the manufacturer in September 1935 and January 1936 respectively and the installation of lenses and mirrors and the calibration of the camera and printer were begun immediately in the Washington office under the direction of Lieutenant Commander Reading.

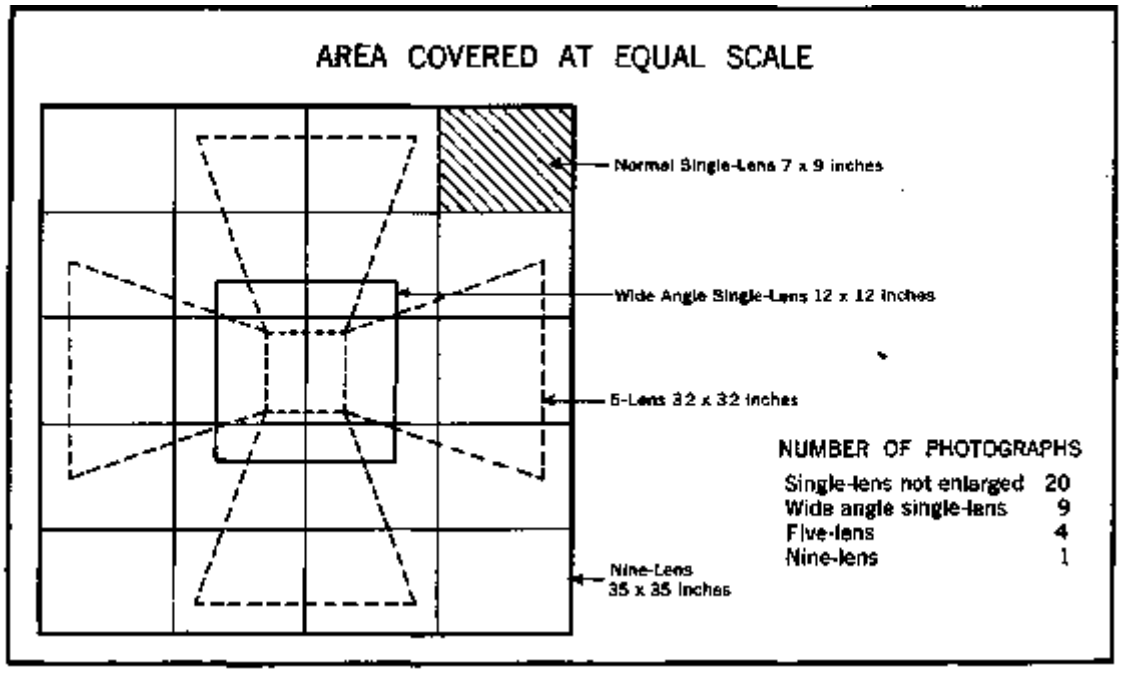
The first test flight of the camera was made at Wright Field, Dayton, Ohio, in November 1936. Minor corrections were made to the vacuum pump, winding motor and clutch, following this test flight, and since then the camera has operated satisfactorily. No further adjustment to the lenses and mirrors has been necessary and only minor adjustments have been made to the vacuum pump and operating mechanism. The adjustment of lenses and mirrors has been checked twice since the original test flight and no change found.

The test flight and subsequent photography were made possible by the U. S. Army Air Corps who provided and equipped a B-10-B Martin Bomber for this purpose. This plane is powered with two 700 H.P. motors, and has a ceiling of 26,000 feet with a speed of 180 to 200 miles per hour at that altitude. The crew consists of a pilot, navigator, and photographer. Since the plane was designed for military use a number of structural changes were necessary in order to mount the camera. In addition, a hoist was installed to lift the camera from its cart into the plane. During the takeoff the camera is located well above the floor level and is protected by a sliding door, being lowered into position after the plane is in the air.

The first mapping project with the nine-lens camera was photographed in May 1937, and covered about 1200 square miles in the northern Chesapeake Bay area. About 50 planimetric maps at a scale of 1:10,000 will be made from these photographs. Surveying operations have been in progress since August 1937, with party headquarters in Baltimore. Additional photography with the nine-lens camera in 1937 included the outer coast of North Carolina from just south of Virginia Beach to Cape Lookout, and the Dismal Swamp Canal from Norfolk to Elizabeth City. In 1938, nine-lens photographs at a scale of 1:10,000 were made of Boston Harbor, Massachusetts; Cape Cod, Massachusetts, and vicinity; and New Haven, Connecticut. A total of 775 nine-lens photographs are now available for coastal surveys.

The Chesapeake Bay project, photographed in May 1937, is illustrative of the practical use of the camera for coastal surveys by graphic methods. The 1200 square miles to be compiled on 50 topographic maps, scale 1:10,000, are covered by 380 photographs, or an average of 7.4 photographs per map. The photographs are overlapped 60 percent both along and between flight lines. The northern part of this survey project, consisting of 430 square

miles, was practically completed in the period from August 1937 to October 1938. The work included 20 planimetric maps at a scale of 1:10,000 and 18 hydrographic surveys, two at a scale of 1:20,000 and 16 at a scale of 1:10.000.



An interesting feature of this project was the location, by the photographic plots, of control for the hydrographic surveys. Field inspection was started by a two-man party in September 1937 and included the identification on the photographs of natural objects and other points of detail which could be recovered and marked for use as hydrographic stations. These points consisted of gables, tanks, stacks, towers, pier corners, lone trees, wharves, piles, duck blinds, mouths and forks of small sloughs, distinctive points of land, points established on range with road center lines, etc. Where necessary to insure recovery, the selected points were marked with stakes. All points were briefly described in field notebooks and references made to the appropriate photographs. Field inspection was discontinued in November and from then until April planimetric maps, showing control stations and shoreline were compiled.

These maps were then reproduced by lithography in the Washington office and hydrographic field and office sheets were prepared. Of these, 14 were exact reproductions of the planimetric maps, with interior topographic detail deleted, and four were made from tracing paper prints or pantographed reductions of the planimetric maps. A considerable saving in drafting time was effected by printing the hydrographic sheets in this manner, since this made it unnecessary to make projections and to transfer and check the shoreline and signals.

Hydrography was begun in June 1938 and the 18 sheets were completed early in October. About 75 percent of the hydrographic signals had been located as heretofore described and the positions of the remainder were determined with a navigating sextant. The use of the plane table was unnecessary on the project. Numerous check angles at the sextant locations of the additional hydrographic stations, sextant angles on shoreline details, and a close ex-

amination of sounding-line crossings have failed to show any discrepancies attributable to this method of signal location. It is believed that with additional experience an even larger percentage of the hydrographic signals can be identified by the field inspection and located during the photographic plots.

The field inspection photographs were again used by the hydrographic party to identify the points at which to place hydrographic signals. Some shoreline details such as piling, pier ruins, aids to navigation, wrecks, and the delineation of indefinite marsh lines which could not be covered readily by the field inspection were checked or added to the maps by the hydrographic party at this time.

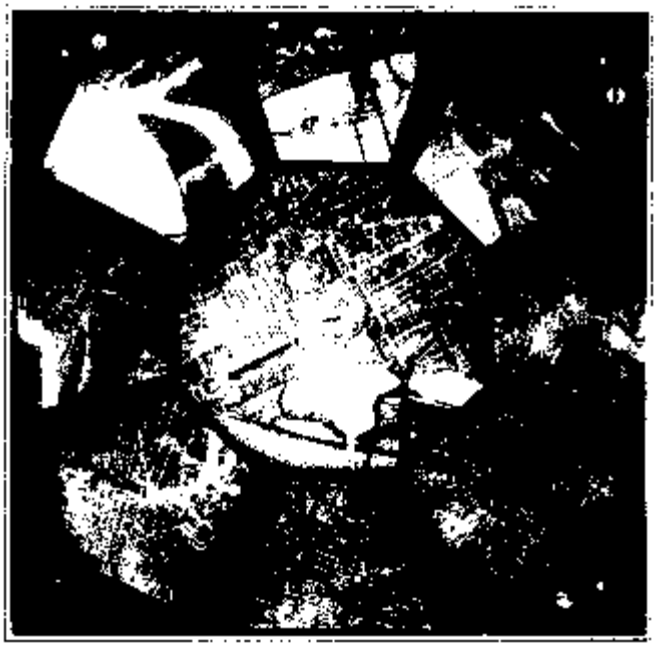
In addition to the work in progress on the Chesapeake Bay project, four planimetric maps of the Dismal Swamp Canal were made in the winter of 1937 and 1938. Field inspection, including the identification of hydrographic control, was begun on the Cape Cod project in October 1938. Field inspection of the photographs of the upper Potomac River from Washington to Quantico was in progress in December 1938. A total of 11 planimetric maps of this area are being compiled in the Washington office.

Other agencies of the Government have requested nine-lens photographs of areas which ordinarily would not be photographed by the Bureau, because they would be of no value in coastal surveys. Among these is the Soil Conservation Service of the Department of Agriculture. Single-lens photographs of certain areas had previously been taken by this agency and the nine-lens photographs were desired primarily for use in locating minor control points by radial line method from the existing first order control. The purpose of this was to eliminate the large amount of field work for second and third order control necessary for the single-lens photographs, since obviously the much greater span of the nine-lens camera permits inclusion of widely distributed control points on a single photograph. This project, which is still in progress, comprises an area of about 9,000 square miles in North Carolina and Virginia, and three additional areas, totaling about 14,000 square miles in the states of New York, Ohio, Colorado, Oklahoma and Texas. The photographs are being made at scales of 1:24,000 and 1:31,000 with flight altitudes of 18,000 to 26,000 feet above sea level, varying, within these limits, with the ground elevation and the scales of the photographs.

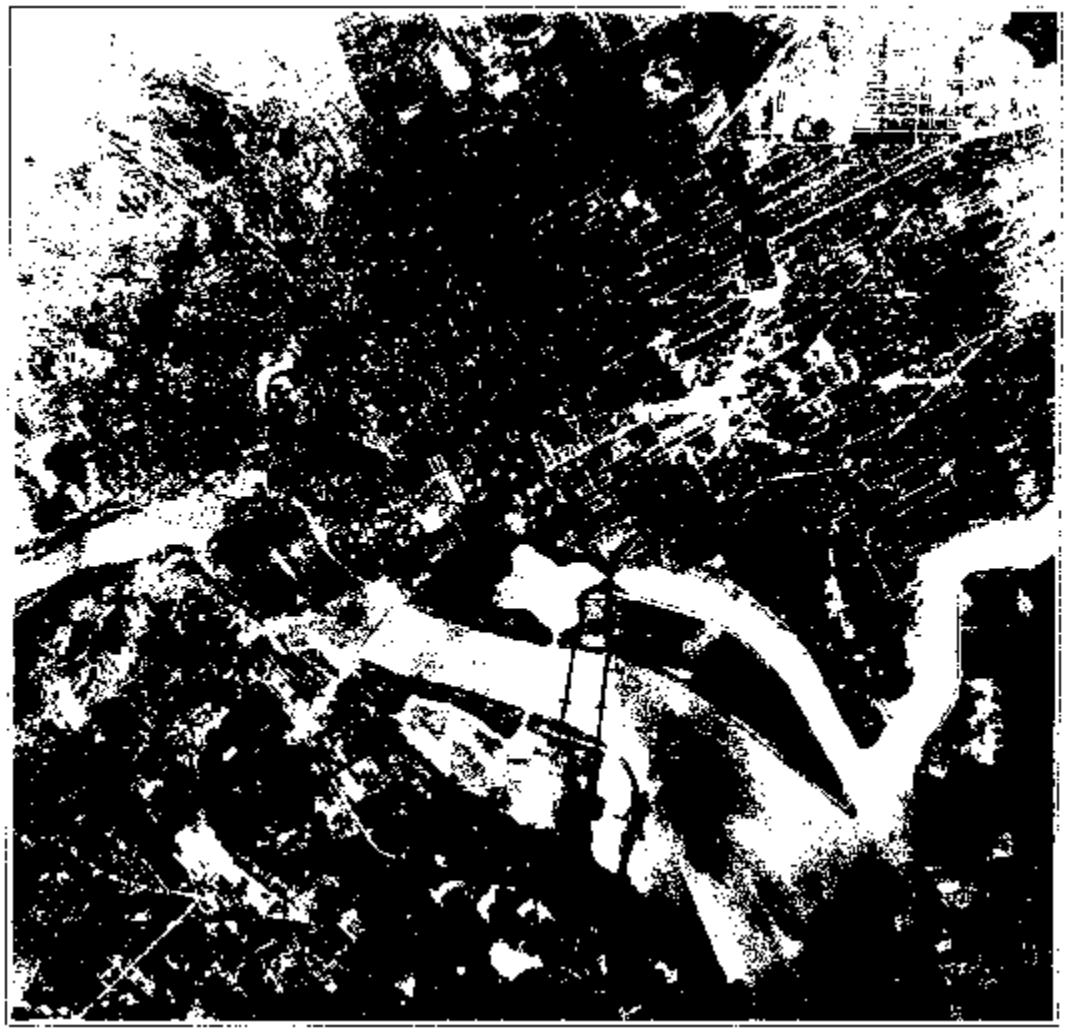
A rectifying camera is now being built under the supervision of Lieutenant Commander Reading in the Washington office and plans are being drawn for stereoscopic plotting equipment. The addition of these will result in increased efficiency and economy in the compilation of planimetric maps from nine-lens camera photographs, particularly in mountainous areas.

NINE-LENS CAMERA DATA

Focal length 8.24 inches (209.7 mm.), field 130 x 130 degrees square.
Net weight 306 pounds (140 kg.), gross weight with all equipment for photography 750 pounds (340 kg.).
Size of camera 29 inches (74 cm.) wide, 27 inches (67 cm.) fore and aft, 31 inches (79 cm.) high.
Size of film 23 inches (58 cm.)by 200 feet (61 meters) (100 exposures plus leader).
Size of composite photographs 35.4 inches (90 cm.) square.



Illustrating the relative sizes of the nine-lens negative and transformed photograph.



Cost of film, including development, approximately $2.00 per exposure.
Cost of ordinary paper, including development, approximately $1.00 per print.
Labor in making composite print approximately 1-1/2 man hours.
Camera can be reloaded in air if desired.

COVERAGE DATA

Scale	1:10,000	1:15,840	1:20,000	1:31,680
Width of strip				
Statute miles	5.6	8.8	11.2	17.7
(Kilometers)	(9.0)	(14.2)	(18.0)	(28.5)
Altitude above ground				
Feet	6,875	10,890	13,750	21,780
(Meters)	(2,095)	(3,319)	(4,191)	(6,639)
Area covered whole photo				
Sq. statute miles	31.2	78.3	124	313
(Sq. kilometers)	(80.8)	(202.8)	(321.1)	(810.7)
Per photo overlapped				
80$ x 60% Sq. stat. miles	2.5	6.3	10	25
(Sq., kilometers)	(6.5)	(16.3)	(25.9)	(64.8)
80% x 30% Sq. stat. miles	4.4	10.9	17.5	44
(Sq. kilometers)	(11.4)	(28.2)	(45.3)	(113.9)
60% x 60% Sq. stat. miles	5.0	12.5	20	50
(Sq. kilometers)	(12.9)	(32.4)	(51.8)	(129.5)
60% x 30% Sq. stat. miles	8.7	21.9	35	88
(Sq. kilometers)	(22.5)	(56.7)	(90.6)	(227.9)
66% x 33% Sq. stat. miles	7.0	17.8	28.5	71
(Sq. kilometers)	(18.1)	(46.1)	(73.8)	(183.9)
Statute miles (kilometers) of strip per loading				
80% overlap	112	177	223	354
	(180.2)	(284.8)	(358.9)	(569.7)
66% overlap	190	300	380	602
	(305.8)	(482.8)	(611.6)	(968.8)
60% overlap	223	354	447	708
	(358.9)	(569.7)	(719.4)	(1139.4)

From a letter to Captain Paul C. Whitney from Mr. H. S. Shaw, Exeter, N. H., dated July 3, 1938:

"I also enjoy reading the Field Engineers Bulletin, which always has things of interest to me. And by the way, I was amused at the story in the last issue about the pigs in the Bay of Fundy (page 118, Field Engineers Bulletin No. 11). One day I read it, by amateur radio, to a lighthouse keeper at Gannet Rock, an exposed place near the entrance to the Bay of Fundy, and although the tide range there is quite moderate, so that the situation is very different from the one pictured in the story, he was interested and amused. His wife made a suggestion to the effect that if the pigs must run like wildfire, that might have the effect of smoking the bacon, thus contributing to its alleged fine flavor!"

A TEST RADIAL PLOT OF NINE-LENS PHOTOGRAPHS

L. C. Lande, Assistant Cartographic Engineer
U. S. Coast and Geodetic Survey

The test radial plots discussed in this article were made for the purpose of determining the accuracy of radial line plotting, using photographs taken with the nine-lens camera of the U. S. Coast and Geodetic Survey.

A single flight strip of seven photographs at an approximate scale of 1:27,000, and extending from Aberdeen, North Carolina, to Fayetteville, North Carolina, was used for this test. The distance between centers of the photographs at opposite ends of the flight was 29.6 miles or 52,200 yards and the average distance between centers of successive photographs was 4.9 miles or 8,700 yards. The photographs were printed on low shrinkage celluloid coated paper and the plot was made with celluloid templets.

An examination of the control data disclosed a number of traverse stations along the Atlantic Coast Line Railroad across the first photograph and normal to the line of flight. These stations were located at intersections of tangents to the rail which enabled positive identification to be made on the photographs. A similar situation was found at the east end of the flight at Fayetteville on the Seaboard Air Line Railroad, except that the stations were not the intersections of tangents to the rails but could be spotted very closely on the photographs from their descriptions.

In addition to the stations at either end of the plot a number of traverse positions of road intersections were available at various intermediate points. These intermediate stations were identified on the photographs and located by the radial plot. Their geodetic positions were used only to check the accuracy of the radial plot locations and were not used to control the plot. They are listed under items 1 to 6 in the table.

A polyconic projection on a scale of 1:27,000 was constructed on low shrinkage cellulose acetate. For the first test plot, only the control at the western end of the flight, in the vicinity of Aberdeen, was plotted on the projection. This test was made to determine what accuracy could be expected by starting from a controlled photograph and, without additional control, completing the radial line plot throughout the remainder of the flight by holding to the center azimuth lines and radial line intersections. This random, unadjusted radial plot can be designated a cantilever extension plot.

The control, centers of photographs and radial points were spotted and transferred to overlapping photographs with the aid of a mirror stereoscope. Celluloid templets for radial line plots were made from the photographs. It is believed that, in general, a higher degree of accuracy can be obtained from a radial plot made with such templets than by the usual method of tracing the direction lines directly on the base sheet. During this procedure the photographs and templets were kept in a room with controlled humidity of 50 ± 10%.

The laying of the templets was started from the western end of the flight and the first two templets carefully plotted. The remaining templets of the flight strip then were laid down holding to

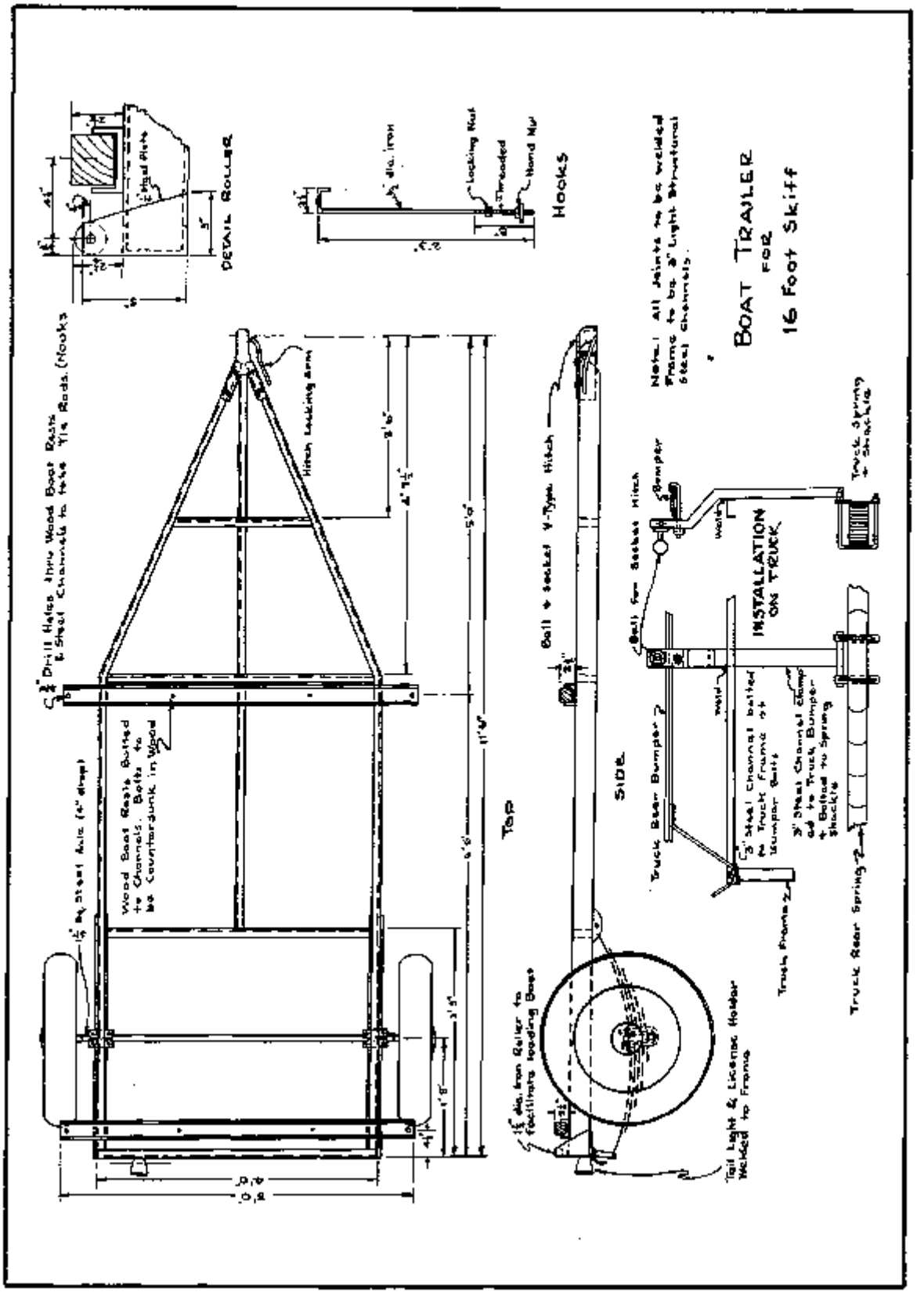
the azimuths between centers and the radial intersections. These latter were pricked through and marked on the projection before plotting the control at the eastern end of the flight. The results of this test are given in column 4 of the table. The average error in distance of point locations at the uncontrolled end of the plot, a distance of 29.6 miles, was 64 meters or 2.4 millimeters on the plotting sheet.

	(1)	(2)	(3)	(4)		(5)	(6)	
Station	Distance from Center of Controlled Photograph Miles	G.P.'s of Stations Meters	Unadjusted Position from Cantilever Random Radial Plot Meters	Distance Error Meters	MM.	Unadjusted Radial Plot Position	Distance Error Meters	MM.
1 B.M. P.Tr. 61	9.8	Lat. 35°05'1818.0 Long. 79 16 532.0	1818.0 526.0	6.3	0.23	1824.0 515.0	18.1	0.67
2 A. P. 56	19.0	Lat. 35 08 211.0 Long. 79 08 1400.0	177.0 1427.0	43.4	1.61	215.0 1392.0	8.9	0.33
3 A. P. 113	18.3	Lat. 35 07 439.0 Long. 79 07 358.0	404.0 384.0	45.5	1.61	428.0 371.0	16.9	0.63
4 A. P. 44	18.4	Lat. 35 07 1417.0 Long. 79 06 229.0	1385.0 250.0	38.2	1.42	1415.0 231.0	2.8	0.14
5 Tank	24.7	Lat. 35 08 742.0 Long. 79 00 919.0	682.0 942.0	65.3	2.42	745.0 927.0	8.5	0.32
6 A. P. 2	25.5	Lat. 35 08 482.0 Long. 78 59 987.0	480.0 1006.0	39.1	1.45	491.0 988.0	17.4	0.64
7 Tri. Sta. P.Tr. 17	35.5	Lat. 35 10 1694.0 Long. 79 00 123.0	1638.0 136.0	56.6	2.09			
8 Tri. Sta. Prince A.	26.4	Lat. 35 09 1493.0 Long. 78 58 616.0	1421.0 621.0	71.2	2.64			
9 Tri. Sta. Camp	27.6	Lat. 35 09 1790.0 Long. 78 57 762.0	1704.0 763.0	74.1	2.82			
10 Tri. Sta. Fayetteville G.	38.1	Lat. 35 03 443.0 Long. 78 52 1447.0	423.0 1497.0	53.6	1.99			

For the second test of the adjusted radial plot, the control at both ends of the flight was plotted on the projection. The templets were relaid and adjusted to tie into the control at both ends of the flight, holding to the center azimuths and radial intersections. The results of this radial plot are given in column 6 of the table.

It is believed that a field inspection of the control points would have increased the accuracy of the plot, especially at the eastern end. Undoubtedly a more accurate plot could have been made if the control had been distributed so as to give a stronger fix than was obtained with the control in a line normal to the line of flight.

A single test of this sort does not, of course, warrant definite conclusion as to the accuracy to be exepcted in all radial plots using nine-lens air photographs. It does indicate, however, that a strip of nine-lens photographs taken at an altitude of 20,000 feet or more, can, by careful work, with low shrinkage materials, be radial line plotted 30 miles (five photographs) between controlled photographs with errors not likely to exceed 0.8 mm for clearly defined objects. It also appears that cantilever extension of five nine-lens photographs from control is practicable with an error not exceeding one part in 500.


Boat Trailer
for
16 Foot Skiff
Detail Roller
Hooks
Top
Side
Installation on Truck
Drill Holes thru Wood Boat Rests & Steel Channels to take Tie Rods. (Hooks
Wood Boat Rests Bolted to Channels. Bolts to be Countersunk in Wood
Hitch Locking Arm
Ball & Socket V-Type Hitch
Truck Rear Spring
Truck Frame
Truck Rear Bumper
Tail Light & License Holder Welded to Frame

A TRAILER FOR A 16-FOOT SKIFF

L. W. Swanson, Junior Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

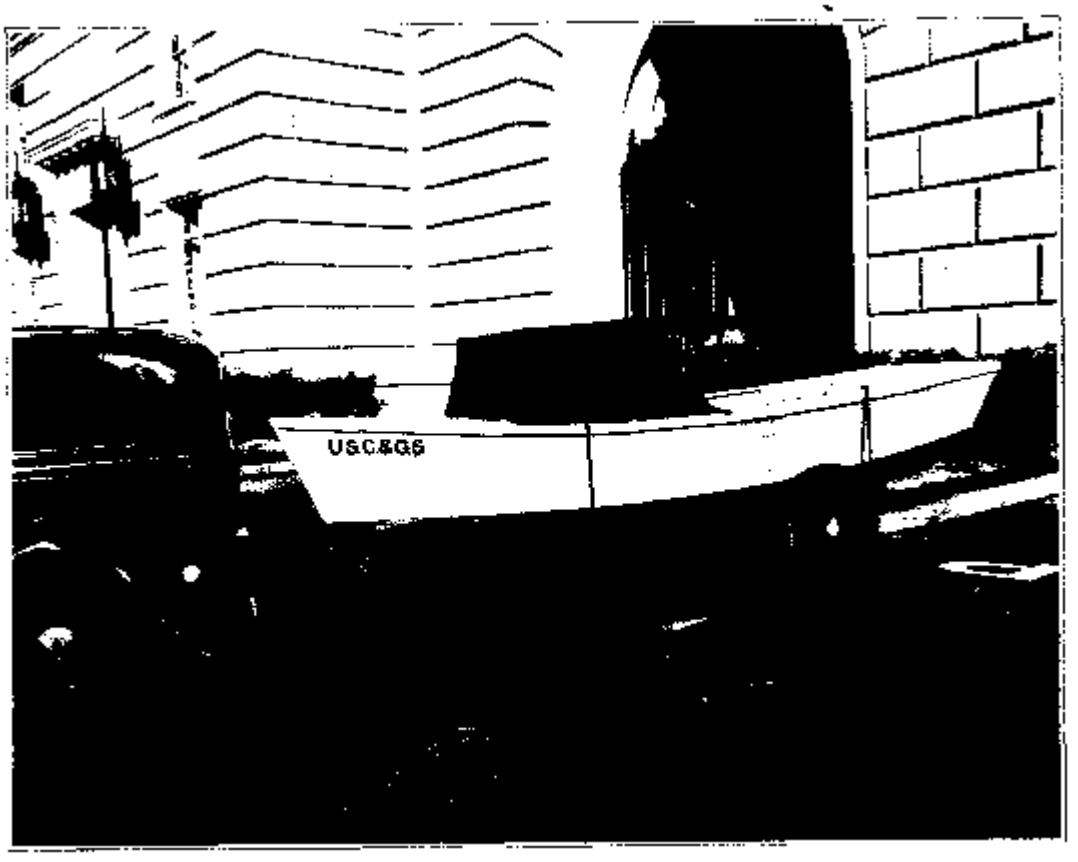
While engaged in a field inspection of air photographs of the Upper Chesapeake Bay area, considerable difficulty was experienced in hiring suitable small boats, necessary for the inspection in the immediate vicinities of the work. To overcome this difficulty a special trailer for a 1/2 ton delivery truck was designed so that a skiff could be carried directly to the working grounds. The skiff was lightly constructed, 16 feet in length, and 5 feet beam. Two men could load it on or unload it from the trailer. The skiff was decked over for 5 feet from the stem and a removable door installed so that a 9 H.P. outboard motor, anchor, chain, fire extinguisher, and tools could be stowed. The canvas spray shield shown in the photograph on the next page is optional. When loaded, the trailer is approximately balanced on the wheels, there being a slight downward thrust on the hitch.

The skiff-trailer was found very valuable during the past season and its use is recommended in similar areas, where there are numerous inland waterways to inspect in an area with sufficient roads leading to the water.

Specifications for Trailer

LENGTH	11 feet 6 inches. WIDTH 4 feet 0 inches.
HEIGHT	Approximately 22 inches.
AXLE	1-1/4 inches with 4 inch drop. 58 inch track.
SPRINGS	Two semi-elliptic springs mounted to frames.Shackles at rear end of springs. Length of springs 36 inches, width 2 inches. Capable of carrying a load of 1000 pounds. Equip all spring shackles with grease fittings.
WHEELS	Size to fit 5.50 x 17 inch tires and Ford V-8 spindle (1934).
FRAMING	Entire framing to be of 3 inch light structural steel channel. All joints to be welded.
HITCH	Hitch to be positive ball and socket V type.Bidder to install the necessary equipment on government truck for pulling trailer.
BOAT RESTS	Two wood (Oak) filled channel iron cross members for boat to rest on.
HOOKS	Four ½ inch round iron hooks with wing nut and locking nut located at each end of channels for clamping boat down to trailer bed. Of sufficient length to hook over gunwhale.
TAIL LIGHT	Tail light to comply with motor vehicle laws and capable of plugging into tail light circuit of truck. Tail light assembly to be readily removable from trailer.

TIRES	No tires.
DRAWINGS	See attached drawings.
MATERIALS	All materials and parts to 'be new and of good quality.
ROLLER	1-1/2 inch roller to he mounted on rear of frame to facilitate loading and unloading boat on trailer.



Skiff and Trailer used by Air Photographic Survey Party for field inspection of photographs.

SPECIAL DRAG WORK

(Extract from Descriptive Report 6129ab)

Raymond P. Eyman, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Surrey

For years, the shrimp fishermen, working in the vicinity of Cape Fear, North Carolina, suffered considerable damage to their nets because of submerged obstructions. The 1937 appropriation of the Bureau included a special sum to defray the expenses of locating these obstructions so that the Lighthouse Service could mark them.

(Editor)

The drag work on the Cape Pear shrimp fishing grounds represented a novel departure from standard drag practice in as much as it was desired to keep the drag on the bottom to find as many obstructions that might interfere with the shrimp nets as possible. It was therefore necessary to modify the usual procedure to a great extent, and naturally experiments were made with several types of drags.

At first a drag of 2000 feet of 1/4 inch galvanized iron chain, towed by two boats, was tried. This, however, proved too much for the launches to tow and was subsequently shortened to 1050 feet. At each end of the drag was a 127 pound weight from which uprights led to the end buoys; at 25 foot intervals along the drag an aluminum toggle was attached, and at the 100 foot intervals, uprights were attached. The upright consisted of wire center leadline buoyed by a toggle. Enough slack was left in the upright so there would be no tendency for the toggle to lift the drag. As the drag proceeded through the water these intermediate toggles or floats were towed under but came to the surface whenever the drag was stopped and thus gave some idea of the location of the drag with respect to the launches. A 50-meter towline of 2-1/2 inch manila rope led from each launch to the end of the drag.

This drag worked fairly well in the deeper water and over hard bottom, but in the areas close inshore or near the river channel where mud was encountered, the chain and end weights settled in the mud and stopped progress, in which case it was often found satisfactory to remove the end weights and buoys and tow the drag direct from the boats. When this latter method was followed, a greater overlap of adjoining lines was necessary to allow for the interval between the boat and the point where the chain reached the bottom. This was found on testing to be about 100 to 150 feet from the boat.

The chain drag seemed to be very effective as long as headway could be maintained; however, once the drag was stopped, either by obstruction, not enough spread between boats, or otherwise, it was found very difficult to get it started again, as the chain seemed to bury in the mud and frequently it was found necessary to take up part or all of the drag and then reset it. The chain was hauled in by winches and faked down on deck by hand.

A rope drag was later tried and seemed to give about the best results for all round performance except that it was subject to excessive wear. This drag consisted of a coil (1200 feet) of 2 inch circumference manila rope with the same end weights and end buoys

as for the chain drag, the intermediate intervals of the bight being divided into 400 foot sections with a 10-pound weight attached and having no uprights, floats, or toggles other than the end buoys. This drag was towed in a manner similar to the chain drag using the 50-meter towline. Toward the end of the season a second coil of rope was added, giving a length of drag of 2400 feet. This worked very satisfactorily with the only exception that a slower rate of progress along the line was made but it gave approximately double the effective width.

The regular wire drag ground wire was tried a few times in lengths varying up to 3700 feet but was found to be unsatisfactory. This drag was hard to handle with the improvised gear, would apparently cut into the mud bottom, stopping progress, and was also found at other times not to follow the bottom closely enough, missing obstructions previously found.

During the dragging, frequent tests were made to insure that all parts of the drag were on the bottom. These tests and the appearance of the drag when brought to the surface gave every indication that each type used, with the lone exception of the wire drag, dragged the bottom.

Whenever the drag fouled an obstruction, the best procedure was to take in the drag to the point of "hang", keeping enough strain on the drag to hold it against the obstruction. At the point where the drag line was brought to a vertical position, a temporary marker would be dropped, the bottom sounded and tested with the lead to determine, if possible, the nature and extent of the obstruction, and the drag then cleared for proceeding ahead. On a few occasions parts of wreckage were brought up with the drag; on others, the chain or rope would have to be cut to clear the drag; also, on a few occasions there would be evidence of iron rust or wood particles adhering to the drag.

A complete investigation as to the nature and extent of the obstructions found would require a much greater expenditure of time and funds than were available and, undoubtedly would necessitate the services of a competent diver with attendant equipment. It was found almost impossible to obtain adequate information by the use of the hand lead, as usually there was very little, if any, change in depth noted and the "feel" of the lead gave only a vague clue; better information was more often obtained by an examination of the drag after clearing.

To have surrounded the obstruction by dragging from various directions would have been time consuming and would have served little purpose other than to determine the possible extent of the "hang". Besides if the obstructions were large, it would be detected by adjacent drag strips.

There were 28 obstructions found which were menaces to the shrimp fishermen's nets. Of these, which were all buoyed by the Lighthouse Service, seven were apparently metal wreckage, seven apparently wood wreckage, and nine apparently rock or coral. The nature of the remaining five was undetermined. In addition, 19 other obstructions were found but their positions in shoal water or nearness to the beach did not warrant their marking by buoys.

THE SKIFF WIRE DRAG

G. C. Jones, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

When wire dragging Sitka Harbor, Alaska, and approaches, the wire drag was found nearly useless in such restricted areas as the 150 foot dredged channel and in Sitka Harbor. Also, in places where it was desired to drag unusually close to the beaches the drag was found too unwieldy and costly.

Attempts were made to use a marline sweep but when a small-topped boulder was caught, there was insufficient guide as to its location and too much time was spent in getting a leadline sounding; also the drag depth was not positive enough. In order to overcome the difficulties it was decided to assemble a regular drag in miniature for use from skiffs.

Sufficient drag length was needed to cover an effective width up to about four hundred feet. That would allow generous overlap with regular drag strips or other skiff drag strips and still permit appreciable new area to be covered. To attain that length and keep towing resistance low, very small ground wire was required. Accordingly, fifty foot lengths of 1/16" stranded sounding wire were assembled with a No. 5/0 brass barrel swivel on one end of a length and a brass snap swivel on the other. The lengths were then connected and wound on a wooden reel.

The same wire was used for uprights, marked as specified in the Wire Drag Manual and fitted with snap swivels on the lower ends. Aluminum toggles were used for intermediate buoys. Three or four pound pieces of scrap metal were used for intermediate weights. The forty pound drag weights were used for end weights and the skiffs themselves for end buoys as on a marline sweep.

Results were gratifying. Five or six hundred feet could be set out in about ten minutes. The drag towed easily with one oarsman in each skiff pulling barely enough to make steerage way. Presence or absence of faint currents could not be detected but it was estimated the drag could be taken through the water at about 0.4 knot without a lift. So towed, under favorable conditions, careful tests showed never more than 0.3 foot lift and generally no lift. With buoys spaced only 50 feet apart, pinnacles and small-topped boulders could be located quickly by the tender and a least depth obtained. The very definite line of floats made it simple for the observers in the towing skiffs to get an accurate check location of each grounding. The absence of floats on the ground wire made it possible to stop for hook-up changes or other purposes without a break in the drag strip, thus adding to the flexibility of the drag and simplifying plotting.

The wire drag examination of a considerable area which was practically impossible to reach with a regular drag with towlines, etc., thus was made simple. The three boulders in the above mentioned 150 foot dredged channel were located readily and probably would not have been found by any other means. A channel of such width is too narrow for an ordinary drag and too wide for a pipe or iron rail drag unless very elaborate and costly. In fact, I was informed locally that the channel had been examined with an iron rail without the boulders being found.

The cost of fitting up the skiff drag was negligible. Used sounding wire is actually better than new, being slightly less inclined to spring back and foul when slack. Any fine stranded wire available will do, and even marline or codline should serve, although these would hardly do for the length needed in this instance, because of towing friction, and the tendency to fray. Aluminum drag floats are ideal for intermediate buoys but if not available a substitute can generally be found, such as fishermen's floats of glass or cork, or even one or two quart glass jugs or bottles with handles. The brass swivels may be most any size as they are not subject to much strain. Their cost is from twenty-five cents to one dollar per dozen, depending on the size used. The snaps on the uprights are a convenience and time saver but gave us the only trouble experienced with the gear by letting go on a few occasions. Better snaps could no doubt be found in a large fishermen's supply house but even so, the smallest size (l/4") screw shackle would no doubt be better for both ground wire and uprights. However, for the uprights, a swivel with a stray end of codline for a tie would do very well. A reel need be carried in only one skiff and since it is not subject to strain it may be of light wood construction, without handles or fastenings.

After working with the above drag I have reached the conclusion that the solution of the problem of a portable drag to be carried by ships, lies in a drag of this type rather than in a heavier drag for towing with power launches. Buoys for the heavier drag must be collapsible to avoid bulk and none has been devised to date which does not deteriorate when stowed and fail when needed. Only a slight change in the design of the aluminum floats, such as a square bail with a light wooden spool in the bail and a catch to lock the spool, would make the floats equally useful for the regular wire drag and for this portable skiff drag.

]FROM DESCRIPTIVE REPORT OF TOPOGRAPHIC SURVEY 6602
WEST END OF UNIMAK ISLAND, ALEUTIAN ISLANDS.

During the winter large herds of caribou feed on the moss and grass on this part of the island. The lighthouse keepers report seeing herds of hundreds of them, the total number on the island being estimated at 30,000. The island is also supposed to be the home of some of the largest bear in Alaska. Many bear tracks were seen but evidently the keen sense of smell of these animals usually enabled them to avoid the survey parties. One bear track measured 17 inches long and 11 inches wide. Nine bears were seen during the season by the triangulation party but only two by the topographic party. Besides feeding on the several kinds of berries on the island, the bears are reported to kill the caribou for food and I have seen them digging for ground squirrels. These latter are very numerous and probably are also a source of food for the many red foxes which were seen. The members of the party saw several dif--rent kinds of birds during the season including ptarmigan and a few families of large white swan. The abundance of game on the island is attributed to the fact that it is a game preserve and practically no hunting has been permitted since 1918.

AN UNUSUAL HYDROGRAPHIC PARTY

R. E. A. Studds, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

One often hears of the "one-man hydrographic party" where the surveyor waded around in shoal water taking sextant positions and reading depths on foot marks painted on his hip boots. The writer was confronted with a situation some years ago where this method would have solved his problem, had not the depths been something over ten feet.

The occasion arose in the Philippine Islands. A prominent sugar company desired to develop a channel in Pampanga Bay near the mouth of the Orani River so that sugar could be shipped to Manila by barge. Since that particular area was not in the immediate program of needed surveys, the Director of Coast Surveys consented to the assignment of one officer for two weeks for the work if the other expenses were defrayed by the company.

This proving acceptable, I left for the locality with the necessary instruments and found, on arrival, an excellent launch with a "patron" or pilot, and an engineer. As much labor as desired was offered, - but it was native and all very much unskilled.

Establishing plane table control with this unskilled labor was, of course, comparatively simple, but conducting a hydrographic party by the usual methods was not so easy. One of the laborers could write and speak English, so he was selected as recorder. He was not, however, familiar with a clock. Neither the pilot nor engineer could speak English, but my limited Spanish included "sigue, espera, atrás, babor, estribor, poco" (go ahead, stop, go backwards, port, starboard, little or slow), which were sufficient for giving orders.

To begin with, a number of small buoys were constructed, using 5-gallon gasoline containers, and each buoy connected to a makeshift anchor with a length of line just sufficient for the depth of water. A system of parallel sounding lines normal to the channel was selected and for each line a range either was built on shore or chosen from natural objects.

A buoy was anchored where the sounding line was to begin and its position determined by two sextant angles while the launch was stopped. The launch, starting some distance back from the buoy, was headed on the range and sounding begun as the buoy was reached. Soundings were taken at ten second intervals but only the depth recorded. Between soundings I would glance at the range and con the launch accordingly. When the end of the sounding line was reached a buoy was dropped as the last sounding was made, and its position determined in the same manner as at the first buoy. Time was recorded at the end of each line merely for the purpose of tide reductions. Since the two ends of the line were fixed and soundings obtained at regular intervals, the depths were spaced equally along the line.

A good survey resulted and despite the rather novel procedure not a great deal of additional time over that ordinarily used was required. It is probably the only instance where one man observed both sextant angles, sounded, recorded the time and conned the boat.

Echo Sounding in Harbour Hydrography *

By Lieut.-Commdr. D. H. MACMILLAN, R.N.R. (Retd.), Extra-Master Mariner, A.I.N.A.

FOR a century, at least, the seaman-surveyor has anxiously searched amongst the unfolding principles of increasing scientific discovery for some method of vertical submarine measurement, which would solve for ever that small margin of doubt which has always surrounded the ancient use of lead and line.

The present century has seen so remarkable an increase in the maximum draught of steamships, that the Port Surveyor must now determine the greater depths with the same meticulous precision as has been demanded of him for the lesser in times past.

In approaching soundings from seaward, the need for close detail and precision was once determined by the five-fathom contour, but modern progress in Naval Architecture, taken together with the " squat " of large vessels in shoal depths at critical speeds, has increased the range for detail to at least seven fathoms below M.L.W.S. Data.

It is the writer's contention that real precision at such a depth is not attainable by ordinary " lead and line " methods, for the following reasons:—

(a) The catenary of the lead-line, due to differential current layers, always causes the " calling " of excessive depths, despite the appearance to the leadsman and surveyor of a " plumb " cast. Surveys over identical sections at different states of tide have frequently given perplexing differences in proof of this, and it is, of course, an axiom amongst seamen that over-estimation of depth is fatal.

(b) The settling of the lead into soft mud and clay. This also gives an excessive depth. The contention that what is not " felt " by the lead cannot obstruct a ship, is a serious fallacy. A heavy-draught vessel requires every inch of bottom clearance at Ordinary Spring and extreme Low Water times, in order that her screw " feed " current may be as ample as possible. Her " squat " is thus reduced, and her general handiness under helm and engines increased.

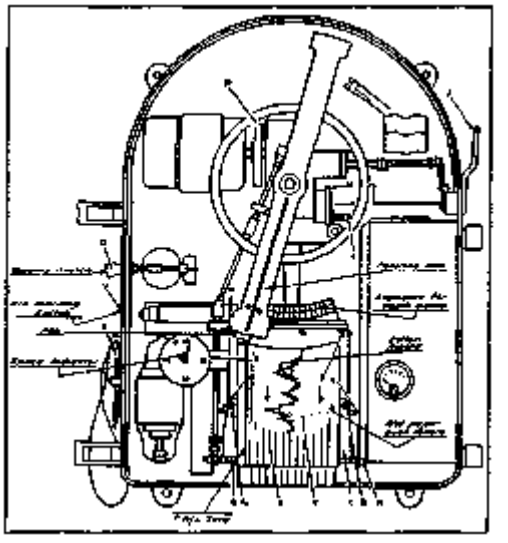


Fig. 1

(c) The tension due to the usual leads (10 to 20 lbs.) is not great enough to ensure that the best type of lead-line (with Kelvin wire heart) is representing depths to the same degree of accuracy as when it is horizontally stretched and " taped " before and after using.

(c) The speed of the sounding boat must be quite low for the best lead work, and whilst giving all due credit to the splendid performances of first-class leadsmen, it should be remembered that the necessarily short instant of "plumbing" and "feeling " at a depth of over five fathoms from a vessel, under way, lacks that deliberation necessary for the critical accuracy which such a measurement surely demands.

When causes (a), (b) and (c) are acting in concert, it is clear that discrepancies between the Navigator and Surveyor are by no means surprising, unless the latter has been wise enough to reduce his soundings by the " full foot " method of tidal reduction, and/or reject inches in his reduced depths. If, however, he is too cautious he will be censured for unnecessarily restricting shipping—a good but irritating fault!

Fortunately, the dream of the old Surveyor-Captains and Admirals has been realised and a panacea for the ills of lead sounding at last discovered.

The Magneto-Striction Radial Arm type of Echo Sounding device has solved the problem by enabling the Surveyor to take ashore a paper record giving a continuous profile of the bottom section which his sounding boat has traversed, to a definite accuracy of within 3 inches, punctuated with " fix " lines indicating the points where his instantaneous double angles for position were taken.

These consecutive numberings agree with the plotted points of the boat's track marked upon the plotting graph of position (see 7a).

" The interesting point about such a record—or Echo-roll—is that it bears internal evidence of its true Zero of soundings after the " bar-check" has been carried out at definite depths.

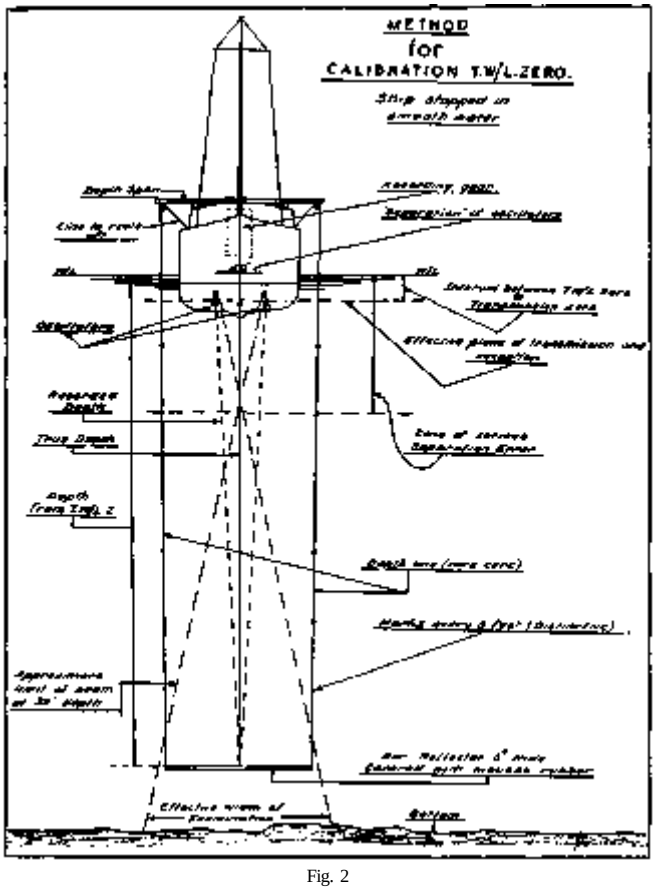


Fig. 2

* Reproduced through the courtesy of The Dock and Harbour Authority.

The section is not only a continuous and accurate record of Electro-sonic soundings taken at the rate of 300 p.m. (i..e., one every 2-ft. at 6 knots), but in addition, represents a track which is not just a line, but a *strip* or *band* of " examined " area, equal in width to about one-third the depth—as the effective " cone " of sonic sensitivity is about 15° from the vertical.

Fig. 3

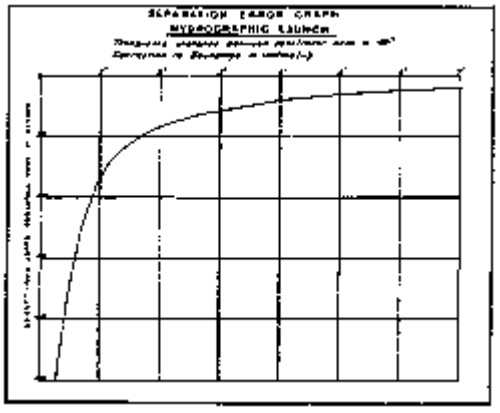
Thus any pinnacle or obstruction within this zone would show a "side" echo or "shadow," and so indicate the need for a further and closer examination.

It is not the writer's intention to describe in detail the technical parts and principles of the instrument, but rather to outline its practical application to the Harbour Surveyor's requirements.

The instrument graphically measures sound intervals by respectively recording the points of transmission and reception upon specially treated starch-iodine paper moving over rollers at a constant speed, which allows time intervals to be automatically recorded. (See Fig. 1).

The depth interval is therefore represented by the linear interval between the recorded point of transmission and reception—denoted respectively by the brown chemical precipitation marks—the scale calibration depending upon a standard rate of sound in water—4,800-ft. per second.

This is mechanically achieved by a rotating arm bearing a " pen " of carefully regulated spring pressure which traverses and contacts the moist paper at a standard speed of 300 r.p.m., which speed is a function of the scale calibration. (See Fig. 1).



Continuous recording by the instrument gives such a close succession of these markings, as to show in practice a *line* of transmission, and a *line* of depth.

By pressing a button at the instant of fixing the position of the Survey Launch, a continuous line is " drawn " upon the record, and an "electric contact " pen enables the numbering of the successive "fixes" to be made without interrupting the record. (Fig. 1).

It should be noted that the scales used for measuring depths upon the record are in sine relationship to the arc traversed by the " pen."

The paper record has, of course, to be dried before plotting can be carried out. and this is accompanied by a certain amount of transverse shrinkage which affects the final scale upon which soundings are read. Fortunately, with the use of standard paper, the co-efficient of shrinkage is very constant and is allowed for in the graduation of the metal scale provided with the instrument.

In addition, as the instrument automatically marks the depths from 0 — 40-ft. at 5-ft. intervals upon the direct scale (i.e., on the wet paper) the dry scale can be checked for accuracy and consistency very easily. When this test is satisfied, the results can be confidently relied upon.

The scales of the instrument used by the writer are approximately 8-ft. and 16-ft. to the recorded inch, each capable by a phasing arrangement of recording a depth range of 75% more than the single traverse of the paper width would permit (i.e., 40 and 80-ft. respectively).

As the scale (8-ft. = 1-in.) is that affording a precision of 3-in. of depth in practice, this scale will be that particularly described and illustrated in this article.

The writer accepted the M.S.X. instrument (as illustrated) upon the essential condition that an accuracy of depth within 3-in. was to be given in practice.

The tests were to be made in dry dock at high-water level, and depths compared with the readings of the inner gauge (top of block zero) and also the sill level. The instrument came through with first-class honours, showing a perfect agreement between the record and dock gauge. In addition to the tops of the blocks, the dock bottom was shown; with launch moving slowly across the dock, the camber of the bottom was also clearly discernible.

Salinity and temperature affect the speed of sound in water, but within the ranges used by the Harbour Surveyor the variations are infinitesimal, and can be checked by the "bar" method described below. (See Fig. 2).

Speed error is directly proportional to " standard " speed, the performance of which can be checked by comparing a specially calibrated pointer borne upon the instrument with a good stop-watch. (Fig. 1).

In practice the writer has devised an " absolute " check upon the instrument, which avoids the necessity of applying increments due to speed variations. A 3-in. width angle bar, weighted at the ends and totalling 70 lbs. in weight, is slung from calibrated lines rove through yard-arm blocks from a spar borne in crutches and clamps athwart the boat directly above the oscillators. The lines are hemp lead-line (cable-laid) stuff (1¼-in. circ.) into which a Kelvin-wire " heart " has been worked. With boat stopped in smooth water, the bar is hooked on by self-mousing hooks to the port and starboard depth lines and launched over the stern.

The depth lines are then reeled out until the required marks say 35-ft.—are *on the luaterline*, on each side of the boat. As these lines are continually checked as a routine by steel tape, the top of the bar is thus at the required depth, the weight of 70 lbs. overcoming differential current effects. The Echo machine is then switched on and the bar " echo " recorded.

As the sea bottom is *also* recorded, if this is hard, the line will be found to slack as soon as the bar is lowered to a position where " Bar " and " Bottom " records are in coincidence. If the bottom is soft the difference in level between the "bottom" on the record and the depth of line-at the moment of " slacking " will indicate the softness of the bottom, and the penetration of the bar. It will thus be seen that the " bar-check " constitutes the criterion for the true waterline zero (T.W/L.Z) of the record bearing it. (See Fig. 3).

Whilst the old surveyor measured his lead-line after sounding, the Echo surveyor will carry out a " bar-check " every time he uses the instrument and watch his instrument by stop-watch throughout its use.

A further small correction known as " separation error " will now be considered in conjunction with a brief outline of some of the features of installation. This correction (which is subtractive) is due to the horizontal distance between the transmitting and receiving oscillators. (See Fig. 4). The recorded depth is thus greater than the true by an amount which decreases inversely as the depth of water.

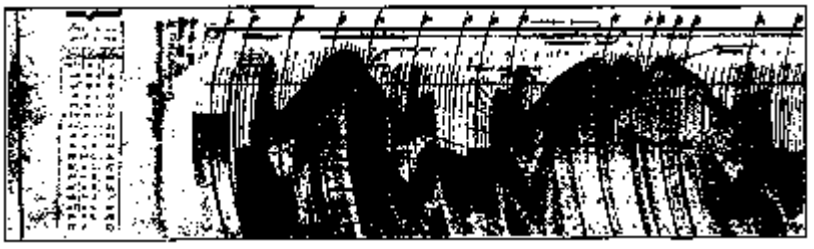


Fig. 5

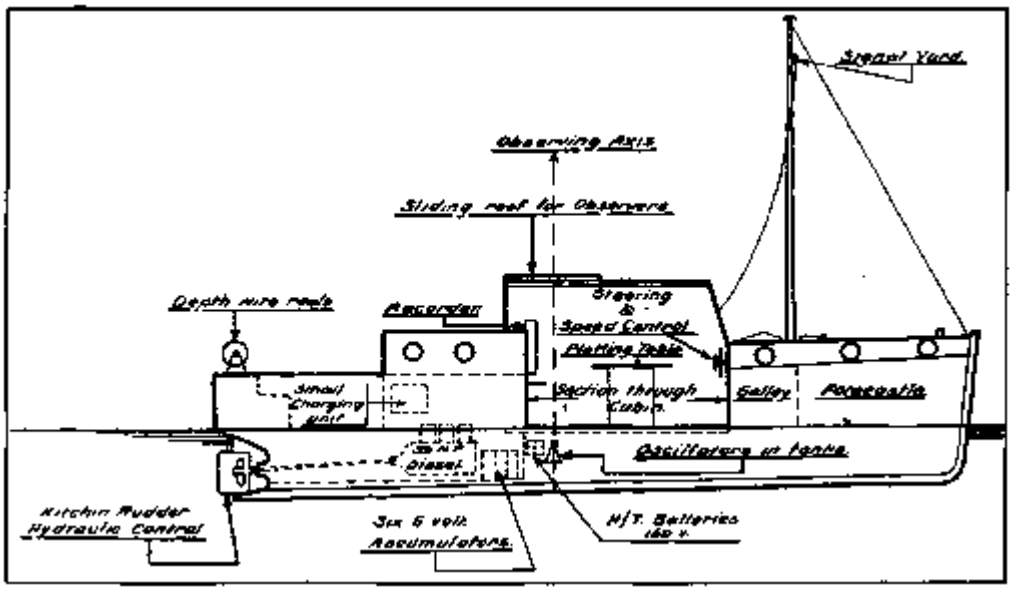


Fig. 6. Profile Sketch Survey Launch

The value of this correction is determined by the formula $C = D - \sqrt{(D^2 - (\frac{S}{2})^2)}$ where C = the subtractive correction to recorded depth D.

D = Recorded depth.

S = Horizontal distance between vertical axes of the oscillators.

For example, if the oscillators are 40-ins. apart, the recorded depth is 7½-in. in excess of the true, at a depth of 2-ft. (below the oscillators); 3½-in. at a depth of 5-ft., and only 1½-in. at a depth of 10-ft.

In such a case, it will be sufficient, as a safe principle in practice, to pencil in the recorded " bottom " 3-in. above its " surface " when the depth is between 2-ft. and 5-ft. (See Fig. 5).

Let us examine some of the points to be considered in installing a sounding set (M.S.X.) in a small Diesel-driven launch, such as that used by the writer. (See Fig. 6).

The dimensions of the vessel were: length 35-ft., breadth 9-ft., and draughts: forward 2-ft. 6-in., aft 3-ft. 6-in. Speed 8 knots.

It was decided to fit the oscillators abreast each other and 40-in. apart on either side of the keel, at a position over which all observed angles for location were to be taken.

This position was also about the L.C.F.*, in order that small changes of trim, under way, would not effect recorded depths.

The effect of moderate rolling is counteracted by the fan-shaped beam sent out by the transmitting oscillator, which is disposed approximately 15° about the vertical axis of transmission. (See Fig. 2). In shoal depths this angle is increased.

The exact vertical distance of the " effective " base of the oscillators above the keel was then taken by level on the stocks, in order that the vertical distance between waterline and "plane

* Longitudinal Centre of Flotation.

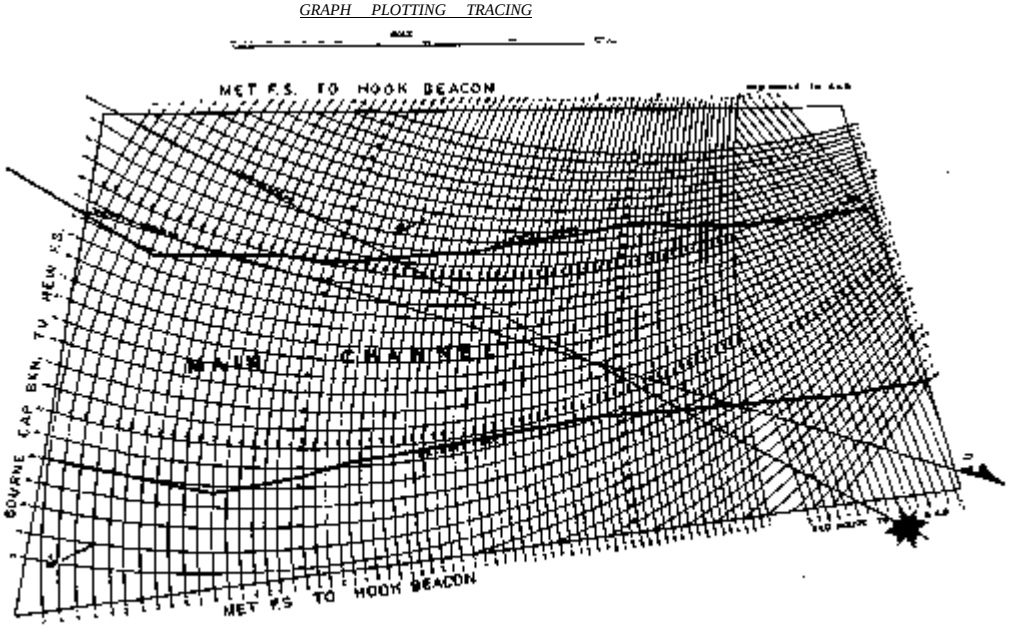


Fig. 7

of transmission " could at any time be computed from mean draught and applied above the " zero of transmission " as a check upon " waterline zero "—in conjunction with any speed variations noted by stop-watch.

As the craft was a wooden one, holes had to be cut for the oscillators and compensation made. This is not necessary in steel vessels.

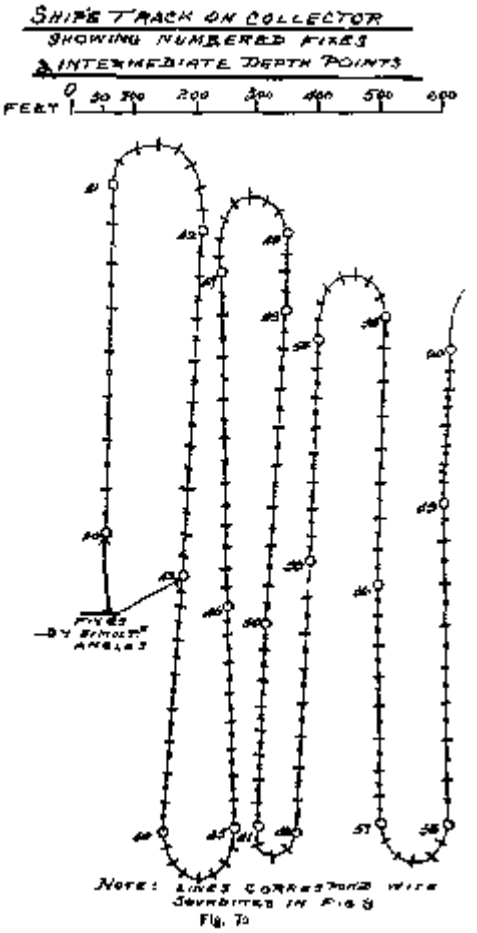


Fig. 7a

In the writer's view, a good shallow draught and beamy launch, of from 35-ft. to 45-ft. in length, is the most suitable for harbour survey work, for the following reasons:—

(1) " Squat " in shallow water is least felt, and thus one correction is eliminated.
(2) Variations in fuel and F.W. disposition and quantity have less effect on mean draught than is the case when the unit is fitted in large tenders.
(3) Rigging and handling of gear for " bar-check " is easy, on account of light draught and relatively small beam, and thus constant checks are simply carried out.
(4) " Separation " error is kept small.
(5) Sextant observers can observe precisely over the set of oscillators when under way.
(6) With " Kitchin Rudder " control " manoeuvreability" is almost infinite.

With reference to this latter feature, the writer has found such hydraulic speed control of great value in Echo work, because speed can be adjusted to get best records with an infinite gradation to wind and sea conditions, quite unattainable by any other means.

A launch fitted as above becomes a survey instrument of mobility and accuracy, the " fixes " observed directly locating the exact positions of the soundings, which can be plotted directly upon a large-scale working sheet without those corrections for " distance from Observer to lead," which in many cases drive the surveyor to a pulling boat for large-scale detail work.

An interesting point about such Echo work, is that when " wash " from passing vessels, a rough sea, or swell, causes " aeration " around the oscillators, the " bottom " record ceases for the time being until normal conditions are resumed. This is an automatic veto upon:—

(1) Sounding in narrow channels at times when shore tide gauge readings may not represent true levels where ships are passing.
(2) Sounding under weather conditions which are not conducive to good work.

It is most important to arrange a sound working drill in the Survey unit above described.

When on " Survey Stations " the following routine is advantageous:—

(a) The two Surveyors take up a position to observe angles overall immediately above the oscillator position, and prepare to plot the sounding course.
(b) One seaman is stationed to keep a look-out and act as " fix-marker " by pressing an electric switch button when the Senior Surveyor calls " stop " at the instant of fixing position.
(c) The sounding operator prepares the machine for recording, switches on when ordered, and keeps a watch on the record throughout the survey—checking and numbering the successive fixes which must correspond with the record kept by the Junior Surveyor in the " sounding book."

It is advisable that one seaman should specialise in operating and tending the machine throughout all survey work, as innumerable small annoyances (cutting of paper, etc.) are thus anticipated and avoided.

As the speed of the instrument is standard at 300 r.p.m. for the radial arm carrying the pen, the sounding operator must frequently check the speed error over 10-minute intervals.

The variation in seconds for a 10-minute " run " gives the depth error in inches at 50-ft., e.g., 3 secs, fast = 3-in. too deep.

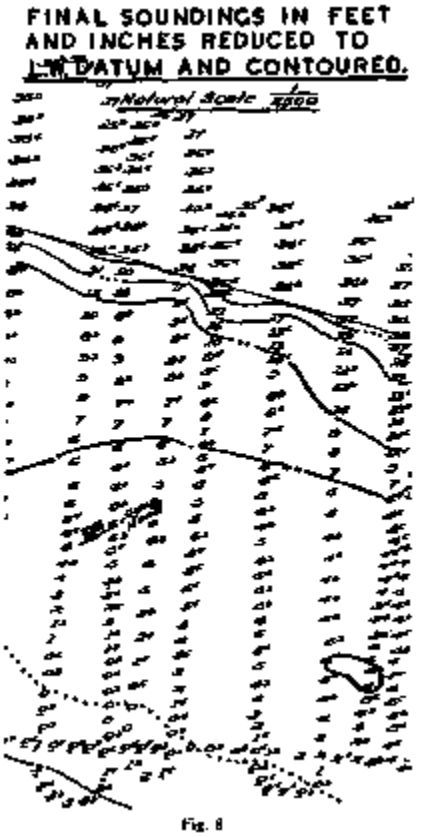


Fig. 8

The writer has rarely known this to change more than one second in a two or three-hour survey, and thus the " bar-check " described above gives a definite criterion for the true " waterline zero " which embraces all corrections.

As in other hydrographic work, all basic standards are checked as a routine. Depth wires are checked weekly by steel tape, stop-watches are timed monthly by chronometer, "phase" and primary zeros are kept in true adjustment, and the necessary spares (valves, pens, etc.) kept handy on board, in order

to save delay in the case of minor breakdowns away from "home base."

The advantage over lead methods of a carefully spaced pattern of survey lines, run continuously, over a given area at 5 to 6 knots, together with a precise and continuous depth record punctuated by "fix markings," is too obvious to need dwelling upon.

It may be interesting to mention a further benefit.

Normally the Surveyor takes advantage of prominent natural objects in the spacing of his sounding lines for covering a given area.

The only other solution, is to steer compass courses whilst surveying, but unfortunately, if the lead is used, steerage way is necessarily so small, and wind and tide have so relatively great an effect, that such courses would be difficult to maintain in all but good-sized tenders.

The speed at which one can survey by Echo methods overcomes this difficulty, and the writer can steer courses upon an adjusted compass, in the craft mentioned above, with all necessary precision.

The magnetic effect of the Echo gear is quite small and easily compensated in practice.

A word about methods of plotting to accommodate the higher speeds of survey.

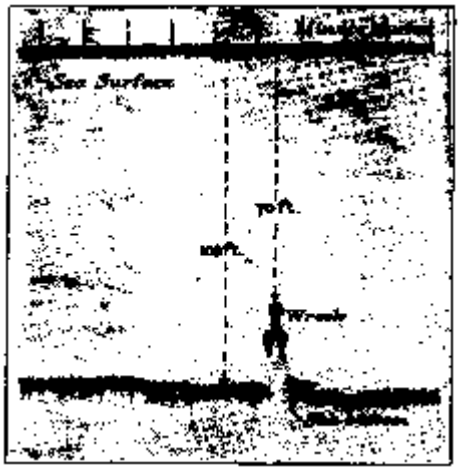


Fig. 9

Apart from small dock wall surveys, run on transits (objects in line) using the hand lead, and wire-measured distances, the best, and even only seamanlike method of plotting the position of a survey vessel under way is by means of two simultaneous horizontal sextant angles taken upon correctly triangulated, and suitably disposed, conspicuous and fixed objects.

The "three point fix," as it is called, enables the Surveyor who is plotting to set the angles upon an instrument known as a Station Pointer, and by its means locate the point upon the "working sheet" laid out upon a plotting table carried on board.

As this routine of reading the sextant, setting the station pointer, and then using it on the plotted trig. points, takes from 20 to 40 seconds (and certainly the latter if one is as careful as one should be), it is clear that during this time, the launch has traversed from 200 to 400-ft. at 6 knots.

By this time, it is necessary to fix again if one wants a detailed course. Under such circumstances the Surveyor is not sufficiently free to " conn the ship," study his contours, or check his course, unless he reduces speed—which action would, of course, annul the advantages of Echo work.

The answer to this dilemma is to be found in producing a " working sheet " bearing arcs of position so plotted that they can be used as co-ordinates, of position. (See Fig. 7).

The objects should be chosen that the resulting arcs at the required area intersect as nearly at right angles to each other as possible, and, of course, vary in radius as sensitively as desired.

This process is a new hydrographic technique in itself, and the writer has no space to deal with it here, but let it suffice to say that by its means the position of a launch, under way. can be plotted accurately within 5 seconds of the time of observing the simultaneous angles for position.

The setting of the station pointer, and the adjustment of it to the " points," are thus eliminated; high survey speed can be maintained together with fixes at close linear intervals, and easy supervision is possible throughout.

We now come to the drawing office side of the work.

Fig. 5 shows an Echo record ready for plotting, and the following points in preparing it must be attended to:—

(a) The true " waterline zero " must be drawn in throughout as deduced from the " bar-check " data contained in the record.

(b) A slip relating the fix markings to the times of gauge readings (every 5 minutes) is prepared and pasted on the record.

(c) The tide gauge readings are then plotted as requisite below the true " W/L zero " at short intervals, and a line joining them all drawn in. This is, of course, the actual Port Low Water Datum of soundings, and it will be seen that the reduced soundings are directly measured from this line.

The usual lengthy arithmetical process of reduction is thus eliminated, and yet another source of error removed.

(d) The next stage is the division of the intervals between the fix markings into a convenient number (say eight) of equidistant longitudinal intervals.

This is done by so dividing the Datum line and then transferring the points to the "bottom" record in a roller frame, which takes into account the arc traversed by the pen on the radial arm.

(e) Standard annotations for reference are finally made upon the record detailing speed variations, consequent depth error, filing number, area sounded, sounding book referred to and dating. The record is now ready for plotting, and providing this organisation is standard and the office staff are skilled, it takes a very short time.

The preparation for final plotting upon a tracing has meanwhile been proceeding, as follows:—

(a) The " working sheet "—usually a plotting graph—is examined to check fixes and consecutive numberings.

(b) A " collector " tracing with " points " and essential details—from a metallic standard sheet—is then placed over and in relation to the working sheet graph, and the survey course and fix points transferred with numberings. This automatically compares working sheet or graph with the standard on metal, and paper distortion is incidently checked.

(c) The intervals between fixes are then sub-divided as above to correspond with the Echo record sub-division. (See Fig. 7a).

As Echo record and collector tracing are now ready, all that remains to be done is to read directly the reduced soundings by scale from the Echo record and inscribe them upon the tracing at their appropriate positions, interpolating any greater detail that may be required.

As a check line can be run across the pattern of soundings during the survey, a complete check upon consistency is thereby given.

The result is then contoured, and further examination made afloat wherever the contours appear to be incomplete or bottom features and tendencies suspicuous. (See Fig. 8).

Again the value of a sounding beam or " cone " giving a lane " of closely-examined area, as against a series of points sounded by a lead, is very great indeed.

The labour and cost of identifying pinnacles or submerged piles in the past is by this means eliminated so long as sounding lines are so spaced as to arrange for " bottom areas " to overlap each other.

The writer has found no difficulty in examining dredged areas by lines run 15 to 20-ft. apart, and maintained sometimes by compass alone. As one who has continuously used the instrument for the determination of dredging quantities, and final passing of dredged depths, he feels that he has given this machine a most exhaustive test, and that given a true knowledge of all factors concerned, an accuracy in final plotting to 3-in. of depth up to 70-ft. is definitely attainable in practice.

In concluding these remarks upon the actual use of this instrument, the independence of tidal streams should be mentioned.

In lead survey work, it is clear that good work cannot be done in a strong tide-way, for even if "up and down " casts are *apparently* obtained, sub-surface variable currents or " slacks " will " sag " the line, unknown to the Surveyor, and give him the fatal excess over true depths.

In Echo work, the shortest interval to the bottom is recorded independently of the relative movement of the water past the survey vessel, and there are therefore only three factors to be satisfied if emergecy requires a survey in a strong tide-way, as embodied in the following questions:—

(1) Is the visual tide gauge used well manned, near enough and so free from hydraulic obstruction as to assure the Surveyor of precise representative levels for the area of survey?

(2) When the survey vessel is steering against the tide, will her essential speed through the water be increased above the " aeration " limit for the craft used?

(3) Are there sufficient shore marks, and long sensitive transits available to enable the craft to make a well-spaced pattern over the area requiring examination?

If these three questions can be answered in the affirmative, there is no reason why such a survey cannot be made in a very satisfactory manner by a seaman-surveyor.

Also, there need be. no qualms about very shallow water work, providing separation error is carefully watched.

The writer has made a detailed survey of a South Coast tidal river, whose bed dried out 2-ft. at M.L.W.S., the Spring range being only 13-ft. The margins up to the points drying out 8-ft. at M.L.W.S. were included, and the results were rapid and most satisfactory.

Fig. 10

When considering the maintenance of this instrument, one finds that £4 easily covered spares, and odds and ends for the first year.

The cost of Echo rolls (wet starch iodine paper) amounted to £12, but the amount of work carried out was easily four to five times that done by lead sounding.

The good weather periods were used to the full, and were sufficient to maintain a full survey programme without any " weather hindrance."

Most of the time of an Echo survey department is employed in interpreting and plotting a set of records which the drawing office sometimes, and not unnaturally, regards as a surfeit!

Efficiency, however, is well served, and the work afloat confined almost completely to ideal conditions for precise measurement without departmental slackness.

The application of Echo principles to salvage work, is already proving a very great advantage to both the Port and Deep-sea Salvage Officer.

By its means, he can closely search a given area in record time, and having located a sunken vessel, can determine the least depth over it, whether it is lying upright or on its beam ends, how much of it is settled into the mud, and also by steering over it, in at most three directions, the direction it is lying on the bottom. (See Fig. 9).

If it is upright, in fairly shallow water, and he desires to make a salvage lift by camels or lighters, he can "break-down" funnel and masts by a wire sweep, and then find, by Echo sounding, the safe clearance above the hull before placing his camels in position, and heaving down for a good "lift."

In deep-sea salvage work, the name " Lusitania " is a sufficient reminder of the value of Echo " search." Fig. 10 is a reduction of an actual photograph of the record used in the location of this vessel and needs no comment.

As the M.S.X. instrument will record a bar 3-in. wide at 50-ft. quite clearly, it will not sound surprising that the writer located a lost anchor in Southampton Wafer after searching for 10 minutes.

The liner which had lost it during the early hours of the morning, sailed with it securely housed in the hawse-pipe the same evening.

The value of Echo work to the Harbour Officer desirous of getting about a harbour in a fog or " black-out " is immense, as the channel contours can be used by watching the Echo record and steering as requisite by compass to maintain the courses along them.

The writer knows at least one large British port where the " wreck chart " of the harbour has been much added to since Echo survey principles were instituted.

There are, however, still further applications of this instrument, one being the determination of times and places in tidal estuaries where silt in suspension is concentrated.

Not only is a light silty bottom distinguished from hard rock-like layers beneath it, but the record clouds at the points where silt in suspension-at certain concentrations-intervenes between oscillators and the bottom.

As the depth of this layer can be seen on the record, it is a simple matter to " visibly " lower a large " silt bottle " into this layer and take a sample.

Also it is possible to run lines across a certain critical section, at stated intervals, throughout, say, a 24-hour period at Spring tides and relate times in the two tidal cycles to the times of clouding, and also the depths at which this occurs.

It would appear, however, that for practical purposes the main avenue for improvement lies in the method of recording the bottom upon the wet starched iodine paper.

The makers of the instrument are, however, well alive to these problems, and research is proceeding apace.

One has no doubt, that the results will be no less complete and successful than those other achievements, so brilliantly embodied in the M.S.X. instrument.

The writer has had next to no difficulty over such minor details, and after over a year's constant use of this instrument he must, as a practical seaman and hydrographer, state it to be his considered opinion that the M.S.X. instrument is a real boon to a Harbour Surveyor and is, in his experience, the only instrument or device capable of giving an incontrovertible and readable accuracy to within 3-in. of depth over a range of 70-ft. under way.

In saying this, however, he would again reiterate that it is most necessary to such accuracy that all the factors affecting the depth record should be mastered and considered.

The resulting accuracy and increased frequency of survey cannot fail to commend themselves to the Hydrographic Surveyors responsible for the waterways of our Ports of Empire.

Echo Sounders in River Plate Trade

It is generally agreed by navigators that the rivers flowing into the large shallow -estuary known generically as the River Plate, are among the most difficult from a navigational point of view. The Estuary itself is no respecter of ships which are inadequately equipped with navigational devices, and, as an appendix to the foregoing article, it is interesting to record that an Echo Sounder is now being adopted by important shipowners whose vessels' work is confined entirely to the Plate area. Among these is the Argentine Navigation Company (Mihanovich, Ltd.), who have recently fitted a Husun British Admiralty Pattern recording Echo Sounder, type M.S.XIIC to their ship "Cuidad de Montevideo." This ship, with a sister vessel, operates a night service across the mouth of the Estuary between Buenos Aires and Monte Video, in accordance with Railway Schedule, so that accuracy of navigation is of the utmost necessity for the safety of passengers and of the ship.

THE FIRST THOUSAND YEARS OF FINDING NEW YORK

Thomas M. Price, Jr., Assistant Cartographic Engineer
U. S. Coast and Geodetic Survey

"Ten pounds to hym that found the new Isle", runs an entry of August 10, 1497, in the privy purse accounts of King Henry the Seventh. Thus the sovereign rewarded the mariner who discovered the continent of North America for England.

A contemporary of that day writes, "The king has given him (John Cabot) money wherewith to amuse himself" (until his return voyage). From this it might be assumed that Cabot, "the Great Admiral", got the ten pounds himself, but many historians contend that this small present was given to the sailor who first sighted land. In either case, it was fortunate for the receiver that King Henry did not suspect the truth of the situation, or the reward might have been ten years in London Tower; for instead of having reached the coast of "The country of the Great Chan", those on board the MATHEW had unknowingly run up against what was to prove for many years a most annoying and unwanted barrier to those desired lands of spices.

Cabot, who "by the commandment of the king had found the new-discovered lands", had in reality probably only *RE*-discovered our North Atlantic Coast, which we now believe to have been frequently visited by other Europeans long before this date. The earlier visits are thought to have continued, interruptedly perhaps, throughout 400 years, but the energy of the heroic Norsemen had then been expended and the importance of their colonies in Iceland and Greenland declined so fast, that one intervening century had been enough to erase from the memory of man the previously acquired knowledge of the land to the west and south of Greenland.

The account which follows concerning the Zeno brothers and the origin of their chart was given out by the descendant in the Zeno family who later produced the map, which he said he found while rummaging through some old family papers. A howl of "Fake!" arose, particularly from the Spanish, who said the whole business was concocted to detract from their glory as discoverers of the New World. Historians are divided in their opinion of the Zeno story, as they are on many undocumented matters, including the interesting pre-Columbian voyages of the Norsemen. Most competent critics, however, accept the authenticity of the Zeno map and the voyages described here.

Nicolo Zeno, Venetian merchant, nobleman, soldier of fortune, lost his course in the North Sea in 1390, put in at the Faroe Islands, assisted Henry Sinclair, the Earl of Orkney, in a successful rebellion against the King of Norway, and was rewarded by being made Prime Minister and Chief Admiral of the Faroe Islands. Soon his brother Antonio arrived from Venice to join him and together they spent many years in the north, at various times making excursions to Iceland, Greenland, and other places in the North Atlantic. The knowledge accumulated from their own voyages, and the information derived from years of contact with the men of the north, were summarized in chart form by Antonio Zeno. Although this chart (figure 1a) was drawn in 1400, Europeans had no knowledge of its existence until 150 years later. The copy given in figure 1a is from a transcription made by Dr. J. G. Kohl.

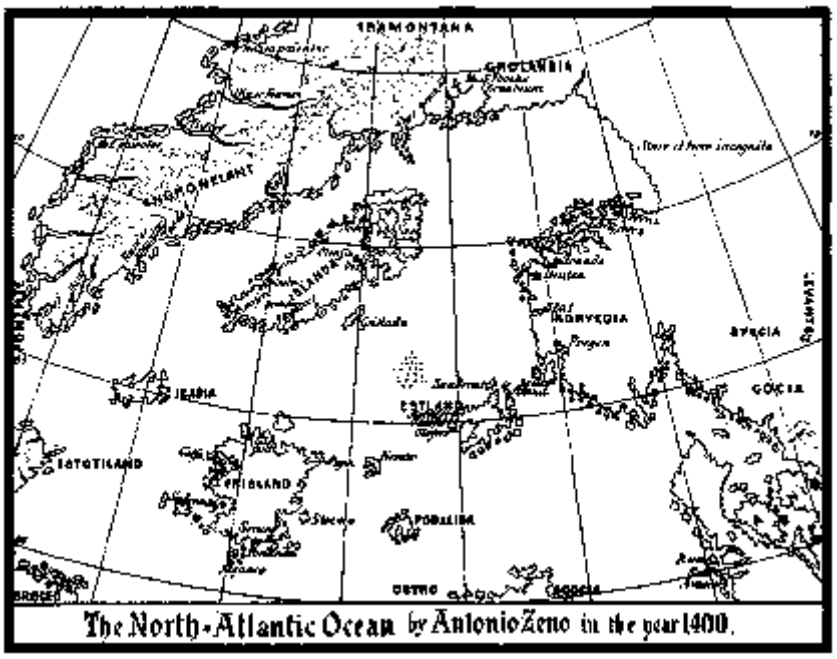


Figure 1a, from J. G. Kohl's copy of the original.

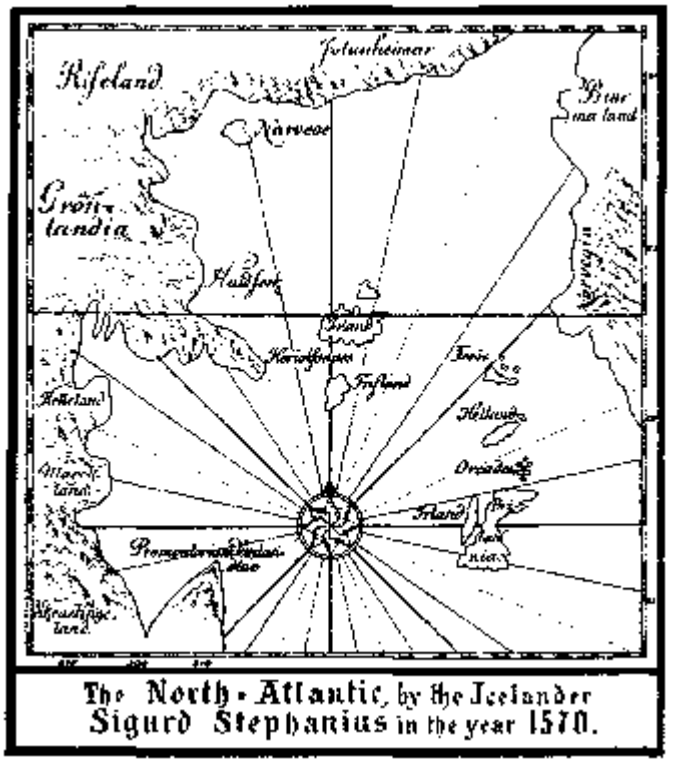


Figure 1b. From J.G.Kohl's copy of the original.

Maps reputed to have resulted from Norse discoveries in America from 1000 to 1400 A.D.

This chart is remarkable in being the oldest map known to us on which a part of the continent of North America has been shown. It is unlikely that the Zeno brothers visited "Estotiland" (East-out-land, probably Newfoundland or Nova Scotia), or "Drogeo" (New England and New York?). Their delineation of this part of the map was probably based on tales which they heard of voyagers driven by storm far to the west, and of traditions at that time still existing among the Norsemen of their earlier communication with these places. The projection was not on the original manuscript but was added when the chart was rediscovered in 1558. Even after this late date, the map was used as a sailing guide by several explorers, one of them being Erobisher.

There is no direct evidence that the old Norsemen made any charts themselves. At present the only proof of their voyages to this continent lies in the ancient written chronicles of Iceland and the Scandinavian countries. But an example of what a Viking cosmographer might have drawn about North America is shown in figure 1b. Although this chart was not constructed until 1570, no other source of information is known that could have resulted in the configuration given the North American Coast, except possibly lost Icelandic originals of Norsemen maps. The names shown are the same as the Norse are credited with having used for several centuries to designate the outstanding features they found in the different sections of our country. It seems probable that "Helluland" (land of the flat stones) is Labrador; "Markland" (land of the woods), - Nova Scotia or Newfoundland; and Vinland, the name applied by Leif, son of Eric the Red, must be somewhere in New England, where Leif wintered in the year 1000. "Cape Kialarnes", meaning ship's nose, has sometimes been identified with Cape Cod. Its resemblance to the prows of their Viking vessels seems to have impressed it on their memory.

Documents preserved from Viking times are reputed to exist which give us our first birth record of an American-born child of European parents. He was named Snorre. There are also accounts of foreign trade in American products, such as furs and precious woods (birdseye maple?), and a good profit was said to have been made therefrom. In their explorations, the Norsemen probably coasted our New England shores; perhaps they even saw Manhattan Island. Regular intercourse seems to have been set up between North America, Greenland, Iceland, and thence to Norway. This continued until 1347 at least, when a short notice in the old Icelandic Annals of that year states: "A vessel having a crew of seventeen men sailed from Iceland to Markland". That is all. It is cited as briefly and casually as an ordinary occurrence.

What did they sail by, these early Norsemen who are reputed frequently to have steered their 80-foot longboats under sail and oars to Markland and Vinland-the-Good? If, as the story goes, it was by the mischance of being caught in a northerly gale while en-route from Iceland to Greenland that carried the first arrival, the young Norwegian trader Bjarni, within sight of our shores, how did those who intentionally followed him reach this pleasant new land of which he told? It appears that the Vikings must have carried out their extensive successful explorations, and fearlessly and assuredly traversed long stretches of open sea entirely by dead reckoning. Generations of seafaring, of daring the violent North Sea far from the sight of land, must have given them an extraordinary ability to judge their direction by the sun and the stars, and to estimate the speed of their vessels under various conditions of

wind and current. They needed nothing more to tie able to make a landfall at Newfoundland, and from there to follow the coast southwest to the great hook of Cape Kialarnes.

The navigators of the Western civilization who first sought to cross the Atlantic were much better equipped. Besides having the mariner's compass and the astrolabe, they had such excellent guides as the globe, a section of which is reproduced in figure 2. Exactly what globes and charts either Columbus or Cabot carried on

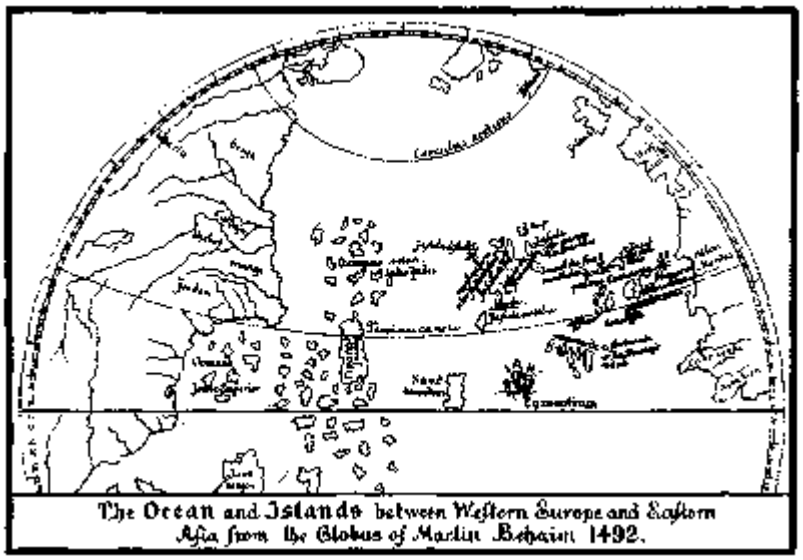


Figure 2. From J. G. Kohl's copy of the original.

Similar globes were carried by Columbus and by Cabot on their first voyages.

their first voyages is no longer known. That they relied on the maps of Toscanelli, as long averred, is now often denied. In any case, it is fairly safe to assume, that the globes they depended on, embodied very much the same geographic notions and were constructed on the same principles as this one of the well known German astronomer and cosmographer, Martin Behaim.

By the astrolabe and cross-staff Columbus could observe the altitudes of celestial bodies and compute his latitude, but no method, except dead reckoning, had yet been introduced by which he could obtain his longitude at sea. Another inconvenience, which he noted before his first voyage was over, was the variation of the compass. This phenomenon caused great distress among his sailors. Needless to say, Columbus was also handicapped by having Cipango (Japan) on his globe where America should have been.

At the time that Columbus made his momentous voyage, there was a certain merchant from Venice, Giovanni Caboto, residing with his three sons in Bristol, England. This merchant, John Cabot, as he is known in English, like Columbus, was born in Genoa. Like many others when they heard of the successful undertaking of Columbus, it is probable that in the heart of Cabot "this fame and report in-

creased . . . . . a great flame and desire to undertake something alike notable". The regular profession of merchant, doctor, licentiate, or even the holding of a university degree in those exciting times did not prevent one from being also a navigator, astronomer, and cosmographer. On short notice one might become a naval commander, a discoverer, the conqueror and governor of half a continent. Witness Amerigo Yespucci, whose name has been perpetuated above all the others, and who was a clerk in a mercantile house.

Sebastian, one son of the merchant Caboto, had gained at an early age, under the instruction of his widely traveled father, a love of the study of geography and navigation. It was said of him that he had acquired, "some knowledge of the sphere. He understood, by reason of the sphere, that if one should sail by way of the northwest, he would by a shorter track come to India than that by which Columbus had sailed". In other words, he had apparently figured out the advantage of what we now call great circle sailing.

It was with this idea in mind, as well as from the desire to avoid the Spanish discoveries in the south, that the vessel which the Cabots and their friends had furnished, fitted, victualed and armored at their own expense, sailed from Bristol in May, 1497. The course was set to the north and the west for a short passage to Kathay. In three months the MATHEW returned to England and was received with great joy because it was believed that the voyagers had discovered among other things "the island of the Seven Cities" and a "large tract of firme land" which must, it was thought, be a part of China.

With great hope and confidence, and now enjoying the financial as well as the moral backing of the king, Cabot made immediate preparations for a return. This next expedition left Bristol in May, 1498. Unfortunately, the charts and journals of both Cabot's voyages are lost, and our information must be gleaned from the contradictory and illusionary reports of contemporary historians. But the best assumption is that, on this second voyage, Cabot made a landfall in the vicinity of Greenland, crossed Davis Strait, and coasted southwestward at least as far as Delaware or Chesapeake Bay. Since he was trying always to work farther west, he may have sighted Sandy Hook.

Had it not been for these voyages, which are the foundation of all English claims to North America, we might be speaking Spanish instead of English in this country today.

The results of the Cabot expeditions were depicted on a map of the world constructed two years later by Juan de la Cosa. Cosa was one of the most celebrated Spanish navigators of the time. He had been master of Columbus' flagship on his first voyage, and had served as cartographer on a later voyage. He is best remembered, however, by the famous chart he drew (figure 3), which is the earliest known on which a great part of the American continent appears. The drafting was done in colors, with the greatest care and exactness, on a 3 by 6 foot piece of oxhide. It was drawn to include the entire world, and to show particularly all the latest discoveries. On this map, the northeastern portion of North America is joined across the North Atlantic to the continent of Asia - the world of that day was "without" a Pacific Ocean.

In cartography this map holds a position similar to that which the Canterbury Tales hold in English literature. That is, it makes

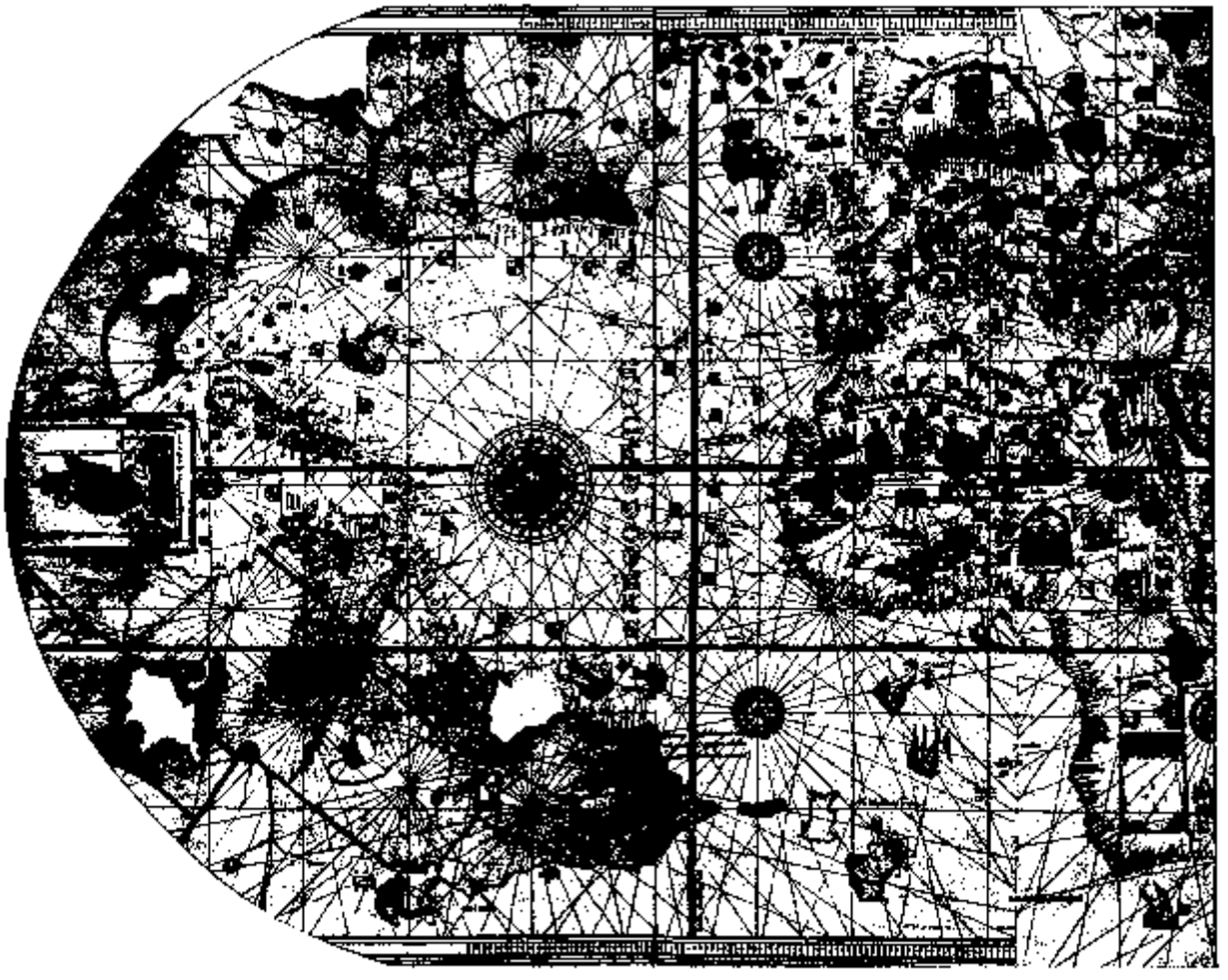


Figure 3. Chart of North Atlantic Ocean by Juan de la Cosa, 1500.

a good starting point in the study of maps as developed by Western civilization. Let's see what was known about it at that time. In the first place, the projection and the orientation (north above, and east to the right) were derived from the principles laid down in 150 A.D. by Claudius Ptolemaeus (Ptolemy), a Greek of Alexandria. The work of Ptolemy, however, had been lost to mediaeval Europe until revealed by the expiring Byzantine. Empire, about the middle of the 15th century, which was less than a hundred years before Cosa's map was made. Ptolemy is also said to have been the originator of the conic projection, but on Cosa's map, as on most others of his time, the simplest of all projections was used: a system of parallel equidistant straight lines. Maps so constructed were known as "plain charts", and navigators were not unaware of the difficulties of "sailing by the plain chart, and the uncertainties thereof".

Cosa put on his chart a border graduation to indicate the degrees of longitude, but nothing except the equator and Tropic of Cancer by which to indicate the latitude. The names "latitude" and "longitude", by the way, are of very ancient origin, having been handed down from the fourth century B.C. by the people along the Mediterranean Sea who conceived the earth as one and a half times longer east and west than north and south. As a prime meridian, Cosa took, as was the custom of that period, the farthest point of the Canary Islands as an origin for longitude, which had continued from the days when the Canary Islands were thought the western limit of the world.

In viewing Cosa's map one is forcefully reminded of the all important part which the magnetic compass then played, not only in navigation but in chart construction as well. The numerous diagonal lines, which radiate from crossing points and compass roses distributed all over the map, are loxodromes, meaning "slanting-course" lines or rhumb lines. These were used to show the approximate bearings between various places and enabled the mariner to set his course. Loxodromic lines first appeared on charts shortly after the mariner's compass came into use in the early part of the 14th century, and for 400 years thereafter these spider web lines still continued to cover most charts.

The best-sellers in maps, during the period of the discovery of the New World, were editions of Ptolemy's "Geographical Guide". This world atlas was over a thousand years old before it became available to western culture and was translated into Latin in 1410. Instead of being received as a quaint antique, it was seized upon as a vital discovery; it extracted from darkness the very world in which the people were then living.

It spread at first by numerous hand copies, and in 1462 (?) was printed. These maps were not only the first to be published in print, but also are among the oldest known specimens of copper-plate engraving. The atlases of Ptolemy, in various editions with new and corrected information, were published as the most popular form of geographical knowledge, for a hundred years.

A great advance in collecting correct information for charts of the newly discovered seas was occasioned by the creation in 1503, in Spain, of the "Casa de Contratacion". This was a state institution established by the king as a court of admiralty, in order to concentrate in one office all transactions relating to the new world. A school of cosmography was established in connection

with it. Provision was made, a few years later, for the construction of an official pattern map. This was to be made by the pilots of the Casa de Contratacion under the supervision of Amerigo Vespucci, then pilot-major. This model map, called the "padron real", was to embody the results of all discoveries to date, and the use of other maps was forbidden. All pilots were ordered to report everything worthy of note to the Casa de Contratacion as soon as they returned to Spain.

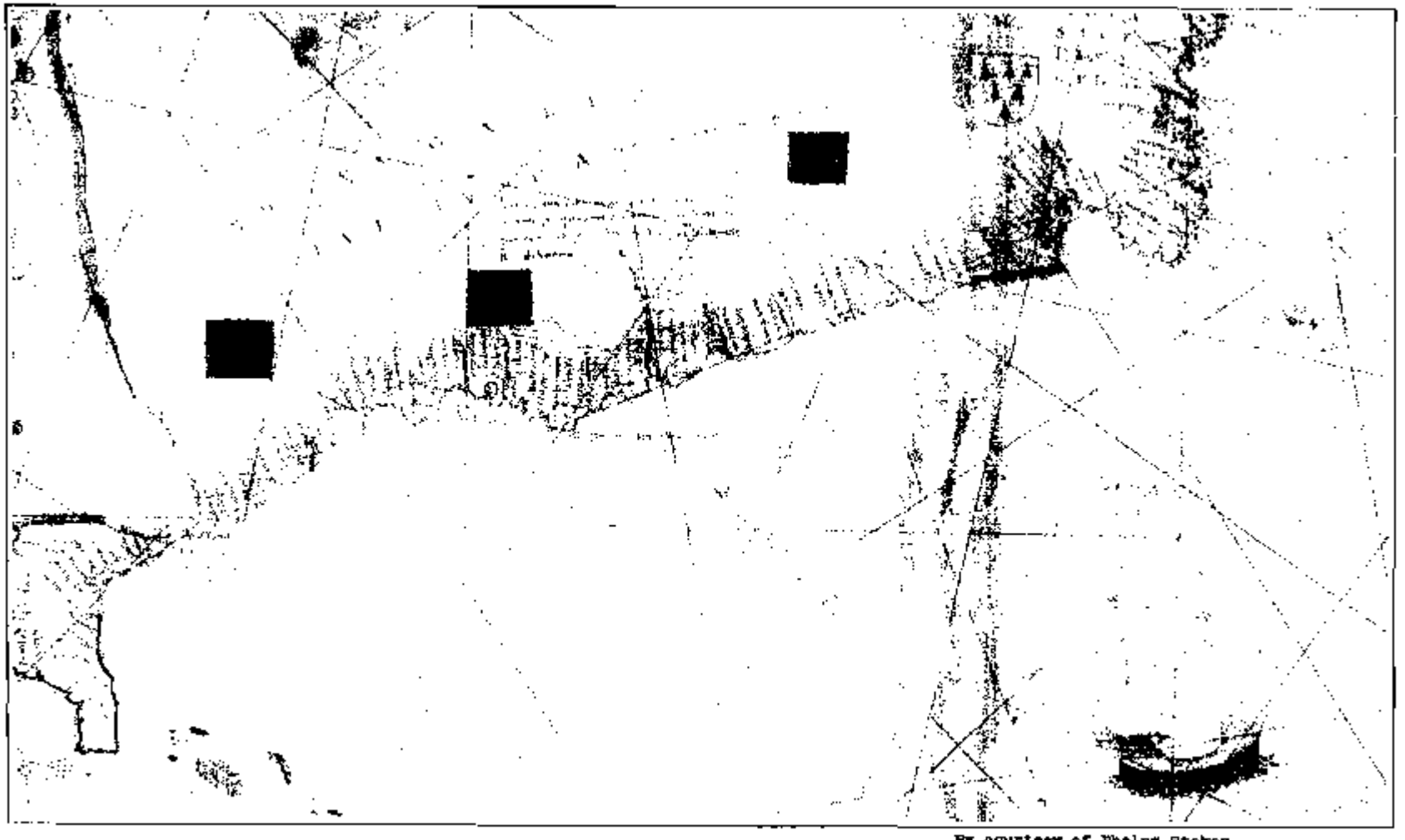
To sit at a convention of the Casa de Contratacion was to be seated beside such men as Gomez, Sebastian Cabot, Vespucci, Hernando Colon, Ribero, and to decide, as in 1524, such difficult problems as the division of the world between Spain and Portugal.

Copies of the padron real could be obtained for a fixed price. At least they could be obtained by certain authorized Spaniards - not others, because it was explained that "it would not sound well to them that a stranger should know or discover "their secrets". An unofficial sketch of the padron real that reached the hands of an outsider would be "a cause of pain to its maker". But the padron real did not prove to be a perfect solution, and the emperor, Charles V, in 1526, hearing that existing sea-charts were still uncertain and contradictory, appointed a commission of pilots and cosmographers to correct the Spanish charts, bring them into harmony, and make such additions as were required by new discoveries. The name of the official map was changed to "padron general", and orders were issued for it to be verified by the pilot-major twice a year.

There were many important charts resulting directly from explorations in the New World, which were never printed and, if reproduced at all, were laboriously copied by hand in very small numbers. This original scarcity has left us with no known copies of certain charts, known to have existed originally, such as those which Henry Hudson must have prepared after his trip up the great North River. Occasionally one of these buried treasures is even now unearthed and a recent fortunate find in the Vatican at Rome was a chart which shows the results of the voyage of Verrazano, one of our earliest explorers. (See figure 4.)

Thirty years after Columbus had discovered the West Indies, and after Vespucci had explored South America, and Ponce de Leon and Vasquez de Ayllon had sailed the coast of Florida and Georgia, and while Cortez was completing the conquest of Mexico, and Pizarro was entering Peru, the King of France suddenly decided that "he did not think that God had created those new countries for the Castilians alone". He forthwith commissioned an experienced navigator of Florence, Giovanni da Verrazano, to cruise against the Spanish, and also to discover a northwest passage to the Moluccas.

Various misfortunes, before departing from Europe, having reduced the number of his vessels from four to one, Verrazano decided to leave the Spanish alone, and to turn his ambitions toward new discoveries. Thus the DAUPHINE early in 1524 left the Madeira Islands on a western track, but after meeting "with as violent a hurricane as any ship ever encountered" the course was altered by "a little deviation to the north". Forty-nine days after the departure, land was sighted. From his landfall, near Cape Fear, he coasted southward searching for a suitable place to repair his ship and take on water, but after seeking 50 leagues in vain, he turned back up the coast. All the country was sandy and low, - sailing



By courtesy of Phelps Stokes.

Figure 4.

Girolamo Verrazzano. 1529.

northward for two hundred leagues "he never saw a stone of any sort". Then one fine spring day the sea-weary adventurers "found a very pleasant place among some little steep hills, through which a very large river, deep at its mouth, forced its way to the sea," and he adds "From the sea to the estuary of the river any ship might pass, with the help of the tide, which rises eight feet". He observed that up to this point the coastline had run for a long distance from the south but afterwards, "it trended for fifty leagues or more toward the east".

In the long letter which Verrazano wrote as a report to his employer, Francis I, he gives to the Old World its first description of the harbor which was to become the site of the chief city and greatest port in the New World. In order to gain knowledge of the mouth of the river before venturing in with the DAUPHINE, "we took the (small) boat and, entering the river, we found the country on its banks well peopled". The inhabitants were "dressed out with feathers of birds of various colors". Then, "we passed up this river about half a league, when we found it formed a most beautiful lake (bellissimo lago), three leagues in circuit, upon which (the natives) were rowing thirty or more of their little boats from one shore to the, other, filled with multitudes who came to see us". The "most beautiful lake", surely, is the Upper Bay. The reception which the natives gave suggests the appearance of New York Bay nowadays, upon the first arrival of a "Normandie" or a "Queen Mary".

Verrazano then went back and brought the DAUPHINE in over the bar, anchoring at the Narrows, or as he says, between "little steep hills". From here, he and his followers could gaze with admiration across the spacious harbor, with its rolling wooded shores; and certainly they must have espied that island which was to be known later as Manhattan.

From New York Harbor they apparently sailed along the south shore of Long Island, running into a "beautiful port" (Narragansett Bay?), and were much impressed with a hilly triangular-shaped island which they named Luisa (Block Island or Martha's Vineyard?); they seem then to have rounded the shoals of Cape Cod, coasted along Maine, taken their departure from Newfoundland, and arrived back in France only five and a half months after they had set sail from Madeiras. (figure 4.)

In this new country, which he enthusiastically declared, "never before had been seen by anyone either in ancient or modern times", the zealous explorer told his royal patron he had seen inhabitants "like the people of the east parts of the world, and especially like them of the uttermost parts of China", also that "these new countries were not altogether destitute of drugs and spicery, pearls and gold", the latter he thought being "denoted by the color of the ground". It is believed by some that Verrazano later returned to this land of opportunity and was killed by the Indians; others have the opinion that he met his fate at the hands of the Spaniards, who hanged him as a "corsario" (pirate) for intruding in their particular domain.

The discoveries by Verrazano were incorporated in chart form (figure 4) by his brother Girolamo (also known as Hieronemus), five years after the voyage. The chart was compiled from notes which Verrazano had kept during the voyage in "a little book", now lost. We see the customary loxodromic lines, and the prominently displayed flags and coats of arms identifying the sections of the new

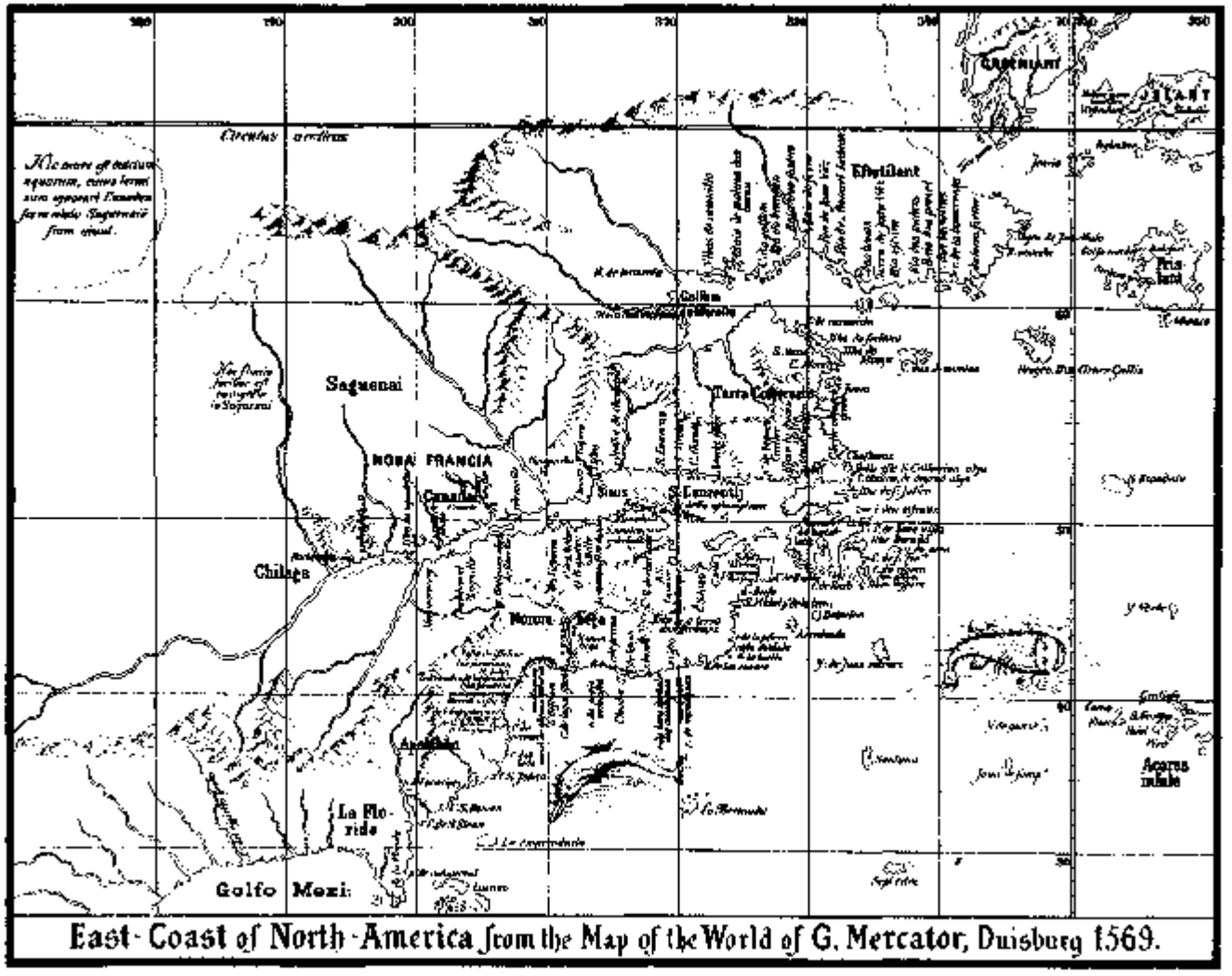


Figure 5. From J. G. Kohl's copy of the original.

Chart on which first Mercator projection was drawn.

lands claimed by the various European sovereigns. Outstanding features Verrazano shows are the shoals off a point, which has been identified with Cape Cod and numerous names assigned to rivers, capes and bays all along the coast. With a little imagination such prominent features as Cape Hatteras, Sandy Hook, the mouth of Chesapeake Bay, and Delaware Bay may be found on the map, although none of the names was established even at the time. The names "San Germano" and "La Victoria" may be found in what seems to be Lower New York Bay. In viewing this chart it should be remembered that the delineation of the coast from Florida to Newfoundland is the result of only three months on the "working grounds" and was plotted from notes only.

Verrazano's discoveries around our present New York, and those of Estevan Gomez who followed shortly after, affected maps in the immediately succeeding years, but the ever bright hope of discovering a short passage to the Indies, gradually eclipsed such lesser findings. By 1568 the knowledge of our coast from Maine to Florida had become so dim that on Mercator's World Map, the finest of that day, the shores of New York and Connecticut have been replaced by a large gulf (in Latitude 40° to 42°). (Figure 5)

Gerard Mercator, whose German family name was Kremer, was an accomplished engraver and maker of scientific instruments who devoted nearly his entire life to geography, and map making. His most important work was the making of a map of the entire world which he accomplished with the aid of his two sons at Duisberg, Germany, in 1568-9. On this map he combined in one grand view, upon eight large sheets, all his geographical knowledge of the globe. It was engraved on copper but what was more important, it was given a new projection of Mercator's own invention and what has proved to be in many respects the most useful projection ever created for navigators. A tracing of a part of this map is reproduced in figure 5. Note the delineation of the Appalachian Mountains which are shown for the first time in proper relation to the Atlantic.

In contrast with Verrazano, a "field man", Mercator was a studious cartographer, an "office man", who compiled his maps entirely from a careful study of the reports and charts of others. The result was fortunate in some cases, as in the St. Lawrence River area, where Cartier's discoveries were perhaps better depicted than was done by the explorer himself. On the other hand, several previous charts, which evidently were not available to Mercator, had shown the Atlantic coast southwest of Maine much better. Following the same accepted principle of good charting which we practice today when we retain rocks not disproved, Mercator carried forward from old maps various traditional islands out in the Atlantic Ocean, such as that of St. Brandan, which have since proved to be entirely imaginary.

Altogether the new chart was a great success. It was spoken of as "the never enough praised universal chart" and its maker was hailed as "the Ptolemy of our age". By 1852, however, there was only one copy of the once renowned map known to be in existence. But the projection had not been so readily forgotten. About the time of the cartographer's death, Edward Wright defined the principles of the projection which Mercator had left unexplained and it gradually attained extensive use. Even so, we find 18th century nautical writers reporting that still "some prefer the plain chart" (plane-chart).

Among the factors which led to the preeminence of the cartographers of Holland during the 16th century, was the production at Leyden in 1585 of the "Spiegel der Zeevaart" (Mariner's Mirror) by Lucas Janszon Waghenaer. These were the first sea charts to be printed as a collection. In several places on these maps soundings were given. This collection was so much appreciated by the seafaring nations of Europe that it was republished in many editions and translated into several languages. The example was followed by Willem Janszon Blaeu who established a map firm in Amsterdam in 1612 and turned out a Zee-Spiegel of his own in 1623 consisting of 108 charts.

Although the methods of making available nautical information more accessible ana understandable to mariners made large strides, there was, between the middle of the 16th and first of the 17th century, a noticeable lack of new information concerning our coast. This 50-year intermission, during which little new geographical knowledge of importance seems to have been gained concerning the east coast of North America, forms a natural dividing line between the age of widespread exploration and discovery, and the beginning of the era of settlement and colonization. The transition is at once reflected in the charts of the New World. Whereas hitherto maps had been small scale sketches, of a reconnaissance nature, seldom including less of the Atlantic coast than from Cuba to Labrador, after 1600 are found charts of particular areas, developed in detail on larger scales.

Stimulated by the explorations and colonizing attempts of Raleigh, and later of Gilbert and Gosnold, and now relieved to some extent of internal and European distractions, the English nation at the end of the 16th and beginning of the 17th centuries began to show signs of a more meritorious interest in America than simply as a place to traffic in slaves and to pirate Spanish galleons. The English rulers encouraged further search for a northerly route to the Orient, and failing in this, lent support to the founding of settlements in the extensive wilderness of Virginia and the land now called New England.

The new dominions having been discovered by individual enterprise, and cleared of excessive hazard by the sword of the state, there next were formed, in Europe, large trading companies to glean the commercial profits from the new fields. It is at this stage of development that Holland enters the North American scene. A 12-year truce with Spain signed in April, 1609, which concluded a long period of continuous warfare between those nations, now gave the Dutch country a chance to devote some of her energies to participating in the opportunities which the New World seemed to offer. Her long background of successful world commerce made her a formidable rival.

And so it was the Dutch East India Company that invited the Englishman Henry Hudson to Amsterdam after he had twice failed to find a northeast passage for the Muscovy Company of London. Hudson's lack of success had cooled the ardor of the English merchants, but the lesser discoveries he had made and the courage of his attempts, had spread his fame abroad. The Dutch merchants were anxious to have him try to find a short route to India for them, their own navigators having failed.

Among the papers that Hudson took with him when he went to Holland to discuss plans for the new expedition were certain let-

ters and maps which his friend Captain John Smith had sent him. In these Smith indicated that a passage to the Western Ocean might exist somewhere immediately north of the Virginia Colony, at Latitude 40°. Hudson proposed this route to the East India Company as well as one west of Greenland through Davis Strait. But the directors of the Company instructed him to make his search between East Greenland and the north of Russia; they forbade him to think of searching elsewhere, but promised that if he should fail there, another route would be considered for a subsequent voyage.

Thus the DE HALVE MAEN, of 80 tons burden, commanded by Hudson and with a crew of about 18 English and Dutch seamen, cast off her lines in Amsterdam on April 4, 1609 and headed across the North Sea to find an opening in the white barriers to the Northeast. Beset by storm, fog and ice, it soon became clear that Novaya Zemlya could not even be reached and Hudson then proposed to his crew that they choose between the alternatives of trying for a northwest passage through Davis Strait or in the vicinity of Latitude 40°. The sailors favored a warmer climate for the next attempt, and so we find them catching codfish on the Newfoundland Banks in July of the same year, and a few days later in a harbor on the mainland, stepping a new mast. From there they rounded Cape Cod, and then stood off to sea on a southwesterly course, making a landfall near Chesapeake Bay. Then they turned northward, coasting slowly not far from shore, looking for the expected opening. They tarried briefly in Delaware Bay. On the afternoon of September 2, there being but "little wind", the HALF-MOON was brought to anchor within sight of the highlands of Navesink. "A very good land to fall with," wrote a member of the expedition, "and a pleasant land to see". They came up abreast of Sandy Hook the next day, and the small boat sounding ahead of them toward the Hook finding no less than four fathoms, the ship was brought into Lower Bay, and came to anchor in five fathoms, "ozie ground".

For over a week the HALF-MOON remained in the Lower Bay, the men bartering knives and beads with the savages in exchange for tobacco and Indian wheat while the boats were busily exploring Upper Bay and the neighboring straits, sounding for the channels. On the 11th of September, recording soundings frequently, Hudson brought the ship up through Verrazano's "little steep hills", and came to anchor after running two leagues beyond the Narrows. This would place him opposite the Battery. The great river, salt from the strong tidal currents, seemed to be the answer to their dreams of a passage leading to the Orient. The following day they began the ascent, sailing by day and anchoring at night. At the end of seven days they were near the present site of Albany. From here Hudson sent his boats ahead some 25 miles further north to find a practicable channel, but convinced at last that the river was "at an end for ships to go in", he started back downstream, and on October 4, left "the great mouth of the great river". Going out he took the HALF-MOON, not through the Narrows, but through the straits west of Staten Island; from thence he "steered away east-southeast and southeast by east off into the main sea".

They arrived safely, November 4, at Dartmouth, England where ship, crew and Hudson, himself were detained by the English government. When the HALF-MOON was released the next spring, Hudson sent his charts and journal by his mate to the East India Company. These documents have unfortunately disappeared, but we do have excerpts from it, quoted by the historian De Laet in 1625. Also we have the entire journal of Robert Juet, who was the HALF-MOON'S clerk and possibly second-mate.

In March, 1611, Don Alonso de Velasco, Spanish Ambassador at London, sent to his king, Philip III of Spain, a special chart which portrayed the Atlantic Coast from Cape Fear to Newfoundland and included in considerable detail, Hudson River, New York Bay and Staten Island. (See figure 6.) With the chart Velasco sent a letter in cipher, explaining that the map had been secretly obtained. It was a copy, he said, of one made by a surveyor whom the English king had sent to Virginia the previous year, and who had returned "about three months ago".

The map is drawn in colors on four sheets of paper pasted together. The colors probably indicate the different surveys from which the original map had been compiled. However, only the use of the blue color is explained; a legend west of the Hudson River says: "All the blue is dune by the relations of the Indians". It is the earliest document on which the names "Manahata" and "Manahatin" appear.

It is claimed by some that this chart embodies the results of Hudson's discoveries. Others point out that although it is unquestionably of English origin, the information on this map must have been derived from sources prior to Hudson or the river would have been shown ending in a shallow stream instead of flowing from a great inland sea. If we accept the latter view, a chart similar to this may have been sent to Hudson by John Smith and was on board the HALF-MOON when it went up the "Great River". However, if this is so, why did Hudson say, when he approached New York, that he entered "an unknown sea"? But whether we believe that the first European to sail up the river was Hudson or give the honor to Verrazano, Gomez, or a still unknown adventurer, the important fact remains that after the voyage of the HALF-MOON trading voyages began the next year, and soon settlements were made which led to the regular colonization and occupation from which evolved, without interruption, the New York of today.

At last, after many "discoveries" of New York Harbor, which occurred throughout several centuries as side issues to greater hopes, we find the great port being explored for its own sake five years after Hudson's voyage. The commercial possibilities were recognized at once by Holland. The enterprising sea-captains and traders, Christiaensen, Hendricksen, Block, and Mey came over from the Fatherland and set to work systematically to examine the new country. Temporary shelters appeared on Manhattan. Adriaen Block built a ship for exploring, the first vessel ever launched in those waters. The RESTLESS was specially designed to combine seaworthiness with a shallow draft, and with it Block ventured through the dangerous channel between Manhattan and Long Island. He named the passage "Hellegat". Thence through the broad expanse of Long Island Sound, exploring along the north shore to Cape Cod, he was able to perceive what had not been recognized before - that Long Island was entirely separate from the mainland. Cornelis Mey meanwhile had been examining the south shore of Long Island. All together, the four of them "diligently explored the bays, creeks, and inlets of the immediate vicinity in every direction". The information thus obtained, drawn up by Block, was made into a Figurative Map which served as important documental evidence in the appeal of the United New Netherland Company for extension of its trading privileges in this territory. The United New Netherland Company was granted a charter in October, 1614, which declared: ".... that they alone shall have the right to resort to, or cause to be frequented, the aforesaid newly discovered countries situate in America between New France and Virginia, the seacoasts whereof lie

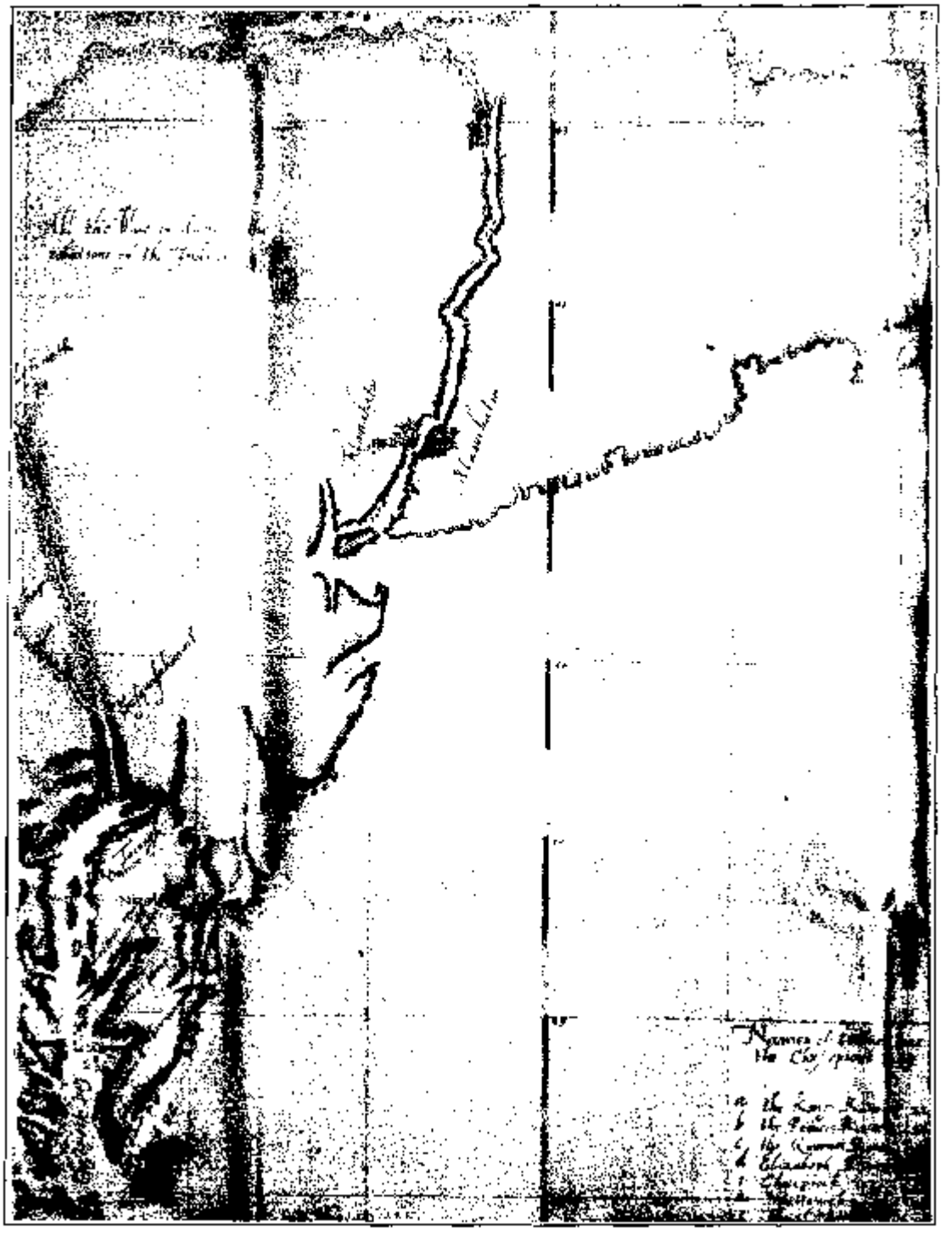


Figure 6.

By courtesy of Phelps Stokes.

in the latitude of from forty to forty-five degrees, now named New Netherland, as is to be seen by a Figurative Map, hereunto annexed, ...".

This is the earliest existing mention of the name Nieuw Nederlandt. The Figurative Map reproduced here (figure 7), which was laid before the States-General of the Dutch Republic when the petition was made for exclusive trading privileges, is an anonymous copy of the original made by Block. It is a beautiful map, drawn in gold and colors on vellum, and admirably preserved. Note the elaborate graphic scale. This type of scale seems to have come into common use about this time. Artistic flourishes, however, instead of being used to decorate the scale, were more often concentrated about the map title. This map was never published because every government was trying to keep its rivals ignorant of its achievements and plans.

For fifty years New Netherland existed as a Dutch province. The first actual settlement of which there is positive record, was made upon the arrival from Holland of Director-General Peter Minuit in the SEA-MEW, at Manhattan, in the Spring of 1626. On February 2, 1653 the City of New Amsterdam was incorporated by proclamation. The first survey and "plot map" of the city was made three years later by Captain De Coninck, a ship-master; it showed the existence of 120 houses. Four years after this, there were 342 houses. A public ferry plying between Fulton Street in Brooklyn and Peck Slip, NewYork had been in service since 1642. On Manhattan a canal was constructed, several streets were paved, a wharf and market built, a wall was thrown up to protect the city, and five bastions mounted with cannon to protect the wall. This was the wall that gave its name to Wall Street.

Many of the geographic names still in use in the vicinity of New York originated in this period. Long Island remains as the Hollanders christened it although the English later officially declared it to be Nassau Island. Staten Island the Dutch named for the parliament of their fatherland - Staaten Eylandt, the Island of the States. Coney Island was sometimes called Coneyn's Eylandt which implies that Coneyn was a surname, and sometimes 'T Coneyn Eylandt which means Rabbit Island. The Hudson River had been spoken of by Hudson as simply the Great River, but the Hollanders soon gave it the official title of Riviere van den Vorst Mauritius, but more commonly called it Noort Rivier - North River, a name extensively used by New Yorkers to designate it today. North River was applied to distinguish it from South River - Delaware River, the two great rivers of the New Netherland province.

One of the most interesting charts from the cartographic viewpoint, that was published during the Dutch occupation, is one that appeared in the Sea Atlas of Pieter Goos in 1666 (figure 8). In this the draftsman has confined his embellishments entirely to the coat of arms about the title; in the chart itself he has attended strictly to business. This chart is well in advance of its time. In its simplicity it is comparable to a modern offshore chart. Soundings appear distributed offshore as well as in the rivers. Shoals have been indicated by the sanding symbol and some equal-depth curves appear to be drawn. The chart seems to have been constructed expressly for the use of mariners. Apparently an attempt was made to give only those details which, in the opinion of the author, were definitely established; interior detail and other features not of direct importance to the navigator were omitted. The

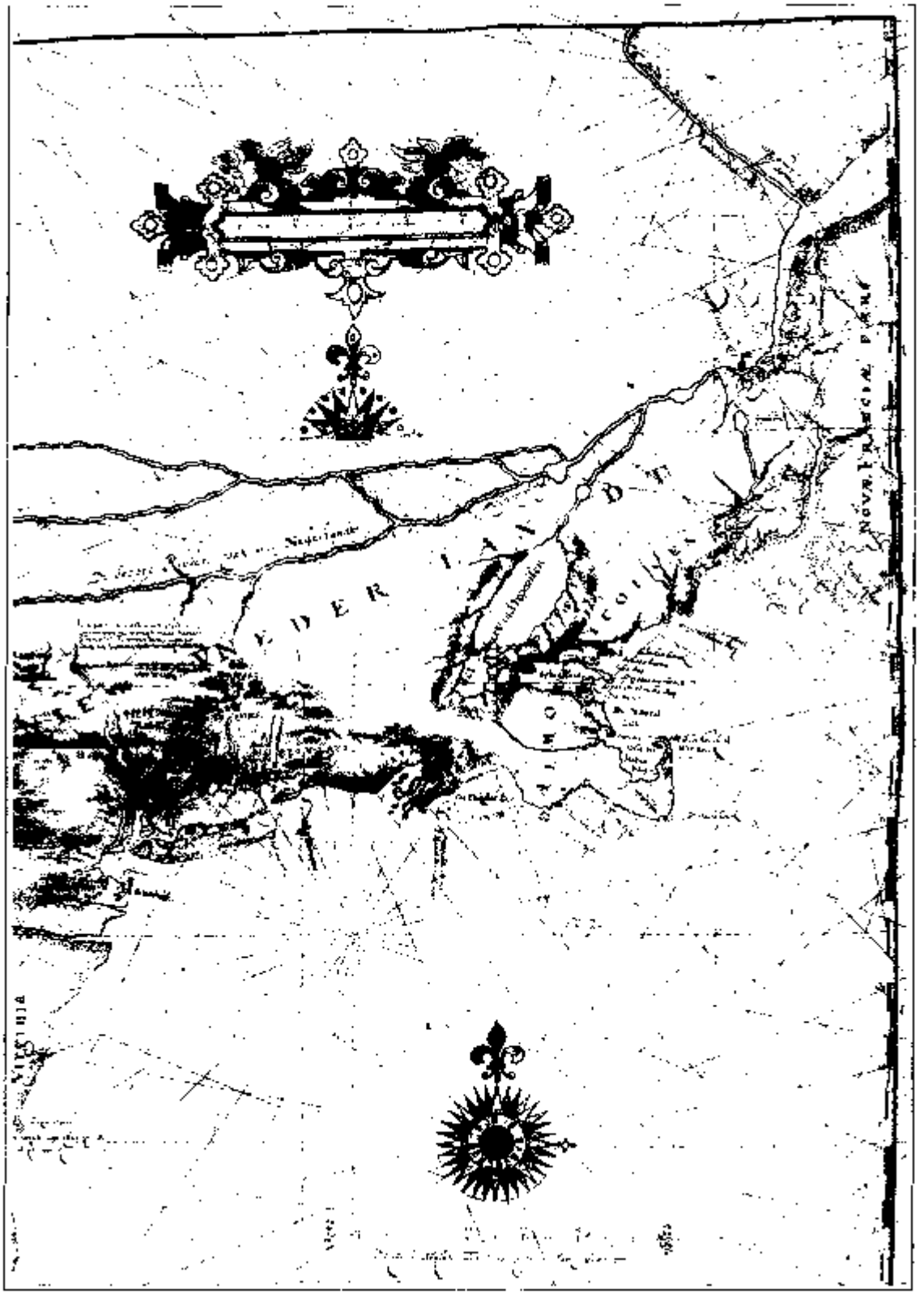


Figure 7. By courtesy of Phelps Stokes.
Figurative Map of Adriaen Block, 1614.

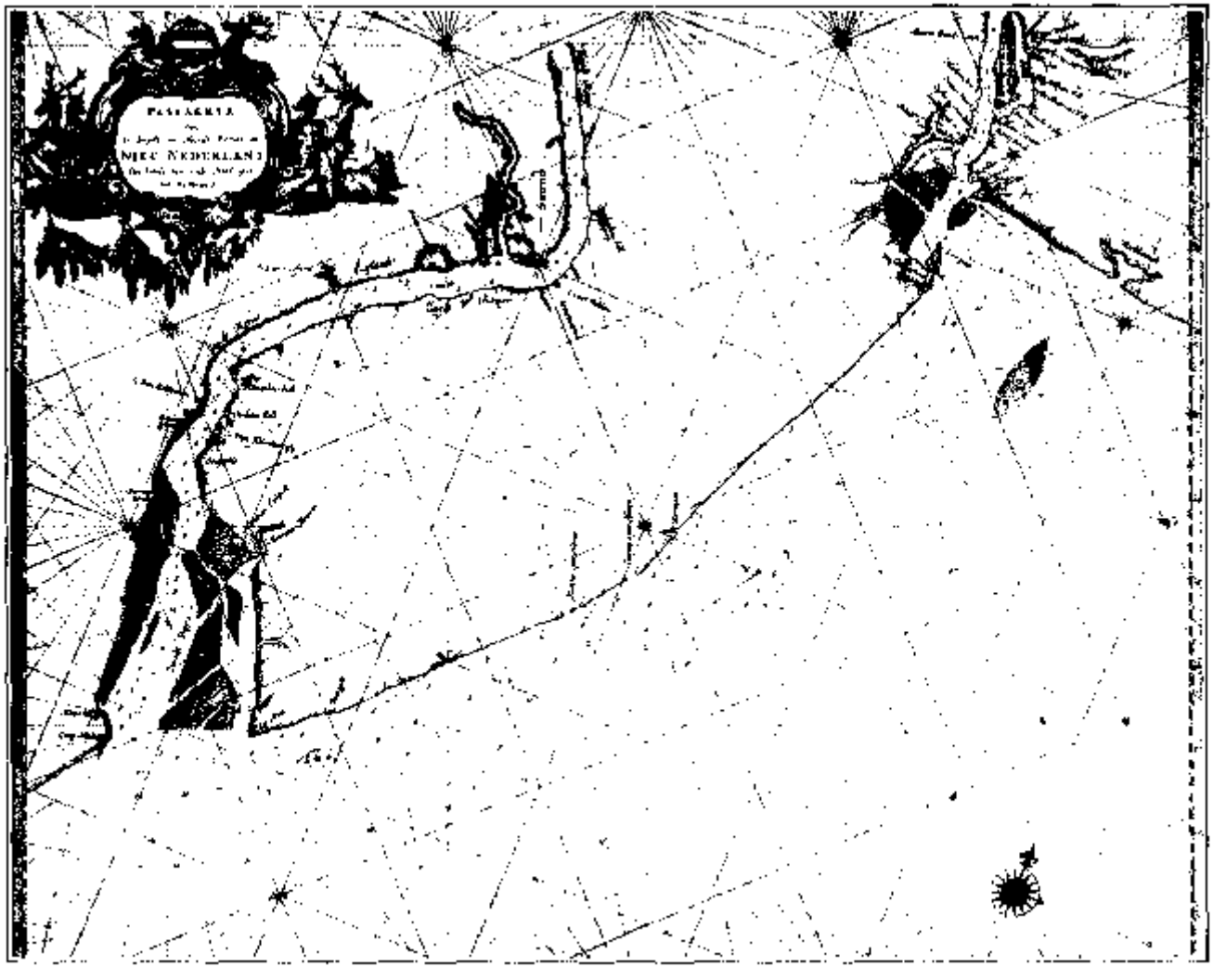


Figure 8.

By courtesy of Phelps Stokes.

Pieter Goos, c. 1660.

cartographer gained a little more coverage by making his projection on a skew but gave himself more work - note the slant put on the border latitude graduations. The original was engraved, 52 x 62 cm. in size and printed on paper. The title reads:

"Paskaerte van de Zuydt en Noordt Revier in Nieu Nederlandt streckende van Cabo Hinloopen tot Rechkewach"

"Chart of the Zuydt (Delaware) and North River in New Netherland drawn from Cape Henlopen to Rechkewach (Rockaway)".

The voyage to New Amsterdam from Holland usually took from six to eight weeks but often a much longer time. It was by way of the Canary Islands and the West Indies, passing northward between the Bahamas and Bermuda toward Virginia, and then up along the coast. A circuitous route, but it avoided the North Atlantic gales and enabled ships to stop enroute to provision and refjt. Approaching Manhattan, the Lower Bay offered immediate protection. From here by a channel deep enough for the largest ships, they entered the large landlocked Upper Bay, one of the world's few perfect harbors. There lay the island of Manhattan, placed and shaped like a great natural pier ready to receive the commerce of the world. The river that washed its western bank, navigable to the northward for more than 150 miles, was second in importance to none on the North Atlantic coast except the Frenchmen's River of St. Lawrence. Furthermore the harbor of Manhattan was advantageously placed midway between Newfoundland and Florida. It was a thoroughfare in a sense that was true of no other place on the American mainland, for those who voyaged between New England and Virginia preferred to pass through the safe waters of Long Island Sound. From the beginning New Amsterdam prospered - and she was envied.

The Hollanders had chosen the finest seat for commerce on the whole coast; they had fallen "as interlopers . . . . . into the middle" between Virginia and New England, complained the English, and were fortifying themselves there "under a pretended authority from the West India Company of Holland". They had "intruded", said a paper called the "Case of the Corporation of New England", upon the rights of King James in the "very best part of all that large northern empire".

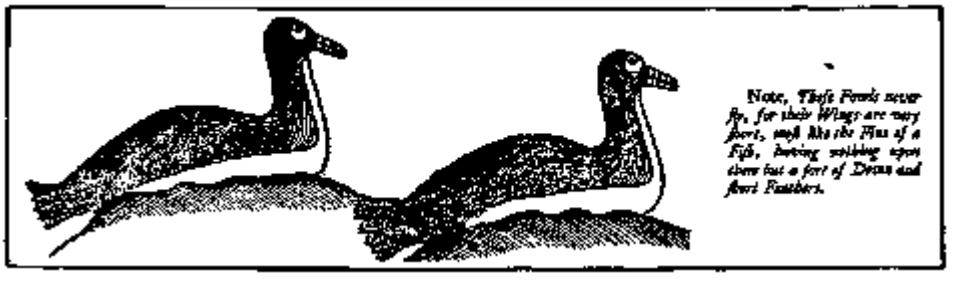
On September 8, 1664, New Netherland surrendered to English force of arms. The first act of the new governor, Richard Nicholls, was to change the name of the city from "New Amsterdam" to "New York", and the English Colonial period began.

It was the English who published the first coast pilot for American waters exclusively. The English Pilot, as it was called, first appeared in 1706, published by the firm of Mount, Page and Son, Tower Hill, London. The book continued, throughout a number of editions, as the chief guide for the trans-Atlantic seafarer, until shortly before the Colonies declared their independence.

Many copies of this fascinating book are still in existence. They are full calf bound, in the generous proportions of 12 x 19 inches. This large size permitted the inclusion, with not too much folding, of fairly large charts. The Atlantic and Gulf coasts from Hudson Bay to the Amazon River were covered, describing the chief harbors, bays, and islands, giving sailing directions, distances and courses, tidal information, and "with many other things necessary to be known in navigation". Mentioned among the "other

things" is the current now known as the Gulf Stream. They were not very sure of its nature, only they knew "by Experience has been found sometimes in twenty-four Hours, such currents as hath carried them either to the Northward or Southward, contrary to the Reckoning beyond Credit.....".

Interspersed throughout about 50 pages of written sailing directions are about 25 large size sailing and coast charts, and about an equal number of smaller, large scale, "special" charts of harbors and islands. The written matter is abundantly illustrated with sketches of dangerous passages, vertical views of the coast, and other material intended to aid the navigator, such as the following sketch which is offered the mariner as a sign to know when he has come on the Newfoundland Banks:



The above penguins, it is further stated, could be recognized because they had a "Milk white Spot" under the right eye but not under the left; these particular birds were to be found only on the Banks. What need of a Fathometer?

The charts published in the English Pilot Book were gathered from various sources, some from surveys of private individuals, some by the Surveyor General, and the Hydrographer to the King, others simply state "by an Officer of the Navy". Many are anonymous. All are carefully drawn, and in detail. The small scale, general charts are on the Mercator projection, with the latitude and longitude graduations given. The prime meridian of longitude differs on the various charts; on some London was taken, others use Tenerife, but the favorite prime meridian was the Lizard, a point near Lands End, England. No longitude whatever is given on the harbor charts. Sometimes the latitude graduations are given but more frequently a graphic scale of miles is drawn and a projection avoided. Soundings are plentifully given; landmarks and ranges for channels are indicated. The symbols for shoals and sunken rocks are the same as used today. Churches and other buildings, drawn in perspective and greatly exaggerated, were used to denote towns. Batteries and fortifications were emphasized - particularly those in the territory of other nations.

A chart similar to the "New Map of the Harbour of New York by a late Survey" which is reproduced in figure 9, was published in many editions of the English Pilot. But the map given here is believed to be unique and has seldom been reproduced. It was published in 1735 by William Bradford, and was advertised for sale as "containing Soundings, and setting of the Tydes, and the bearings of the most remarkable Places, with the Proper Places for Anchoring". The English Pilot chart, which seems to have been based on the same survey, was issued without alteration from 1731 until 1767, and generally carried the name of Mark Tiddeman as the author.

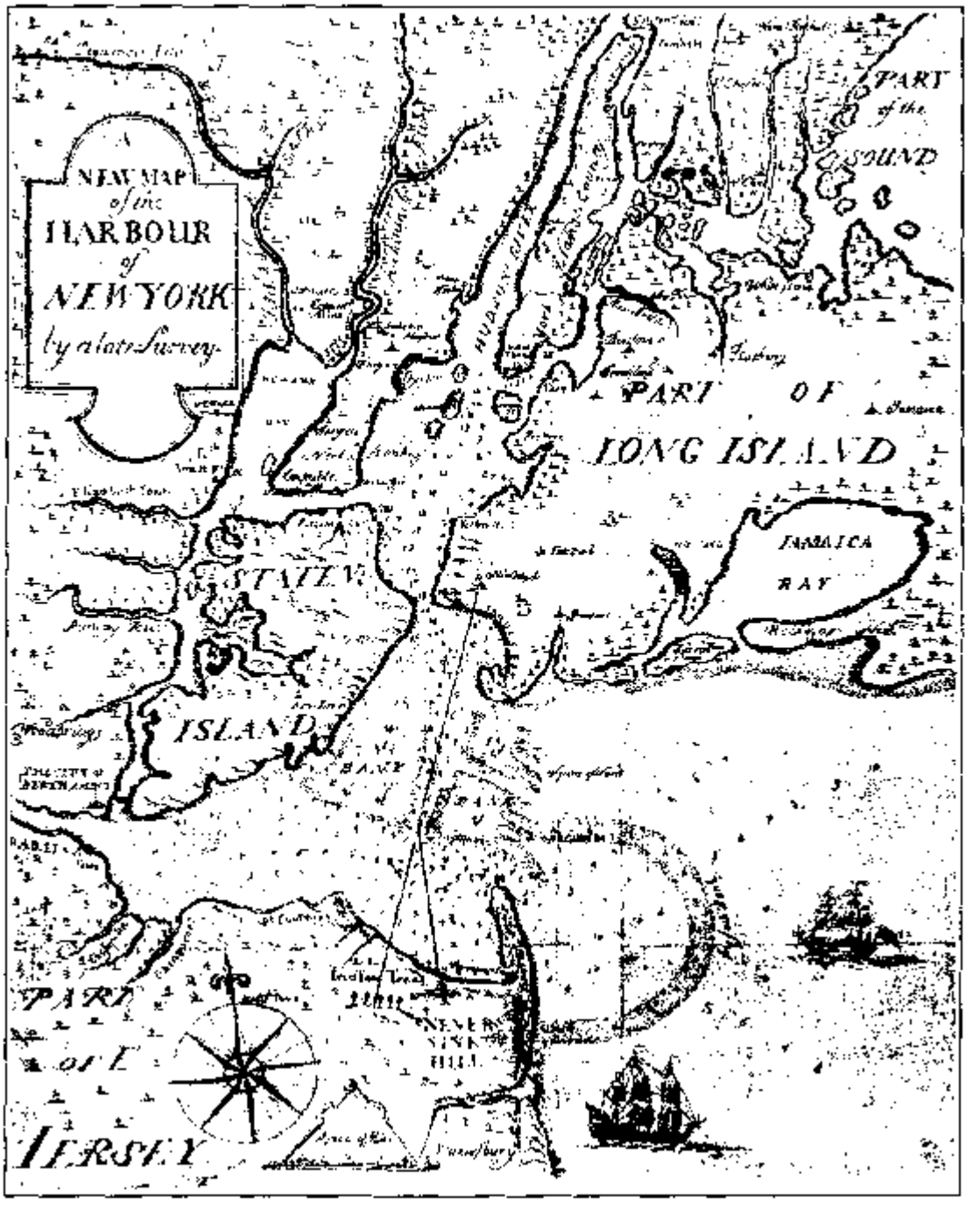


Figure 9. By courtesy of Phelps Stokes.

Published by William Bradford, 1735.
A chart similar to this appeared in the
English Pilot, marked, "by Mark Tiddeman".

The science of cartography had made great strides throughout the 17th and early 18th centuries, and the charts of the East Coast and principal harbors of America were at least not terribly bad when supplemented by written instructions for avoiding dangers and following channels. But two prime necessities for safe navigation were still lacking: lighthouses and a quick accurate method of determining longitude at sea.

Appliances available to the navigator for fixing positions by astronomical methods were limited, until the 18th century, to finding only the latitude of the ship at sea. No method of finding the longitude was devised other than by dead reckoning, until the introduction early in the 18th century, of a practical form of the lunar problem. But this was a complicated and difficult procedure even after the sextant came into use. In 1740, a commission which the British Parliament had created "for the discovery of longitude at sea", offered a reward of £10,000 for a method of determining the longitude within 60 miles.

Modern methods of navigation may be dated from the invention of the chronometer in 1735, although the value of the instrument was not proved to navigators until some 40 years later. Until the chronometer came into use afloat it was not possible to find the longitude by a simple calculation. As for aids to navigation, the whole seacoast of the American Colonies before the Revolutionary War was marked with only 12 lighthouses. Since two of the towers were double, there were actually only what can count as 10 navigational aids. One each was in Rhode Island, New Hampshire, Connecticut, New Jersey, Delaware, and South Carolina; the other four were in Massachusetts. This number of lighted aids seems exceedingly small, but it must be remembered that there were very few lighthouses in existence then even on the coasts of the British Islands. Light was provided by lamps with wicks burning whale oil, vegetable oil, or lard oil. There were no lenses, and the power of the lights was increased simply by adding to the number of lamps inside the panes of glass which formed the lantern, backing them up with a polished reflector. The first lighthouse to be built on the North American continent was the Boston Light, erected in 1716.

Our oldest light tower which is still standing as first constructed is the Sandy Hook Lighthouse. It was built in Colonial days partly from proceeds of lotteries authorized by the General Assembly of New York and partly from a tonnage tax imposed on ships. The tower is 85 feet in height and painted white. It was first lighted on the night of June 11, 1764. During the Revolutionary War, the British fortified the lighthouse; it was known as the lighthouse fort, and from it the Tory refugees made their bloody raids.

English commercial and naval ships had not had any charts of the American Colonies which they considered very dependable. A distinct need was felt for hydrographic information and new charts, to be regularly corrected, and to bear the stamp of official approval. Joseph E. W. Des Barres, Esq. was picked for the job. He went to Halifax in 1763 and began the work of compiling the surveys of various companies, individuals, and British naval vessels, making his own surveys where necessary. Two land surveyors were hired to assist him. After ten years, Des Barres returned to England to start the printing.

The result was a group of charts which Rich, in his Biblio-

theca Americana Nova, calls, the "most splendid collection of charts, plans, and views ever published". This was the Atlantic Neptune.

The first edition came out during the Revolution, the last in 1784. The chart of New York Harbor published in the Atlantic Neptune is reproduced in part in figure 10.

There were altogether about 257 plates of charts and views. No two copies of the Atlantic Neptune have been found containing exactly the same collection of plates and no complete list of the plates exists. The engraving was beautifully performed; the large vertical views, to which whole pages are sometimes assigned, are works of art. Besides the charts and vertical views, pages are devoted to remarks on the appearance of certain localities from the sea, the tides thereabouts, and sailing directions.

The work is generally divided into three parts, each a massive volume of 24 x 30 inches and containing about 40 pages. The charts range from one to four times the average page size. Part 1 includes the northern section of the coast from "the Bay Eundy along the Shores of New Brunswick and Nova Scotia to the Gut of Canso in the Gulph of St. Lawrence"; part 2 "Exhibiting the Coast and Harbours in and around the Gulph and River of St. Lawrence"; and part 3 includes "the American States from Passamaquody——to the River Mississipi in the Gulph of Mexico". For a chart enthusiast the "discovery" of the Atlantic Neptune is an exciting experience. The Coast and Geodetic Survey owns a finely preserved copy.

For a half century after the United States gained its independence, the country was without a governmental chart producing agency. Charts available at the close of the War were those of Des Barres, Romans, and Gauld - imperfect and entirely unreliable as to geographic position. An idea of their uncertain character may be gained from the fact that Galveston was placed on Spanish and English Admiralty charts 105 miles out of position. In general, mariners were left to acquire their knowledge from the shipwrecks of others. The English no longer had the incentive to improve the charts of our coast, and the United States government took no steps to acquire and furnish hydrographic information. The organization of a federal coast survey was authorized in 1807 but instruments were lacking and before they were obtained the War of 1812 intervened. Surveys were started in 1816-7 but were soon abandoned and not resumed again until 1832. The little which the government did was withheld from the public, on the grounds that it would compromise the defenses of the country. It was only by private enterprise that improvement was made.

The outstanding contributors during this trying period were Edmund Blunt and his two sons. As Blunt himself expressed it: "in attempting to give directions for the navigation of a coast 6000 miles in length. . . . . he has undertaken a duty, the performance of which belonged RATHER TO THE GOVERNMENT THAN AN INDIVIDUAL". The capitals are his. Edmund Blunt was a printer by profession, who lived in Newburyport, Massachusetts, Besides a printshop, he ran a bookstore where he carried a line of navigating instruments, stationery and charts. One of his sons tells us that his father "had a passion for creating, collecting, and publishing accurate nautical information, even in those early days when little hydrographic information existed". Then, of course, a printer must find something or other to print. Anyhow, Blunt conceived the idea of pub-

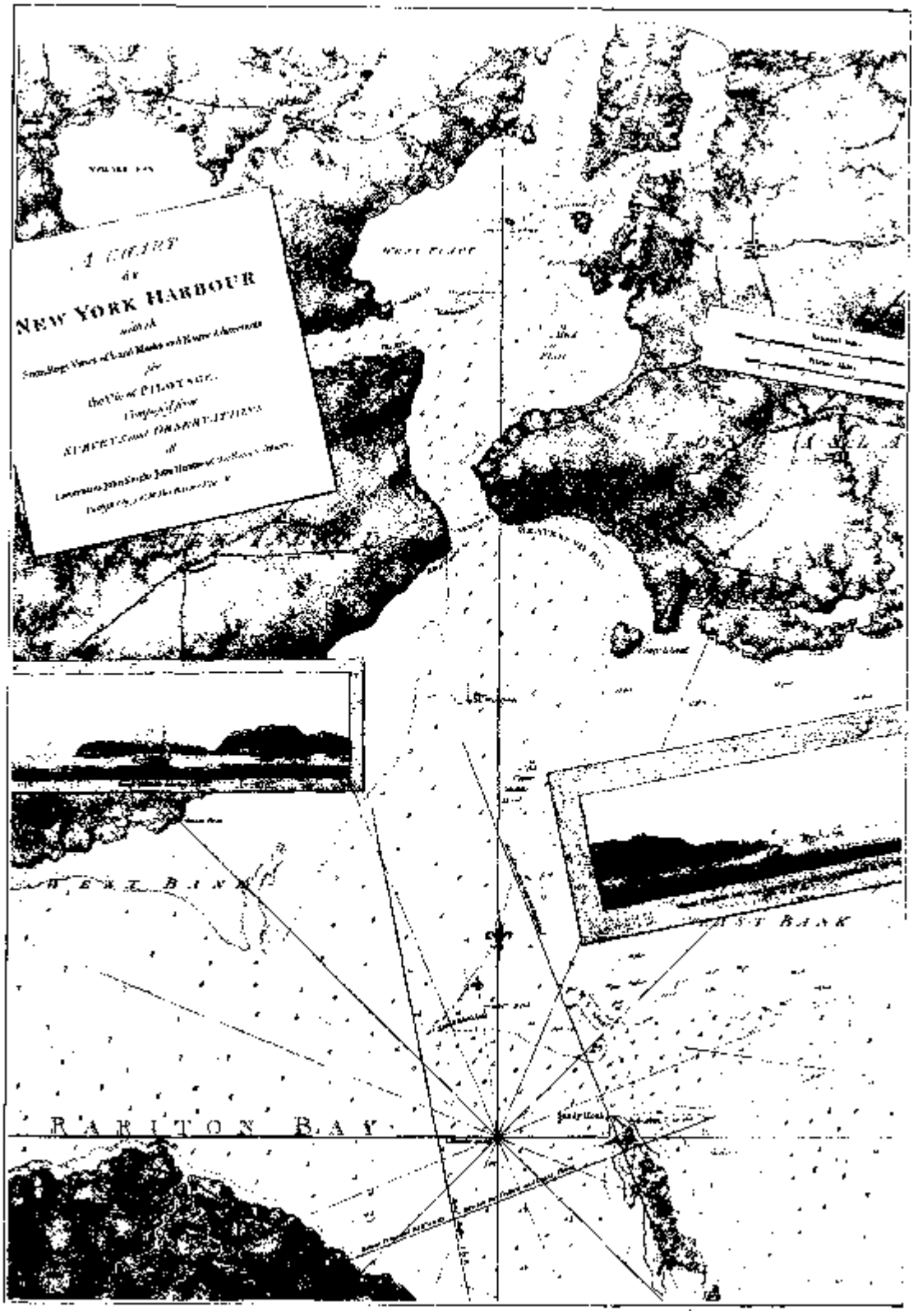


Figure 10. From tne Atlantic Neptune, 1763-1784.

lishing an American Coast Pilot. He engaged an American shipmaster by the name of Lawrence Furlong to write the book, but the resulting manuscript was in such crude form that it had to be revised and corrected by a lawyer. The first American Coast Pilot book went on the press in 1796, consisting of 122 small octavo pages with paper as coarse as a paper-towel but with a very substantial binding. Sailing directions for the principal ports on the East Coast comprised most of the volume, New England harbors receiving the most attention. No charts were included, but a tide table was given, as well as the latitudes and longitudes of various important places with the courses and distances between them. The book opens with the statements of several captains and pilots that they have examined the contents, found them correct and "do recommend it as a valuable work, and worthy the attention of all navigators". Mr. Blunt says at the close of the book that he "will be happy to receive information from every judicious seaman, respecting the different places they may visit on the Coast of America, and corrections for what he has already published, in order to complete his plan of publishing correct Directions for all the harbors in the United States". And also at his bookstore and printing office "may be had on the most reasonable terms Hadley's Quadrants, warranted good".

The book gave great satisfaction and the succeeding editions were corrected and greatly enlarged. The last edition, the twenty-first, which was published in 1867 by George W. Blunt, who had continued his father's work, contained 926 royal octavo pages of comprehensive, well-presented information covering not only the East and Gulf coasts but part of South America as well.

But starting the Coast Pilot was just the beginning of Edmund Blunt's endeavors to fill the gap until a federal coast survey agency could be established. He next undertook to make hydrographic surveys and charts. The first attempt was the survey of the little port of Annisquam, not far from Newburyport, Massachusetts, which the fishermen needed as a refuge in northeast gales. Next, in 1819, Blunt had surveyed, at his own expense, the Great Bahama Bank route to the Gulf of Mexico. In this his two sons took part. One of them, Edmund, took up hydrographic and geodetic surveying as a profession, aiding in the surveys, which his father later promoted, of Nantucket and Georges Shoals. The investigation of Nantucket Shoal proved that the southern limit had hitherto been charted 22 miles too far south. After this discovery, vessels were able sooner to escape the retarding effect of the Gulf Stream, and the time that it took a ship to return from Europe to New York or Philadelphia was reduced about 24 hours.

The junior Edmund Blunt spent many years of his life making surveys of New York Harbor, Long Island Sound and the outer coast of Long Island. In 1833 he was appointed First Assistant in the United States Coast Survey, a position which he held until his death in 1866. The first chart of New York Harbor published by the Coast Survey shows his name as one of those who did the triangulation of this area. Blunt's own survey of New-York Harbor (figure 11) was made on a scale of approximately 1:120,000. No scale is given on his chart but the margin contains latitude and longitude graduations, divided into single minutes, very much like a modern chart. The direction of the tidal current at various places is indicated by small arrows. Soundings are shown in fathoms (to quarter fathoms) reduced to low water, but they are rather sparse. It is interesting to note that the lighthouse at Sandy Hook was accentuated, on the otherwise black and white chart, by the use of

Figure 11. Edmund Blunt about 1820.

color - a red center with a yellow glow around it.

In 1807 Congress authorized President Jefferson "to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or headlands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid".

This law was the origin of the present Coast and Geodetic Survey. The original enactment was handicapped in its execution by unsettled national conditions, the War of 1812, and the failure of Congress to make regular appropriations. But in 1832 Congress revived the act, extended the scope of the work, appropriated some money, and the bureau became definitely established.

F. R. Hassler, the distinguished Swiss mathematician who was appointed Superintendent, commenced field work at this time by measuring a base line of nine miles on Fire Island Beach. The triangulation was extended north to St. Croix, Maine, and south to Cape Henry, Virginia, providing a basis of accuracy and permanency, and means of correlation which had been wholly lacking in previous coastal surveys. Meanwhile, in 1835, hydrographic and topographic surveys had been commenced in the vicinity of New York Harbor and at about the same time, surveys were made of the harbors of Bridgeport and New Haven, Connecticut. The first chart was published in 1835, of Bridgeport Harbor. The chart of New Haven Harbor and one of Newark Bay soon followed. These were all on 1:10,000 scale. The engraving seems to have been done by a commercial establishment. Apparently the first charts produced entirely by the personnel of the Coast Survey were of New York Harbor, published in 1844-5 on two scales, 1:30,000 and 1:80,000. A section of the latter is reproduced in figure 12.

Whereas the earlier (1835-1839) harbor charts contained no projection (merely the position to the nearest second of arc of one of the charted lighthouses being given), that of New York was not so remiss. At last we find a chart of the harbor of New York with a projection which could be called good even today. New York City Hall was taken as the prime meridian, but there were marginal ticks which referred to Greenwich longitude.

A comparison with anything, which had previously been called a chart of our coast, makes the first products of the Coast Survey look like an entirely new form of the art. The outstanding improvements of course were uniformly high accuracy of geographic position throughout, thorough hydrography and complete topography. Perhaps they included a little too much of the latter, but it made a fine map of part of the interior, and certainly good maps of the country were even scarcer then than they are today.

During this period, the middle of the last century, the government awoke to several other vital needs of navigation. The Lighthouse Board was organized in 1852, the Lake Survey in 1841, and the Hydrographic Office in 1866. The state of affairs before the establishment of the Lighthouse Board is told by George W. Blunt in the preface of the 1867 edition of his Coast Pilot:

"The lighthouses of the United States coast, as a general

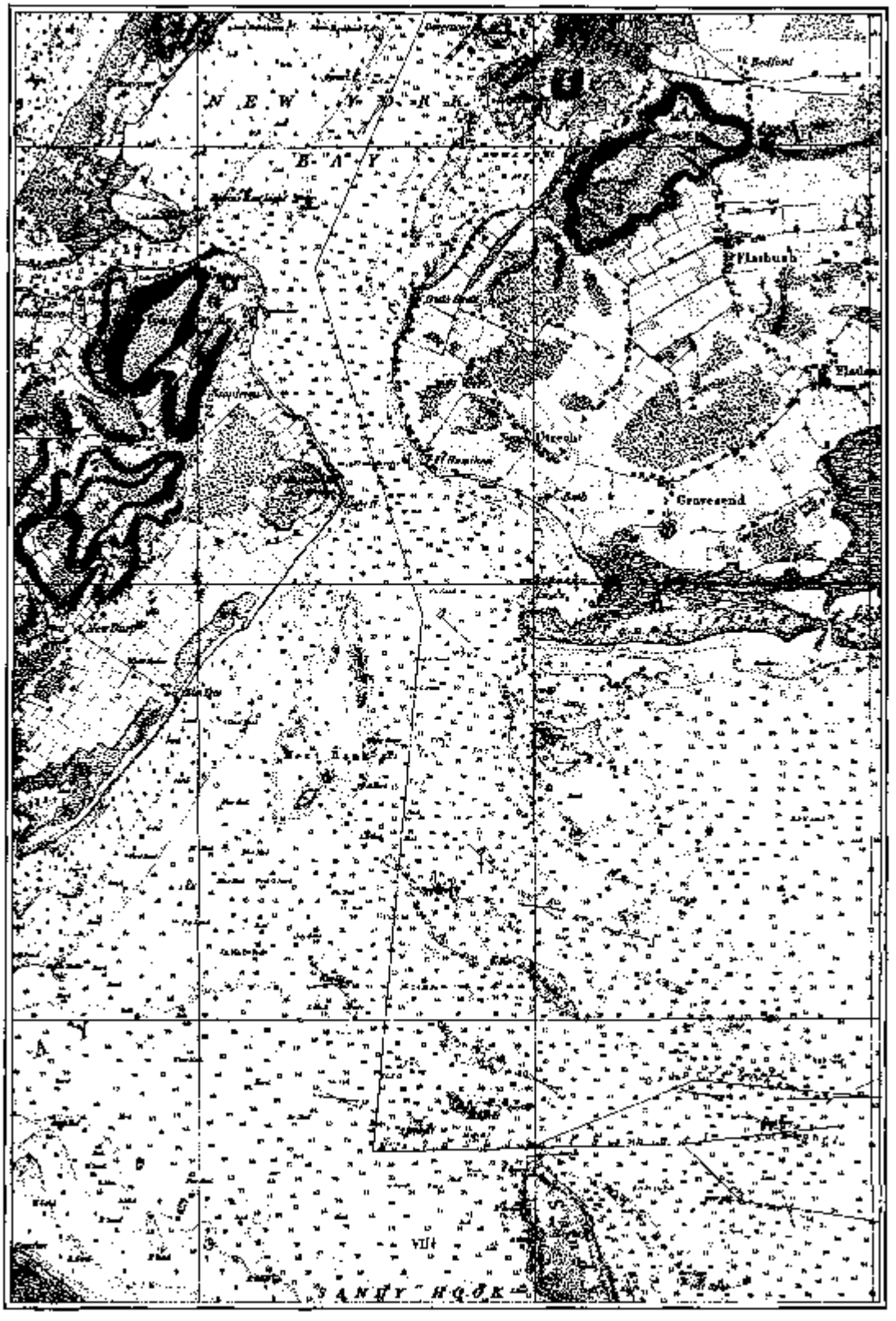


Figure 12. UU. S. Coast survey, 1845.

rule, were miserable, and no reliable statement of a public character was published; all depended on private information until the organization of the Lighthouse Board in 1852".

An idea of the lack of aids to navigation may be gained from the fact that even at the time of the Civil War there were only 290 lighthouses, whereas at the present time, between Maine and Mexico (not including the West Indies), there are 3242 fixed lights, not to mention almost a thousand lighted buoys and more than 10,500 unlighted beacons and buoys.

What progress does today's chart of New York Harbor represent over its ancestor of 100 years ago? The most striking difference at first glance is the present use of colors, an unmistakable improvement over the old black and white engraved charts. But legibility has been improved in a number of other ways, mainly by simplification and giving preference to the needs of mariners. This is illustrated in the subordination of interior topographic detail and emphasis on landmarks. A careful selection of soundings permits the configuration of the bottom to be represented adequately without a confusing number of depth figures. Depth curves and hypsometric tints enable one to distinguish quickly between safe and dangerously shallow water.

Vertical views together with the mass of sailing directions, tide and current tables, and various insignificant explanatory notes have been eliminated from the chart. The needed accessory information is made readily available in detail in separate publications such as Tidal Current Charts, Tide and Current Tables, and Coast Pilot books of the Coast and Geodetic Survey, and the Light Lists published by the Lighthouse Service. Charts are published on different scales to fit the requirements for various types of navigation. For New York they range from a 1:1,200,000 scale sailing chart for use in approaching the coast from the open ocean, through several intermediate scales for purposes of coastal and harbor navigation, to a 1:10,000 scale anchorage chart.

An important phase of modern cartography, which, as we have seen, was almost entirely neglected in the past, is the systematic correction of existing charts in order to keep them current, by the application of new information from various sources and by a regular program of revision surveys. Also, mariners are kept informed of dangers and changes to aids through the "Notice to Mariners", issued jointly by the U. S. Lighthouse Service and the Coast and Geodetic Survey.

The present day requirements of low-cost, quantity-production have been met in the reproduction of charts by the employment of the latest methods of photolithography and offset printing, specially adapted and refined to meet the ultra high standards which the reproduction of an instrument of navigation requires. During the past fiscal year the Coast and Geodetic Survey issued nearly 330,000 nautical charts. This is exclusive of the condemnation of about 20,000 obsolete charts, which would have been dangerous for the mariner to use. Of all the harbor charts, No. 369 (New York Harbor, 1:40,000 scale) is in the greatest demand - the average annual issue for the past two years exceeding 3300 copies.

It might be of interest to take a modern chart and list some of the different means that are now offered a navigator for finding the position of his ship as it approaches the crowded entrance to

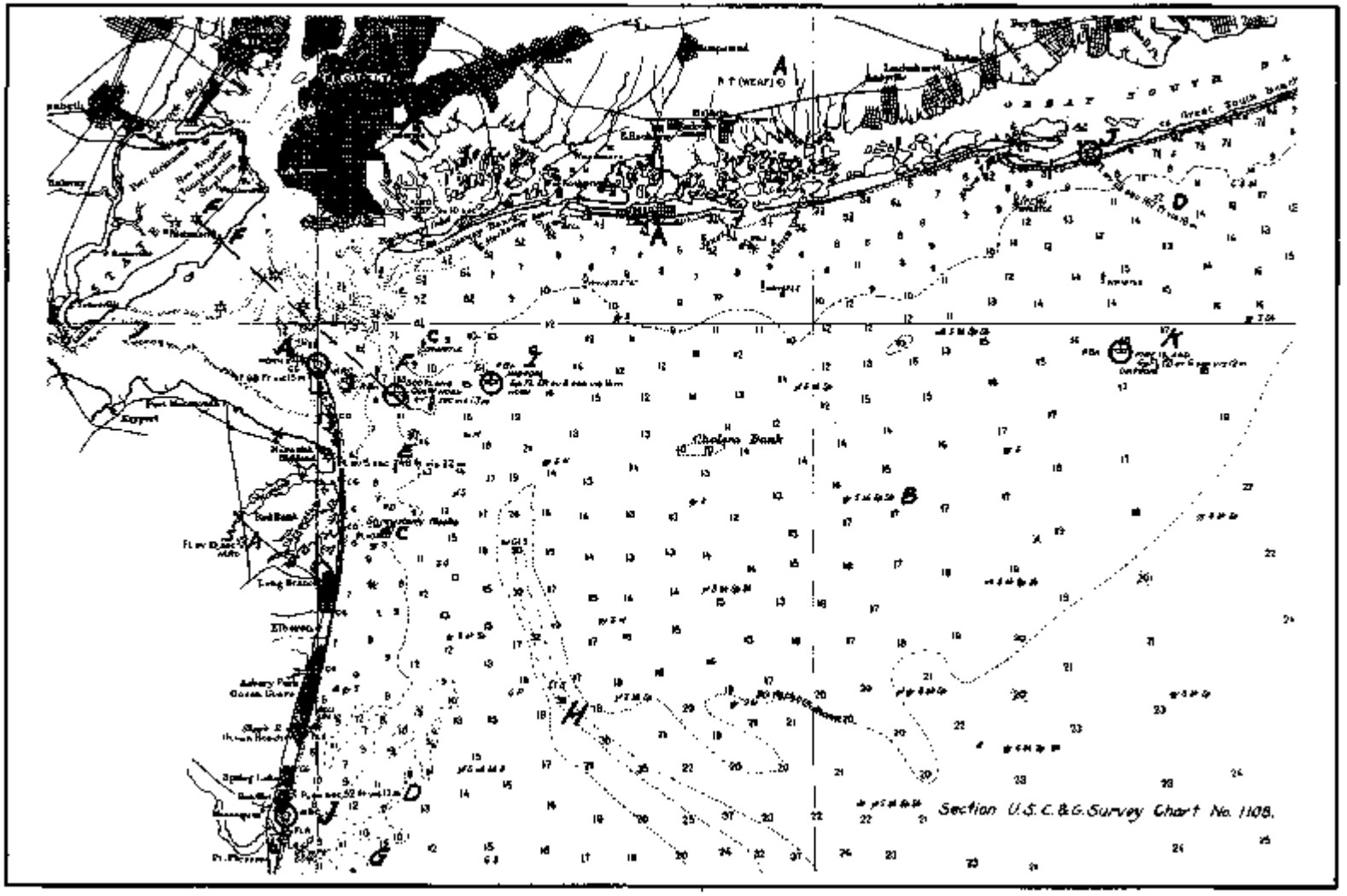


Figure 13. The Approach to New York in the 20th Century.

New York Harbor. The following letters refer to a section of Chart No. 1108 reproduced in figure 13.

A. Landmarks

For bearings and angles

By day: Structures and natural objects.
By night: Lights.

B. Bottom Characteristics

An ancient method, still in use, for determining an approximate location.

C. Danger Warnings and Channel Indicators

By day: Towers, beacons, buoys.
By night: Lights of various characteristics.

In thick weather: Whistles, horns, sirens, bells, submarine oscillators and bells.

D. Visibility of a light

The distance from the light, when first seen under normal atmospheric conditions will be approximately the stated visibility corrected for height of eye.

E. Height of object

A vertical angle, together with the bearing, will give a position.

F. Range

For line of position.

Identification of range by the height, color and characteristic of the lights.

G. Soundings

A series of soundings taken and placed over the chart gives a good position if the bottom is sharply characteristic; it has more application if a bearing is obtainable. The advent of echo-sounding instruments as standard equipment on the larger vessels has made this one of the most valuable procedures. Formerly restricted to fairly shallow water, the method may be used with echo-sounding apparatus while running at full speed in any depth of water, provided soundings are available on the chart. Where a submarine valley occurs, as at "H", the large abrupt change of depth gives an excellent indication of position.

I. Radio beacons

Bearing or cross bearings by radio compass aboard the vessel.

J. Navy Radio Direction-finder Stations

A bearing from one station, or a position if there are a group of stations, is transmitted to the vessel by radio.

K. Synchronized radio beacon and sound signal

Distance from sending station obtained. Sound signals transmitted through air or water.

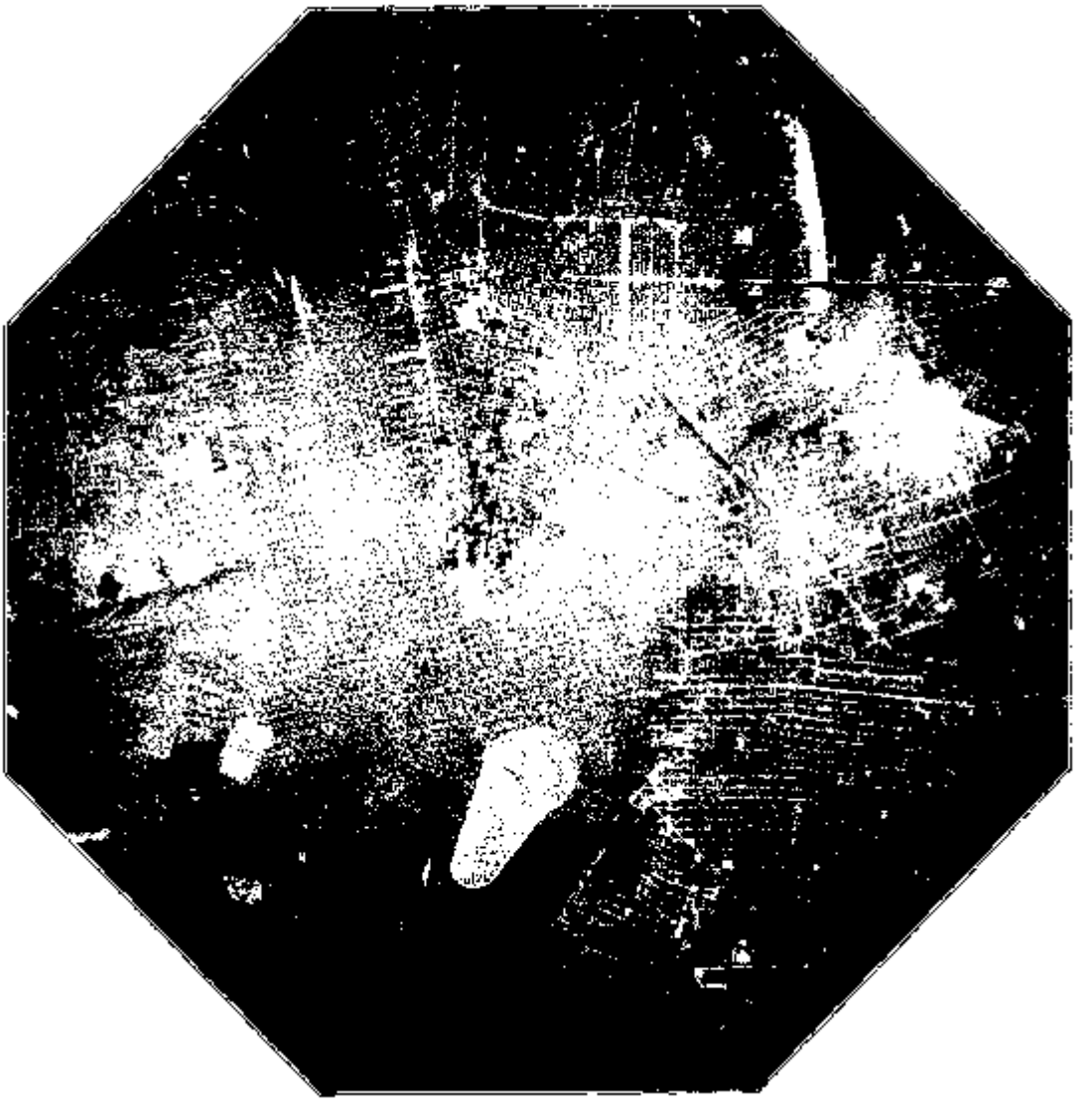
After a thousand years of voyaging, finding New York ,is still a problem. We sometimes wonder, "How in the world did the ancient seamen, entering strange waters in their little crafts without any charts and with only crude navigating devices, manage to survive?" The answer is, they frequently didn't. Furthermore, the ships they had did not draw much water, they could heave to at night or in thick weather when in doubt, and proceed cautiously when near the shore, using their lead constantly.

It is much more astonishing to think that a liner of today, shoving a bulk of 80,000 gross tons through the water, at a normal speed of 29 knots, drawing up to 40 feet of water, and carrying a thousand or so passengers who resent any delay, can safely reach its destination when no one on the bridge may have ever been to that particular port before. In spite of a wheelhouse bristling with the latest contrivances, and a coast studded with aids to navigation, if the officers of the ship could not tell exactly where their vessel was in relation to its surroundings, they would be figuratively, and perhaps literally, "sunk". A good chart supplies this essential information accurately, rapidly, and completely.

As the Encyclopedia Brittanica concisely notes, "The progress of the art of navigation was, and is, of course, still inseparably connected with chart drawing". As far as we know, there were no charts of America a thousand years ago. The Norsemen in their purported voyages seem to have depended, in their navigation, entirely upon "instinct". Then advancing through the years, we have been able to perceive what a close relation has existed between map making and the history of territorial discovery and exploration, the settling of the country and the development of commerce.

The astonishing discoveries and developments in the 20th century are in science and in industrial processes. Cartography reflects these trends none the less; for in order to keep pace with the increasing speed and draft of vessels, the never ending changes along our shores wrought by man as well as nature, and in order to bring greater safety to the tremendously increased number of travelers at sea, and to meet, at the same time, the widening, changing demands of defense, industry and commerce, it has been necessary today to employ in the surveys of the coast all that contemporary science and engineering can offer.

The story of the second thousand years of finding New York

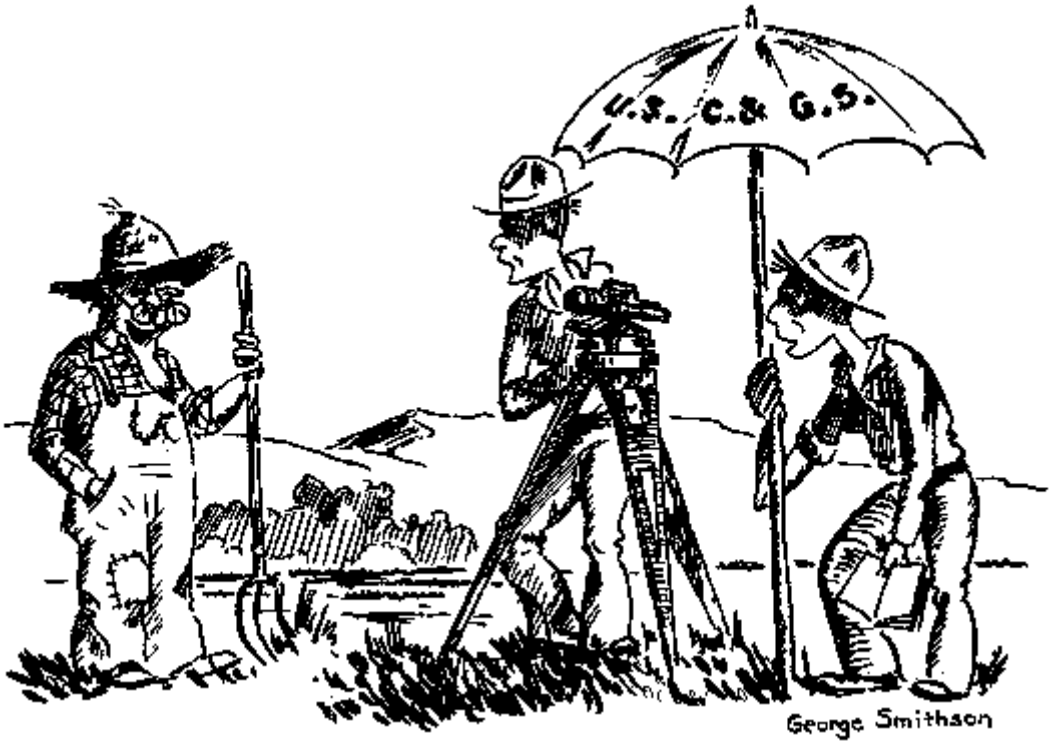


MAPPING MANHATTAN IN 1938

Section of vertical air photograph used in contemporary topographic surveys. Taken July 16, 1938 at 8:30 a.m. with U. S. Coast and Geodetic Survey nine-lens camera; exposed in l/50th second while traveling 180 m.p.h. at an altitude of about 21,000 feet. The original photograph when printed includes an area of 275 square miles on a 1:30,000 scale in a single unbroken vertical picture. (One of the earliest views of the city, drawn before 1642, is attributed to the help of a camera obscura.)

may some day be written. It may commence with the groping of small slow, steel ships, which were restricted to the water and had to find their way blindly about by echoes from newly explored submarine gorges; it may speak of the days when fog had not been conquered and the crude method used to compare the time of travel of a synchronized radio and sound wave to determine the distance away from a station ship anchored along the sea lanes, and the mariners so ridiculously handicapped by lack of scientific knowledge and instruments, would occasionally even run into these lightships.

No matter what the imagination may conjure of the future, we can feel assured that the hydrographic, geodetic and cartographic engineer will not be left behind in the "march of time" to parch in a dead sterile field, but, on the contrary, will tomorrow, as yesterday and today, find himself closely allied with, and taking an important part in the most exciting events of history.



Illustrating an episode which happened to Ensign C. J. Beyma, when leveling in Santa Clara Valley, California. It was a hot day and an irate tax payer, seeing the man holding the instrument shade, said "It's a wonder you don't have some one fanning you too!"

THE WRECK OF THE PATTERSON

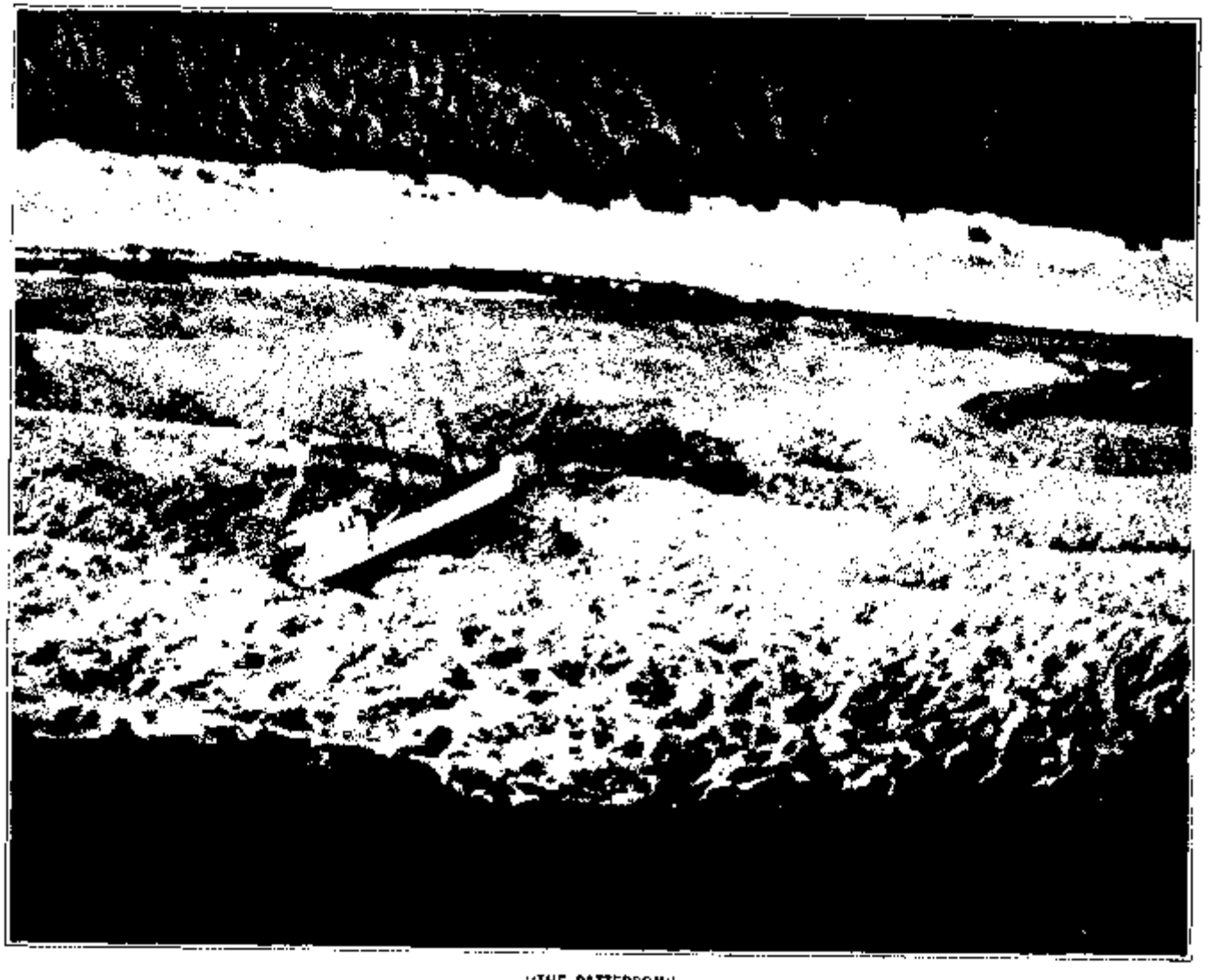
As the Bulletin goes to press, word is received that the Motorship PATTERSON, formerly, and for many years a Coast and Geodetic Survey ship, is aground near Cape Fairweather, Alaska. Heavy seas and its exposed position practically assure the total loss of the vessel. One member of the crew was washed overheard as the vessel grounded.

Many officers will regret the tragic end of this veteran of Alaska waters. Built at Brooklyn, N. Y. in 1883 for the Coast and Geodetic Survey, the PATTERSON was named for Carlile P. Patterson, Superintendent of the Bureau from 1874 until his death in 1881. Originally an auxiliary barkentine of 719 tons displacement, the vessel was 163 feet in length and 27-1/2 feet beam. It was originally powered with a Cross compound engine of 356 HP.

Particular care was taken in the PATTERSON'S construction. Both its first Commanding Officer, Lieutenant Richardson Clover, U.S.N. (the Bureau's vessels at that time were manned by Navy personnel) and its engineer officer, Passed Assistant Engineer H. N. Stevenson, U.S.N., served as assistant Inspectors of Construction. The Inspector of Construction, Commander C. M. Chester, U.S.N., thought well of this arrangement. In a letter to the Superintendent, he stated: "Lieut. Clover, who has been associated with me in the preparation of the data from the inception of the project of building a vessel especially adapted to the survey of Alaskan waters - - - was stationed in New Tork, taking the immediate charge of the work and under his constant watchfulness nearly every timber and bolt of the vessel received careful inspection. It is believed that the scheme of having the officer on whom was to rest the responsibility of a long voyage to the Pacific, and afterwards possible trying circumstances on the coast of Alaska, associated in the construction of the vessel has been fraught with good results to the Government as well as to himself as her future commander. - - - Mr. Stevenson was located in Philadelphia, Pa., where the steamer's machinery was being made by Messrs. Neafie & Levy. This officer - - - had been also associated with me in planning the machinery, and, as her future engineer officer, was deeply interested in the careful construction of the motive power of the vessel".

The PATTERSON was launched January 15, 1884 and commissioned on April 1, 1884. After a few sea trials, the vessel began its memorable trip to the West Coast, via the Strait of Magellan, on July 26, 1884, arriving in San Franciseo Friday, February 13, 1885, where it was overhauled and founded for the Alaska assignment. The vessel left for Sitka on April 26, and began survey work May 27, 1885, ironically enough within 20 miles of the scene of its disaster. Thence followed many years of commendable service, charting Alaska waters, until in May 1918, the PATTERSON was transferred to the Navy for war service. A year later it was returned to the Coast and Geodetic Survey, but the acquisition of younger ships by the Bureau led to its sale in December of the same year to The Northern Whaling Company of New York.

Reconditioned and converted to a motorship, the PATTERSON returned to Alaska under command of Captain C. T. Pederson and again thrust its prow into unsurveyed waters. Engaged in the lucrative and adventurous business of trading miscellaneous stores for furs, Captain Pederson sailed her into the Arctic, around Point Barrow,

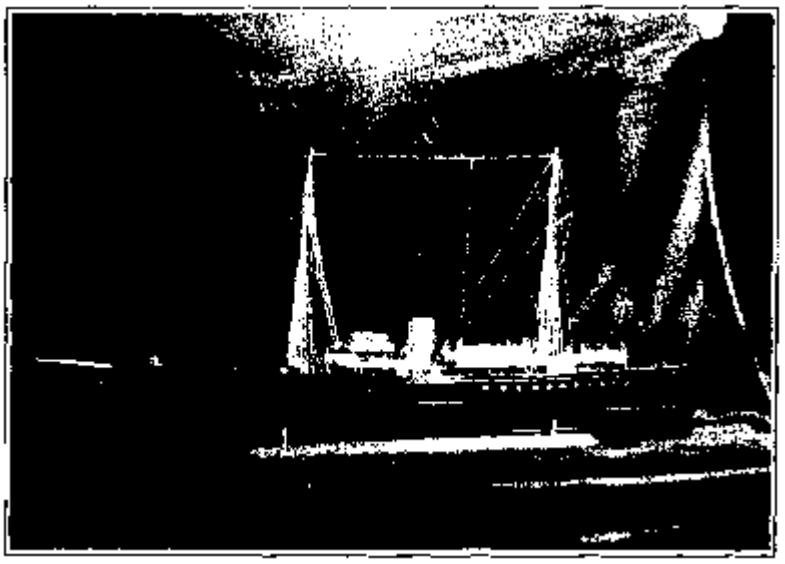


"THE PATTERSON"
Photograph by U. S. Navy

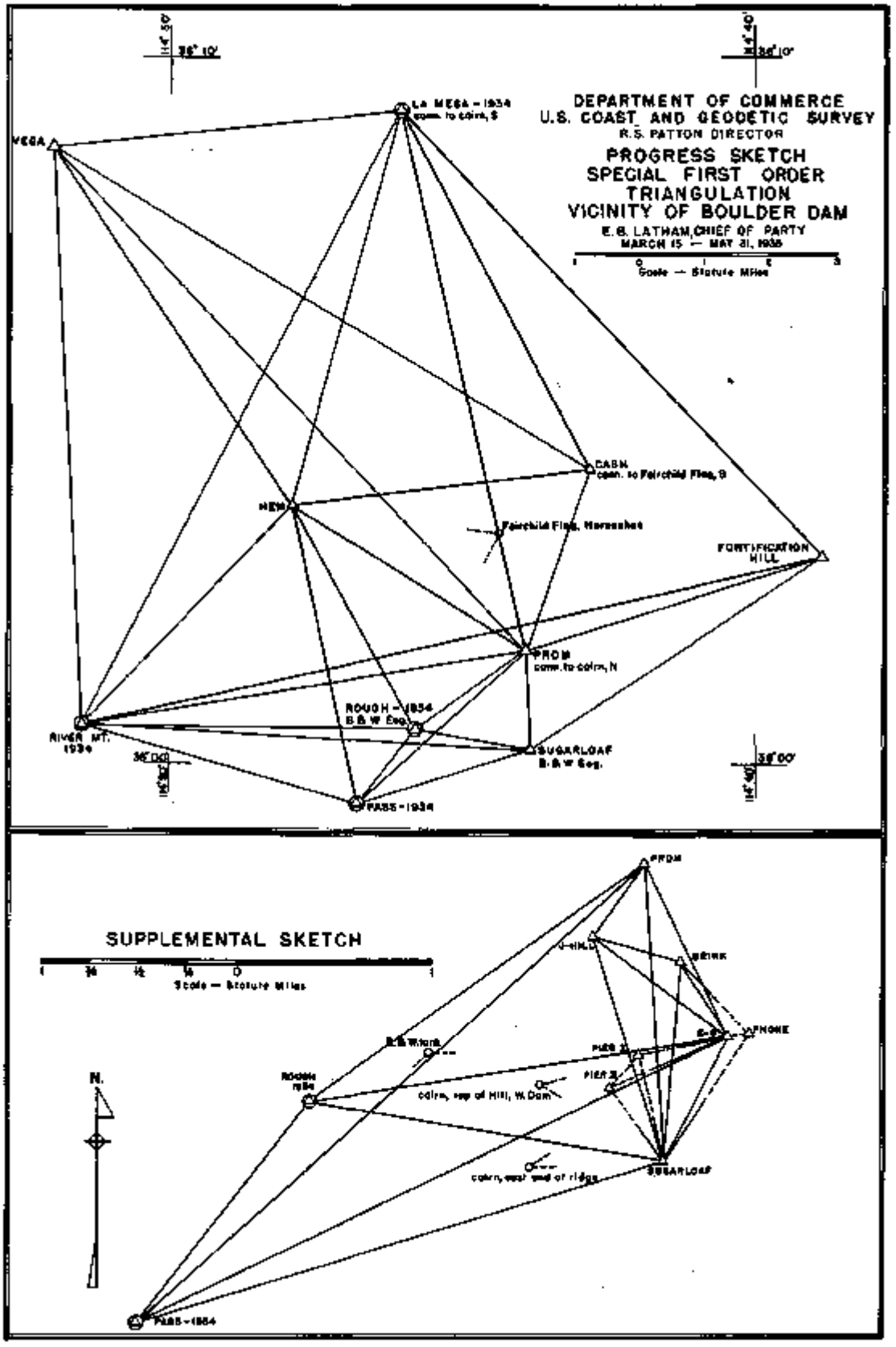
then along the northern coast of Alaska as far east as Herschel Island, reaching at times even to the mouth of the McKenzie River. His trading stores consisted of everything imaginable, including phonograph needles, groceries, outboard motors, and perfumery. In 1924, Captain Pederson acquired ownership and, together with his family, continued fur trading, his wife acting as nurse for the crew.

The PATTERSON was again sold in 1936, this time to the Gilkey Brothers, Seattle, organized as Patterson, Inc. Mr. Charles Gilkey, president of the company, placed the aged vessel in the less hazardous work of carrying freight to Alaska ports. Now, however, as if protesting this relegation to unfamiliar comparative safeness, ill luck and misfortune became the PATTERSON'S fate. On the first voyage under the new owners, the master, Captain Walter Tinn, became ill and was taken to a hospital in Nome. In early October, 1938, the vessel ran aground in Cook Inlet. Later, on arriving in Seattle, a stranding occurred in Lake Union, after almost ramming a houseboat. Returning to Alaska, it ran aground in Wrangell Narrows on November 15, but was able to work clear before aid arrived.

It is perhaps appropriate that the final resting place of the PATTERSON should be in waters near which so many years had been spent in surveying and in commercial activities.



Our congratulations to Lieutenant (j.g.) C. A. Burmister for his prize winning model of the U.S.C. & G.S.S. OCEANOGRAPHER, pictured above. In a competitive showing of miniatures at the Nordhoff-Moore Department Store, Seattle, Lieutenant Burmister's model won first prize in a field of some 300 entries, among which were 30 models of various types of ships.


DEPARTMENT OF COMMERCE
U.S. COAST AND GEODETIC SURVEY
R.S. PATTON DIRECTOR
PROGRESS SKETCH
SPECIAL FIRST ORDER
TRIANGULATION
VICINITY OF BOULDER DAM
E.B. LATHAM, CHIEF OF PARTY
MARCH 15 — MAY 31, 1935
Scale — Statute Miles
LA MESA - 1934
VEGA
CASH
HEM
FORTIFICATION HILL
PROM
ROUGH - 1934
RIVER MT. 1934
SUGARLOAF
PASS - 1934
SUPPLEMENTAL SKETCH
Scale — Statute Miles
PROM
V-HILL
BRINK
PHONE
N.
ROUGH 1934
SUGARLOAF
PASS - 1934

A STUDY OF REFRACTION ON THE BOULDER DAM SURVEY

E. B. Latham, Junior Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Mead Lake is an artificial body of water being impounded by Boulder Dam. It will be the largest artificial lake in the world and will eventually contain over thirty million acre-feet of water, the greatest weight ever to be superimposed on the surface of the earth as a result of man's work. The dam is 727 feet high, is anchored to bed rock and weighs nearly 6,600,000 tons. The weight of the dam is greatly overshadowed when compared with that of the water to be impounded in the reservoir, which will be something over 40,000,000,000 tons.

The site of Boulder Dam is a natural oven. The canyon, at the dam site, is 1000 feet deep. The downstream face of the dam receives the full force of the sun's rays from about 9:00 a.m. until about 4:30 p.m. The dam itself becomes very hot, and this heat is retained throughout the following night. After sunset, the radiation of this heat causes a rising current of hot air, which, coupled with the general conformation of the topography, results in a northward flow of air through and out of the canyon from south to north.

Under these conditions, a system of triangulation was executed for the purpose of furnishing data on the positions of marked points in the vicinity of Mead Lake and on the dam itself. It is planned to redetermine these same positions by "repeat observations" under different conditions of earth loading due to the water storage. The data thus determined, when combined with spirit level observations, are expected to furnish valuable information concerning the design of large dams and for geological studies of the deformation of the earth's crust due to the newly formed lake.

The triangulation stations, as shown on the accompanying sketch, were selected primarily for the purpose of providing data for studying possible future earth displacement. Many lines were necessarily very short and over very rough terrain. A part of the scheme is in the immediate vicinity of the natural oven known as Black Canyon. Lines of sight between many of the stations were subject to unusual refraction.

A portion of the Instructions for the work is quoted below:

> "To obtain the information desired through this work, it is highly important that it be executed as accurately as possible. You will, therefore, make double the number of observations that are required for first-order triangulation. That is, at each of the first-order stations, two complete sets of 16 positions will be obtained, each of the sets to be made on different days.
>
> "In the matter of triangle closures, it may be difficult, due to the short lines involved, to obtain results much better than the requirements for first-order triangulation. Your observations should be made under the best conditions and all work should be done with the view of obtaining the highest degree of accuracy consistent with the completion of the work in a reasonable amount of time. The average closure will be that required for first-order

Table I

Station Occupied	Stations Observed	Sets on Each Direction	Sets Rejected	Percentage Rejected	Percentage of Total Rejected
BRINK	PHONE*	2	0	0	
	E-8	4	2	50	
	SUGARLOAF	2	0	0	
	J-HILL				28
CASH	FROM*	3	1	33	
	HEM	3	0	0	
	VEGA	3	0	0	
	LA MESA				11
E-8	SUGARLOAF*	3	0	0	
	PASS	3	1	33	
	PIER II	3	1	33	
	ROUGH	3	1	33	
	PIER I	3	0	0	
	J-HILL	4	2	50	
	BRINK	4	2	50	
	FROM	3	1	33	
	PHONE				32
FORTIFI-CATION HILL	SUGARLOAF*	5	1	20	
	FROM	6	4	67	
	RIVER MT.	4	2	50	
	LA MESA				47
HEM	FROM*	5	1	20	
	ROUGH	2	0	0	
	PASS	4	1	25	
	RIVER MT.	4	2	50	
	VEGA	4	0	0	
	LA MESA	2	0	0	
	CASH				19
J-HILL	FROM*	7	5	72	
	BRINK	5	3	60	
	E-8	3	1	33	
	SUGARLOAF				60
LA MESA	FROM	4	2	50	
	HEM	3	0	0	
	RIVER MT.	2	0	0	
	VEGA	2	0	0	
	FORT. HILL*				
	CASH	2	0	0	
					16
PASS	ROUGH*	3	0	0	
	FROM	3	0	0	
	E-8	3	0	0	
	SUGARLOAF	2	0	0	
	RIVER MT.*	2	0	0	
	HEM	3	1	33	
					8
FROM	RIVER MT.*	5	2	40	
	HEM	4	0	0	
	VEGA	3	0	0	
	LA MESA	4	2	50	
	CASH	5	3	60	
	FORT. HILL	7	5	72	
	E-8	4	1	25	
	SUGARLOAF	7	0	72	
	J-HILL	3	0	0	
	PASS	4	2	50	
	ROUGH				43
RIVER MT.	VEGA*	4	2	50	
	LA MESA	4	2	50	
	HEM	4	0	0	
	FORT. HILL	2	0	0	
	FROM	2	0	0	
	ROUGH	2	0	0	
	SUGARLOAF	2	0	0	
	PASS				20
ROUGH	PASS*	3	1	33	
	RIVER MT.	6	4	67	
	HEM	2	0	0	
	FROM	3	1	33	
	E-8	5	2	40	
	SUGARLOAF				48
SUGARLOAF	PASS*	3	0	0	
	RIVER MT.	5	2	40	
	ROUGH	3	0	0	
	PIER II	3	1	33	
	J-HILL	3	0	0	
	PIER I	3	1	33	
	FROM	3	0	0	
	BRINK	3	1	33	
	E-8	1	0	0	
	PHONE	4	0	0	
	FORT. HILL				17
VEGA	LA MESA*	3	0	0	
	CASH	2	0	0	
	FROM	3	0	0	
	HEM	2	0	0	
	RIVER MT.				0

* Indicates initial direction.

work, but no closure will be accepted which is more than two seconds. It is felt that this accuracy can be obtained by close attention to such details as the proper centering of instruments and lights and avoiding phase and conditions that produce horizontal refraction".

The writer feels that had it been possible to start observations in January or February instead of in March, much of the difficulty encountered from refracted lines would have been avoided. As it was, the party was able to do a satisfactory job in spite of adverse weather conditions. The average correction to a direction after the adjustment was 0".26 with a maximum of 1".31. The average correction to an angle was 0".39 with a maximum of 2".16.

Three tables were prepared for analyzing the observations. Table I shows the total number of sets taken at each station on each direction, the number of rejected sets on each direction with the corresponding percentage of rejection, and the percentage of the total sets at each station that were rejected. Station VEGA was the only one, out of the thirteen stations occupied, at which final values were obtained without the necessity of reoccupation. No rejections were necessary for 49 of the total 85 directions, 28 had from 20 to 50 percent rejections, and eight had from 50 to 72 percent rejections. It must be remembered that of the 49 directions that had no rejections, 13 were initials for which there could be no rejections. Omitting these 13 initial directions, and considering the remainder, there were 36 out of 72 directions or 50 percent without rejections; 39 percent with from 20 to 50 percent rejections; and 11 percent with from 50 to 72 percent rejections.

Table II

Direction	Total Sets	Rejected Sets
BRINK to SUGARLOAF	4	2
CASH to HEM	3	1
E-8 to PIER II +	3	1
E-8 to ROUGH *	3	1
E-8 to PIER I *	3	1
E-8 to BRINK	4	2
E-8 to PROM *	4	2
E-8 to PHONE *	3	1
FORTIFICATION HILL to PROM *	5	1
FORTIFICATION HILL to RIVER MT.	8	4
FORTIFICATION HILL to LA MESA	4	2
HEM to ROUGH*	5	1
HEM to RIVER MOUNTAIN *	4	1
HEM to VEGA	4	2
J-HILL to BRINK	7	5
J-HILL to E-8	5	3
J-HILL to SUGARLOAF *	3	1
LA MESA to PROM	4	2
PASS to HEM	3	1
PROM to HEM	5	2
PROM to CASH	4	2
PROM to FORTIFICATION HILL *	3	2
PROM to E-8 *	7	3
PROM to SUGARLOAF *	4	1
PROM to J-HILL	9	5
PROM to ROUGH	4	2
RIVER MOUNTAIN to LA MESA	4	2
RIVER MOUNTAIN to HEM *	4	2
ROUGH to RIVER MOUNTAIN	3	1
ROUGH to HEM *	5	4
ROUGH to E-8 *	3	1
ROUGH to SUGARLOAF *	5	2
SUGARLOAF to ROUGH	5	2
SUGARLOAF to J-HILL *	2	1
SUGARLOAF to PROM *	2	1
SUGARLOAF to E-8	3	1

+ Observed at one end only

* Indicates refraction on both ends of the line

The 36 directions that had rejections are listed in Table II. Of this number, three directions were observed in one direction only, 16 show evidence of abnormal refraction on both ends of the eight lines that they represent, and 17 show evidence of this refraction on one end only of the line. Taking once more the total of 85 directions that were observed, seven directions were on but one end of a line, leaving 78 directions or 39 lines that were observed at both ends. Of these 39 lines, eight show abnormal refraction on both ends of the lines, 17 show refraction on one end only, and 14 lines show no refraction at either end.

It is generally conceded that the refraction encountered in triangulation is caused by the lack of homogenity in the atmosphere through which the lines of sight pass. A line of sight passing from a warmer medium to a cooler medium is bent away from a straight line.

The topography contiguous to a line of sight is, perhaps, one of the greatest of contributing causes to refraction. Lines that pass along the slope of a hill or along the face of a bluff will be bent more than those passing over flat ground. If several sections of the ground under a line are cultivated and adjacent to other sections that are wooded, the line may be bent several times.

Usually observations on first-order triangulation are begun sometime between sundown and darkness and continued until completed. It is assumed that during this time, under ordinary conditions, the cooler air is settling. The surface of the ground, however, radiates some of the heat that has been absorbed during the day and this tends to offset the effect of this settling air.

If observations are made on a night when the air temperature is falling, the ground radiation will be correspondingly large. This condition tends to equalize the temperature of the lower air strata, which we will classify as "favorable observing conditions". Under the opposite condition, when the ground temperature is lower than the air temperature, the ground will tend to absorb heat and this differential in temperature will cause the air in the lower strata to be more disturbed.

The opinions expressed above indicate that the best results will be obtained by observing at the time when the ground radiation most nearly balances the settling of the cool air. Experience points out that this time is usually just at sunset and for a short period thereafter. Over lines passing across Black Canyon, however, the best time to observe was found to be just after sunrise.

It was determined that observations at certain stations had to be made at a time when the hot blast through Black Canyon would not affect the lines of sight. Observations were started, therefore, at sunrise and continued until about 10:00 a.m. It was found that directions observed between the hours of 8:45 a.m. and 9:30 a.m. closed the triangles and that at certain stations those taken before and after that time did not. At this time conditions were as follows: the face of the dam was still radiating heat,that had been absorbed the day before, into Black Canyon though the sun itself was not yet striking it. The sun, however, was gradually heating the air over the canyon until the temperature differential between the air inside and that outside of the canyon was very small, thus effecting a minimum of refraction of the lines of sight passing over the canyon.

Some practical considerations are offered which the writer has found helpful on the project under discussion.

1. Observing parties must be at their stations ready to observe before sundown.

2. Lightkeepers must have their lights on and pointed before sundown.

3. It may be desirable, when extreme conditions are encountered, to observe first the lines which appear to be subject to refraction.

4. As a precautionary measure, always compare the directions obtained from the first eight positions with those obtained from the second eight positions of the circle. If any appreciable difference is noted, the first eight positions should be repeated. It is suggested that the sequence of position settings be changed, as follows, in order to eliminate, to some extent, the instrumental errors:

First 8	Second 8
0° 00' 40"	11° 00' 40"
22 01 50	33 01 50
45 03 10	56 03 10
67 04 20	78 04 20
90 00 40	101 00 40
112 01 50	123 01 50
135 03 10	146 03 10
157 04 20	168 04 20

5. When discrepancies are apparent in inspection, select an initial station giving the best conditions rather than the natural initial which is the line farthest to the left of the observer.

6. A careful record of weather conditions should be kept and all changes in wind direction and force noted. These data are particularly useful when deciding when to reobserve the troublesome stations.

7. It must be realized that refraction conditions can change very rapidly. The following procedure is recommended when reoccupying a station:

(a) Select the direction that is apparently in error and take this direction with one or two others.

(b) Observe a set of 16 positions just at sundown. If the sky is overcast, the set can be started before that time.

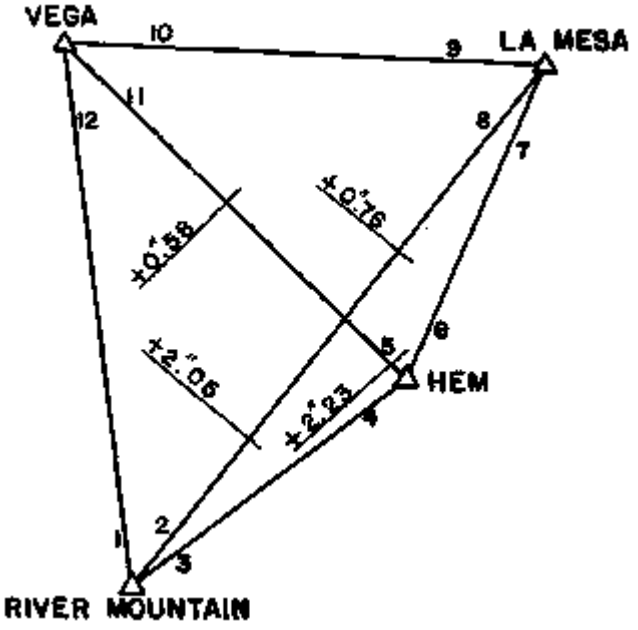
(c) If a satisfactory direction is not obtained, take one position about every ten minutes, and watch for a change which, as a general rule, will be accompanied by a series of very ragged directions.

(d) When a change is apparent, and the atmosphere seems to have quieted somewhat, complete the observations as soon as possible.

8. The writer's experience has been that ragged runs are not evidence of refracted lines nor do smooth runs indicate the absence of refraction. A copy of the Abstract of Directions obtained at station J-HILL is shown in Table III. Here is the unusual case of 12 directions on four stations falling in one group with but one rejection, and the last four directions in another group with the means of neither group near the final accepted values for the directions. Additional observations on this same night had to be rejected and it was not until several days later that satisfactory observations were obtained.

9. Special publication No. 120 and amendments thereto direct that when two sets are obtained on a direction, each set should be retained if it is within 0".5 of the mean, but the direction closing the triangles best should be retained if either is more than 0".5 from the final mean. In the application of this rule, it is suggested that the initials be transferred to a direction that is known to be correct before definitely rejecting any direction.

10. The directions at a station should not be reobserved until the station to be reoccupied has been determined by a closure sketch and side-equation test. It is useless to reoccupy a station that is already correct, as a wrong direction may be obtained that will close the triangles, thus introducing an additional error into the work which will not be detected until the triangle computations have been far advanced.



The setup of a side equation is fully explained in Special Publication No. 138 "Manual of Triangulation Adjustment and Computation", and in "The ABC of Triangulation Adjustment". No theoretical discussion will be attempted here.

The closure diagram is simply a sketch of the figure on which triangle closures are shown. In the following example it can be seen from the closure diagram that the line River Mountain - Hem is displaced or that direction (3) or direction (4) is in error.

- 4+6	Hem	103°	18'	44".86		- 8+9	La Mesa	66°	33'	58".65	
- 1+3	River	43	59	11.09	+ 2".05	- 1+2	River	89	41	34.95	+ 0".58
-11+12	Vega	29	42	04.10		-10+12	Vega	93	44	46.98	
+ 7+8	La Mesa	11°	30'	09".07		- 7+9	La Mesa	68°	03'	47".72	
- 4+6	Hem	152	12	17.02	+ 2".23	- 5+6	Hem	47	53	32.16	+ 0".16
- 2+3	River Mt.	16	17	36.14		-10+11	Vega	64	02	40.88	

The procedure followed in setting up the side equation test is described briefly, as follows. Referring to the closure diagram it will be seen from inspection that angles at each station influence three triangles. For any station (vertex) selected, the length of one line to that station from another vertex of the quadrilateral

Table III

Abstract of Directions

State: Nevada
Station: J-HILL
Observer: E. B. L.

Date: May 17, 1935

Position No.	Stations Observed			
	PROM	BRINK	E-8	SUGARLOAF
	0° 00'	65° 51'	87° 54'	123° 28'
	"	"	"	"
1	0.00	66.3	50.1	60.7
2	0.00	68.8	50.0	64.2
3	0.00	66.4	47.4	62.4
4	0.00	67.3	47.4	64.4
5	0.00	68.2	48.0	62.0
6	0.00	68.3	46.9	61.0
7	0.00	67.1	47.0	61.6
8	0.00	66.9	51.0	64.5
9	0.00	68.9	49.2	62.9
10	0.00	(R71.9)	51.7	65.7
11	0.00	65.7	50.9	61.6
12	0.00	69.9	53.7	63.7
Mean of 12		67.62	49.44	62.89
13	0.00	49.3	39.1	50.8
14	0.00	51.0	37.3	55.1
15	0.00	45.5	34.8	54.4
16	0.00	47.8	34.1	51.7
Mean of 4		48.4	36.3	53.0
Accepted means from other observations		42.10	32.02	50.54

Note: All lines influenced by a very hot wind blowing through Black Canyon. Observations made shortly after sundown.

can be computed in terms of the other two lines converging at the station selected from the other two vertices of the quadrilateral. In order to set the angles down in proper tabular form, assume that we are computing through the triangles from some line used as a starting line, entering in the second column the angles opposite the starting lines, and in the sixth column the angles opposite the lines computed to. Enter log sines to angles and tabular difference for 1" in columns 3, 4, 7 and 8. Sum the log sines, and the difference between the sums is the closure or "constant term".

Consider first the possibilities when the pole (the point around which the equation is formed) is at River Mountain. The following equation is obviously correct:

$$\frac{\text{River Mt.-Vega}}{\text{River Mt.-La Mesa}} \times \frac{\text{River Mt.-La Mesa}}{\text{River Mt.-Hem}} \times \frac{\text{River Mt.-Hem}}{\text{River Mt.-Vega}} = 1$$

Substituting the sine of the angle opposite each side for the side the equation is transposed to:

$$\frac{\sin(-8+9)}{\sin(-10+12)} \times \frac{\sin(-4+6)}{\sin(-7+8)} \times \frac{\sin(-11+2)}{\sin(-4+5)} = 1$$

and the tabulation is shown thus:

Directions	Angle	Log.Sin	Tab. Diff. 1"	Directions	Angle	Log.Sin	Tab. Diff. 1"
-10+12	93°44'46"98	9.999 0709	- 0.1	- 8+9	88°53'38"65	9.921 4109	+ 1.4
- 7+8	11 30 09.07	9.299 7491	+10.3	- 4+6	153 12 17.02	9.658 6781	- 4.0
- 4+5	104 18 44.86	9.986 3068	- 0.5	-11+12	29 42 06.10	9.695 0300	+ 3.7
	+sum	9.296 1268			-sum	9.285 1190	

The correction to be applied to close the figure depends on the difference between the sums of the log sines of the angles (-8+9) (-4+6) (-11+2) and (-10+12) (-7+8) (-4+5).

The closure sketch indicates that it is probable that direction 3 or direction 4 is in error. It is now assumed that direction 4 should be decreased by 1".5 which would improve triangle closures from 2".05 to 0".55 and 2".25 to 0".75. If direction 4 is decreased 1".5 seconds the sine (-4+5) is increased by 8 in the seventh place of logarithms and the sine (-4+6) is increased by 60 in the seventh place. The difference between sums is reduced from 78 to 26. This computation therefore seems to indicate that direction 4 at Hem should be reobserved.

Next take the pole at Hem and transpose the equation:

$$\frac{\text{Hem-Vega}}{\text{Hem-La Mesa}} \times \frac{\text{Hem-River Mt.}}{\text{Hem-Vega}} \times \frac{\text{Hem-La Mesa}}{\text{Hem-River Mt.}} = 1$$

to read:

$$\frac{\sin(-7+9)}{\sin(-10+11)} \times \frac{\sin(-11+12)}{\sin(-1+3)} \times \frac{\sin(-2+3)}{\sin(-7+8)} = 1$$

Directions	Angle	Log.Sin	Tab. Diff. 1"	Directions	Angle	Log.Sin	Tab. Diff. 1"
- 7+9	88°05'47"72	9.967 3092	+ 0.8	-10+11	54°02'40"68	9.953 8858	+ 1.0
-11+12	29 42 06.10	9.695 0300	+ 3.7	- 1+3	46 59 11.09	9.856 8546	+ 2.0
- 2+3	18 17 38.14	9.448 0191	+ 7.2	- 7+8	11 30 09.07	9.299 7491	+10.3
	+sum	9.110 4084			-sum	9.110 4089	

It is now assumed that direction 3 should be increased 1".5. This will increase the sine of (-2+3) by 108 in the seventh place of logarithms and the sine of (-1+3) by 30 in the seventh place. The difference in the sums is increased from 5 in the seventh place to 73 in the seventh place. The computation indicates that a change of 1".5 in direction 3 would not improve the result. Further computations to determine which station to reobserve are unnecessary.

Instead of taking the pole at Hem it might have been taken at Vega. The equation is formed in the same manner with the following result:

Directions	Angle	Log.Sin	Tab. Diff. 1"	Directions	Angle	Log.Sin	Tab. Diff. 1"
- 7+9	68°05'47".72	9.987 3593	+ 0.8	- 5+8	47°03'52".16	9.870 3368	+ 1.9
- 4+5	104 18 44.86	9.986 5068	- 0.3	- 1+3	45 58 11.09	9.856 8546	+ 2.0
- 1+2	29 41 34.95	9.694 9100	+ 3.7	- 8+9	56 33 36.85	9.921 4109	+ 1.4
	+sum	9.648 5811			-sum	9.648 5823	

The difference between the two sums is 12 in the seventh place. Should the direction at (4) be decreased 1".5 the sine (-4+5) will be increased 8 in the seventh place and the difference between the two sums reduced to 4 in the seventh place. If on the other hand, the direction at 3 is increased 1".5 the sine (-1+3) is increased 30 in the seventh place and the difference between the sums is increased 42. These results indicate that station Hem should be reobserved.

In the figure discussed, it is noted that several small angles (angles with large tabular differences) enter into the side equations, notably (-7+8). This condition does not obscure the results in this case, but by taking the pole at Vega, the small angles can be eliminated from the equation. This procedure would have been necessary if the angle (-7+8) was very small, as the large tabular difference for an angle of 2° for instance, would confuse the results of the side-equation test.

Lieutenant W. M. Scaife, engaged in surveys of the Columbia River, with headquarters at Portland, reports considerable interest by local surveying organizations in the work of his party. Not all requests for advice, information and service he receives are of an engineering nature, however. In his letter, Lieutenant Scaife states:

"Included among the calls have been several of somewhat unusual nature. One man thought that I was a 'G-Man' and wanted me to arrest a suspected criminal. A letter was received asking for the 'elevation of the spot where the Richfield sign used to be'. A woman made a telephone call regarding a cat with fits, and told us that she was not interested in what government outfit we called ourselves, but that she wanted us to take care of the cat situation immediately".

PRIMARY TIDE STATIONS

The outline map on the opposite page shows the present distribution of primary tide stations maintained by the Division of Tides and Currents, U. S. Coast and Geodetic Survey. In addition to those shown, others are operated at Ketchikan, Seward, Juneau, and Sitka in Alaska, and at Honolulu in the Hawaiian Islands. At all these stations standard automatic tide gages are in continuous operation, observations at some places extending back as far as 1897. Their purpose is to provide the basic tide data which can be determined only from long-period observations.

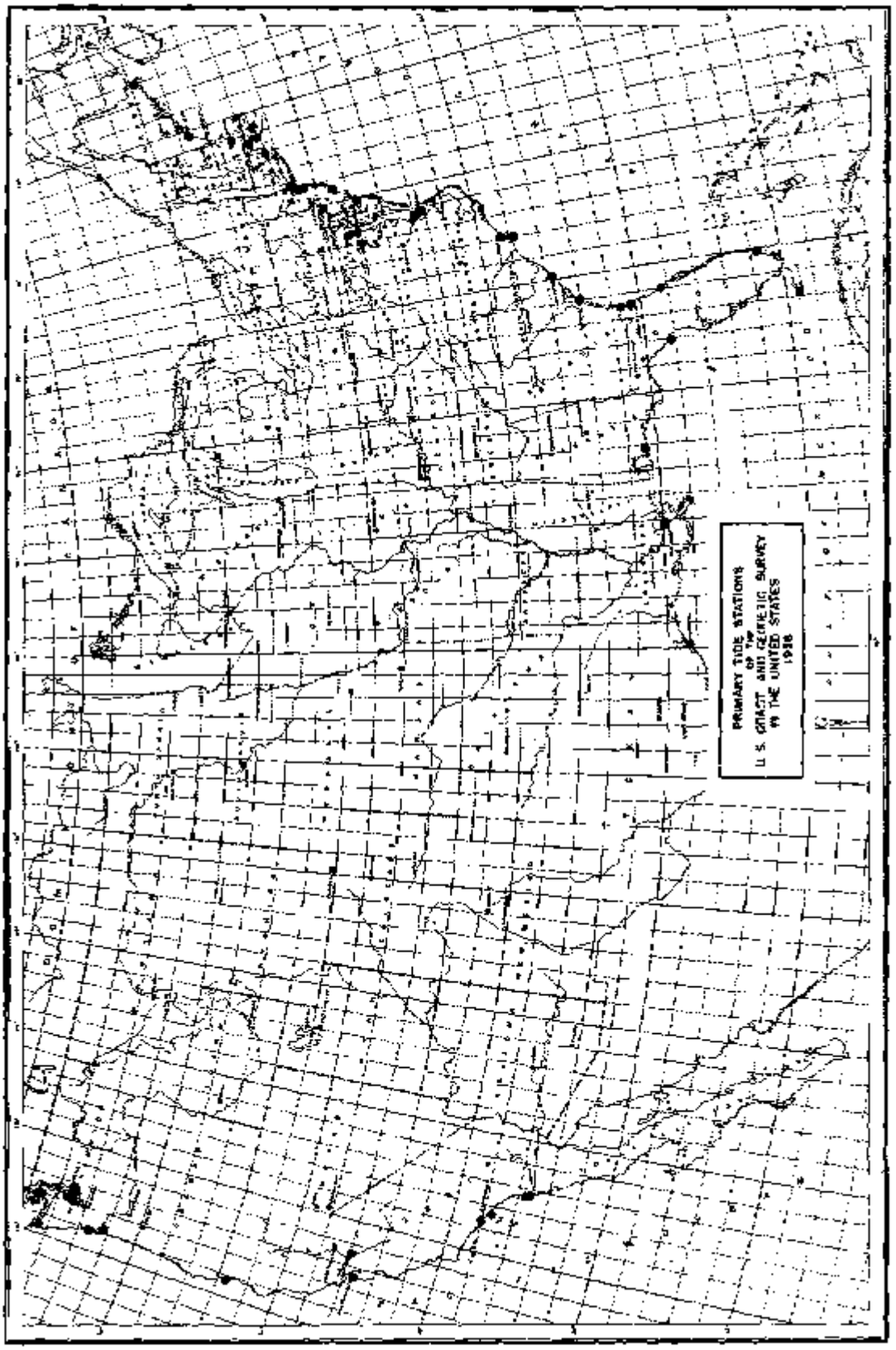
A number of different factors enter into the location of these stations and account for their distribution. Each of the varying types of tide encountered along different sections of the coast must, as far as possible, be represented by at least one primary station. This is necessary so that short-period observations made in connection with hydrographic surveys or for other special purposes may be reduced to mean values by comparison with simultaneous observations at some primary station of suitable characteristics. A satisfactory comparison requires that the tides at both primary and secondary stations be essentially similar in type.

Ports of commercial and industrial importance must also be represented because requests for tide data from such centers are frequent and varied. Since these form the reference stations of our tide tables for which daily predictions are published, continuous observations, permitting periodic revision of constants for prediction purposes, are necessary for these locations.

Still others are located with the special view to obtaining the basic sea level determinations for the first-order level net. Sites for this purpose must be selected as representative of open coast conditions. The special needs of cooperating engineering and scientific agencies also account for the locations of some of these stations.

Since these primary tide stations constitute the "control" for all other tide observations of whatever purpose, continuous operation and precision of results are essential. When and where conditions permit, stations are inspected at least once each year for the purpose of checking the condition and operation of instrumental equipment, of verifying the elevation of tide staffs and the adequacy of existing bench marks, and of making any repairs or alterations that the stations may need.

The importance of these inspecting duties is urged on those officers who from time to time may be instructed to perform them. Especially is this true of outlying stations where failure to detect or to anticipate the principal operating difficulties has occasionally resulted in serious loss of record, since the facilities available to the tide observer generally permit of only routine operation and not of major repairs or alterations to the station or its equipment. Careful attention to the instructions given on pages 43-45 of the "Manual of Tide Observations" will do much to prevent the missing or defective record which tends to defeat the purpose of the primary tide station.


PRIMARY TIDE STATIONS
OF THE
U.S. COAST AND GEODETIC SURVEY
IN THE UNITED STATES
1936

SIGN LANGUAGE NUMERALS *

Milton A. Karp
New York, New York

In surveying work, the rodman is often beyond hearing distance of the instrument man or the note keeper. Quite often, a rod reading or target setting must be communicated from one party to another. Rather than waste time in having one party walk out to the other, a signal system for numbers seems desirable. An added advantage of the signal system is that there is less chance of error through its use, than there is in shouting across an appreciable distance. The following is a set of signals I have come across while surveying, which is simple, quick and easy to give and read.

One - The left arm is extended downward at a 45 degree angle to the horizontal.
Two - The left arm is extended horizontally.
Three - The left arm is extended upward at a 45 degree angle to the horizontal.
Four - The right arm is extended downward at a 45 degree angle to the horizontal.
Five - The right arm is extended horizontally.
Six - The right arm is extended upward at a 45 degree angle to the horizontal.
Seven - Both arms are extended downward at a 45 degree angle to the horizontal.
Eight - Both arms are extended horizontally.
Nine - Both arms are extended upward at a 45 degree angle to the horizontal.
Zero - One arm is waved in a circle.

R. E. Mirick, Construction Engineer
Kildeer, North Dakota

In regard to the foregoing, it has been my experience that any system of signs that requires the observer, especially if inexperienced, to differentiate between right and left hand is confusing.

Our number system contains three groups of three and a zero.

One - Extend either arm upwards 45 degrees from vertical.
Two - Extend either arm horizontally, the other arm held by side.
Three - Extend either arm downward 45 degrees from horizontal.
Four - Place either hand on chest and extend other arm upwards 45 degrees from vertical.
Five - Place either hand on chest and extend other arm horizontally.
Six - Place either hand on chest and extend other arm downward 45 degrees from horizontal.
Seven - Extend both arms upwards 45 degrees from vertical.
Eight - Extend both arms horizontally.
Nine - Extend both arms downward 45 degrees from horizontal.
Zero - Hold both hands horizontal, palms near together, in front of chest.

* Reprinted through the courtesy of Engineering News-Record.

In teaching this system to a beginner, remind him of the three groups of three and the zero; then caution him to place the number being signalled in its proper group of three, as indicated by the arm held by side, hand placed on chest, or both arms in position, as the case may be; and finally to determine the number by the quadrant in which the extended arm is held.

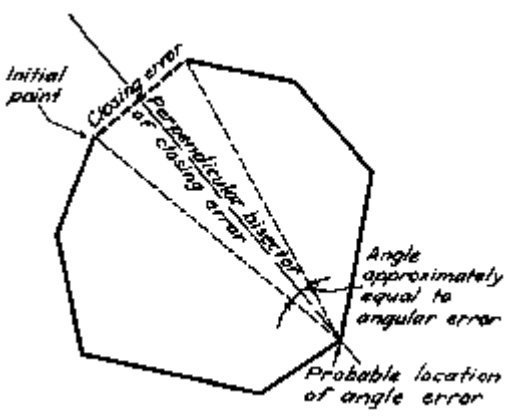
Thus: **One** is indicated by one arm remaining in place by side and the other arm extended upwards in First position, i.e. first in the first group of three. Five is indicated as being in the second group of three by one hand placed on chest, and the number itself is indicated by the other arm extended horizontally. Nine is indicated as being in the third group of three by the fact that both arms are used in making the signal, and the number is indicated by the arms being in the third, or lower, position. The zero signal is obvious.

CORRECTING CLOSURE ERROR *

BY

George C. Commons

When, in making a survey, the last course fails to make an angular closure, due to an error in angles at some transit point, the method illustrated will often serve to locate the error, thus giving one angle to check in the field, instead of repeating the entire survey. The principle of the method is that in plotting the survey according to the field notes, the portion made after the angular error may be pivoted about that point to the amount of the error, so as to make a closure.



To apply this method, the survey is plotted in the order in which it was made, and the closing line is drawn in. A perpendicular is erected at the midpoint of this closing line, and the following tests are applied: (a) If the perpendicular bisector of the closing error passes through or near to an angle point of the survey, and (b) if the angle subtended at this angle point by the closing error approximates the angular error of closure, and (c) if pivoting the later portion of the survey about this angle point so as to eliminate the closing error is in the direction required to correct the angular error, then it is very probable that the error is at this angle point.

* Reprinted through,the courtesy of Engineering News-Record.

SONO-RADIO BUOYS IN 1938

George M. Marchand, Junior Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

and

Almon M. Tincent, Senior Chief Radio Operator
U. S. Coast and Geodetic Survey Ship GUIDE

Experiments were conducted during the past field season of the Ship GUIDE with three different arrangements of the hydrophone for radio acoustic ranging with sono-radio buoys. These were (1) the hydrophone attached to the anchor cable of the buoy; (2) the hydrophone anchored separately; and (3) the hydrophone suspended below the sono-radio buoy itself.

Photograph 1.

In the first arrangement, designed for use in depths of 15 to 17 fathoms, considerable care was necessary in insulating the connections between the hydrophone and the cable because of the motion of the latter.

The anchor consisted of a 200 pound circular block of concrete, bound by a heavy duty tire casing. A 25-fathom length of l/2-inch galvanized wire cable led to a bracket on an auxiliary or watch buoy. A length of 7 fathoms of similar cable connected this buoy with the sono-radio buoy. The watch buoy was constructed from a 15-gallon drum and served to relieve the sono-radio buoy of the support of the anchor cable. The cable connecting the two buoys was kept near the surface of the water by small aluminum floats,commonly called toggles, such as are used in wire drag work. The connections were well insulated with rubber to prevent noise, and the lower five fathoms of the anchor cable were covered with garden hose.

A hydrophone of the small inertia type,* two inches in diameter and three inches long, was attached to the anchor cable about four and a half fathoms from the anchor, and insulated with soft rubber. The rubber hydrophone cable (Tyrex) was then seized to the anchor cable at intervals of two feet (photograph 3).

Immediately above the hydrophone, one end of a five-fathom length of l/2-inch diameter pure rubber was seized to the anchor cable with marline and stretched to three times its length. While so stretched, this was seized to the cable at three-foot intervals. On releasing the tension, a serpentine shape was produced both in the wire cable and the rubber hydrophone cable. Below the hydrophone, a two-foot length of rubber was similarly used. The purpose of these rubber springs was twofold; first, to protect the hydrophone against jerks; and second, to provide a means of automatic

* See "Electromagnetic Hydrophones or Magnetophones", by Herbert Grove Dorsey, this issue.

Photograph. 2.

Photograph 3.

adjustment for height of tide and swell. The watch buoy had sufficient reserve buoyancy to produce a strong pull on the submerged gear so there was no danger of the hydrophone sagging to the bottom during slack water.

This type of installation was first used off Punta Gorda, California. It was left in place for a period of ten days during which time some of the worst weather of the season was experienced. For several days splendid returns from bombs were obtained with no extraneous noises. Later it began to broadcast spasmodic clicks which interfered considerably with its efficiency. Bomb returns were received from this station at 60 seconds time distance, with the sensitivity adjusted to 60 percent of the maximum.

Photograph 4.

Photograph 5. Sono-radio buoy off Punta Gorda, California.

Photograph 6. Picking up a sono-radio buoy.

It was desired to pick up this station after a period of 10 days operation but due to boisterous northwesterly weather it was only possible to pick up the sono-radio buoy at that time. On returning at a later date when more favorable weather conditions existed the watch buoy could not be found. It was unlikely that the buoy had dragged, since it had remained in position during 10 days of rough weather, so it was assumed it had sunk or broken adrift.

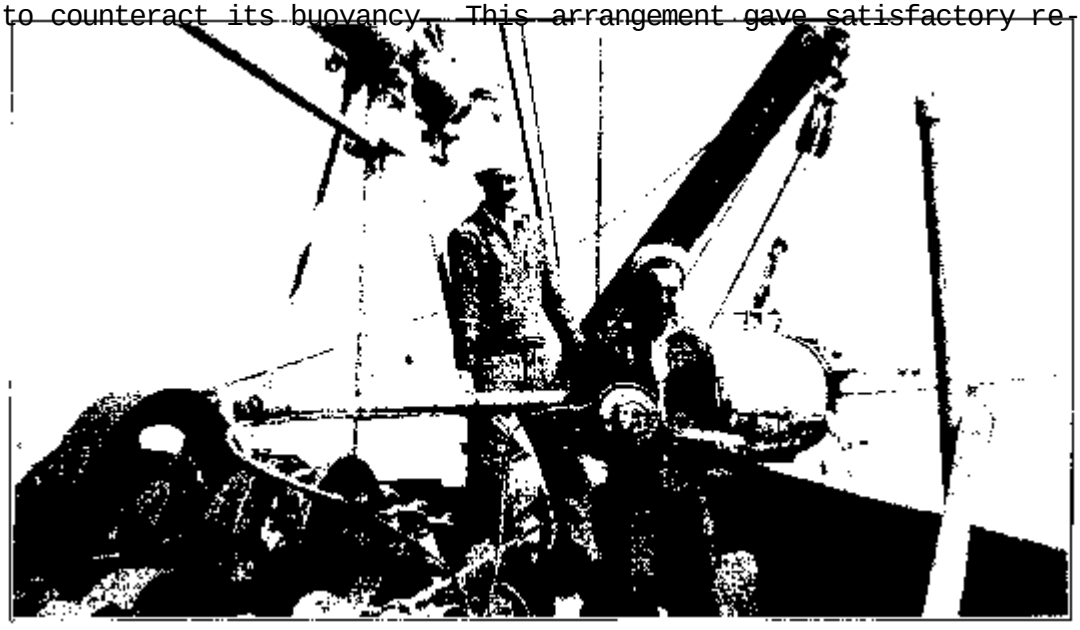
Another sono-radio buoy, similarly assembled, was used later with good success off False Cape. On this and subsequent installations two pieces of 2" z 4" lumber, eight feet long, were stapled to the wire pennant connecting the two buoys. Noises developed in this station after a few days, and it was decided to abandon this type for the time being. It may be said, however, that this arrangement is thoroughly practicable, especially when a station is needed for a short time only. With more time and funds spent in preparation it could be made practically noise-proof. It has the advantage of being readily portable, and can be planted or lifted in a few minutes by four or five men working from a launch.

The second arrangement, suggested by Commander O. W. Swainson, consisted of a large hydrophone (self-floating type) anchored at some distance from and connected to the main anchor. Rubber-covered 1/8-inch steel aircraft wire was used to connect the hydrophone to the sono-radio buoy. The hydrophone was anchored by a 50-pound section of rail and suspended about four or five fathoms from the bottom. The rubber cable was carefully insulated with sections of garden hose at all points of fastening. In all other respects the arrangement was similar to that in the first method except that no rubber was used on the anchor cable other than the garden hose on the lower five fathoms. To prevent chafing of the rubber cable on the main anchor several fathoms of cable nearest the anchor were covered with hose.

In putting out a station of this type it is necessary to use care in lowering the two anchors as it is desirable to have both land at the same time. Usually the distance between the hydrophone anchor and main anchor was about 120 feet, which permitted the gear to be conveniently handled from the ship. Should greater separation between the two anchors be desired, the hydrophone can be anchored from a launch.

This arrangement proved to be most successful and the efficiency of the station was considered to be equal to that of a shore RAR station. For a period of 10 days it was practically noiseless with the sensitivity set at 80 percent of maximum. The bomb returns on the chronograph tape were always well defined, even to the outer limits of the hydrography, a distance of 70 seconds in time.

The third arrangement consisted of suspending the hydrophone below the sono-radio buoy. The large type hydrophone was used and a bracket was fitted to the container for attaching a small weight to counteract its buoyancy. This arrangement gave satisfactory re-



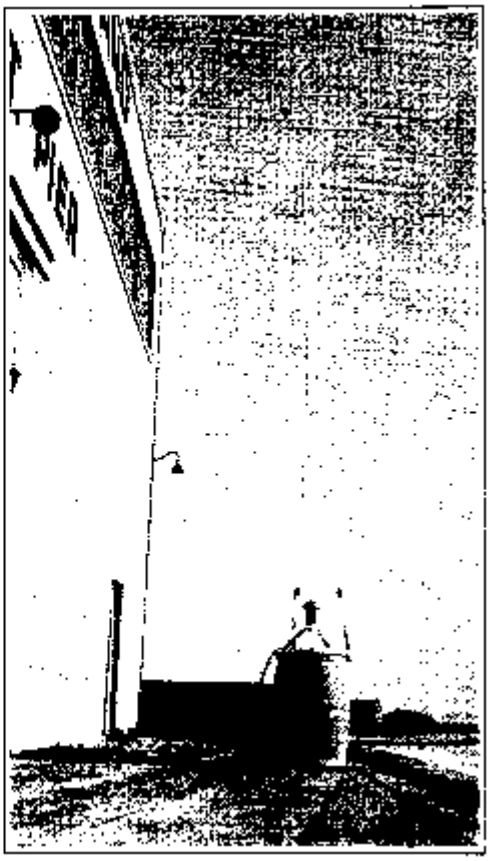
Photograph 7.

suits with the sensitivity set at 70 percent of maximum. However, for long periods of operation it is much inferior to the second arrangement.

The experience of the past season has led to several improvements in the Ship GUIDE'S sono-radio buoy equipment. The weight of the bracket supporting the antenna has been reduced by using lighter steel and securing the bracket to the buoy by means of three brass hook screws. The new bracket is designed to fit inside the rim of the buoy top and is insulated from the top with sections of split garden hose. This makes it possible to remove the buoy top for adjusting the radio equipment much more quickly than heretofore.

Another innovation being tried is a sheet aluminum pennant attached to the top of the antenna. The pennant is several feet long

Photograph 8.



Photograph 9.

and free to stream in the wind. It is expected to increase the efficiency of the unit.

A new antenna is being devised for use in future work. It consists of a telescopic pole of chrome molybdenum tubing. The pole is made of 2 sections, the lower of which is two inches in diameter and seven feet long and the upper, one inch in diameter and six feet long, with a two-foot flag section of 1/2" tubing mounted on the top. The lower section only is guyed, permitting the telescoping of the upper section, and thus greatly facilitating the handling of the buoy on board ship. Experience has proven that chrome molybdenum is much superior to duraluminum for this purpose because its greater flexibility permits safe handling under adverse conditions.

The electrical equipment of the buoy described on page 73, Field Engineers Bulletin No. 11, for December 1937 has proved very successful. No change has been made to this equipment except that 1.4-volt tubes (1A5G, 1C5G, 1N5G, etc.) are being used in place of the previous two-volt tubes. These new tubes have been developed as a result of correspondence with the principal vacuum tube companies.

A life test, using the former two-volt tubes, was made on two buoys. The filaments were left burning continuously, being supplied by identical batteries. One buoy dropped below the minimum operating voltage of 3.6 after 105 days of operation, while the other one still is operating with a voltage of 3.96, having been in operation for 130 days at this writing.

No life test has been made on the new 1.4-volt tubes but it is conservatively estimated that their life rating will approximate six months, and their use should save considerable labor and expense during a field season.

Identical electrical units still are being maintained in both buoy and shore stations. This has proved to be very convenient since a buoy receiver-transmitter can be substituted for a shore set by merely replacing the 1.4-volt tubes by six-volt tubes or vice versa.

Although only one sono-radio buoy anchor dragged during the past season, it is believed that the weight of the anchor should be increased to about 400 pounds, for greater security.

In 1937, the hydrophone cable used by the Ship GUIDE had the following specifications:

> Single conductor, tinned aircraft wire, l/8" diameter, preformed, 19 strands (number 22), 30 percent rubber sheath, 0.45" diameter, breaking strength 2100 pounds.

This cost $0.06 per foot. For the 1938 season, after a study for a more suitable cable, 5000 feet of cable were purchased which had these specifications:

> Single conductor,tinned aircraft wire, 3/16" diameter, preformed 49 strands (7 x 7), 60 percent rubber sheath, 1/2 inch outside diameter, weight per 1000 feet, 155 pounds. Breaking strength to be at least 3200 pounds.

The additional cost of $0.02 per foot for this cable was deemed well justified by the greater flexibility, strength and durability obtained, and the particular suitableness of the cable for sono-radio buoys.

* * * * * *

Extract from Season's Report 1938 of Commanding Officer, U.S.C. and G.S. Ship GUIDE, E. W. Eickelberg, H. and G. Engineer, U. S. Coast and Geodetic Survey.

RAR shore stations were operated at Shelter Cove, Trinidad Head and Crescent City, California. Sono-radio buoys were estab-

lished as needed throughout the season. Very little difficulty was experienced with these sono-radio buoys due to dragging of anchors. After experiments conducted to find the installation which would he the quietest and give the best results, excellent returns were obtained from these buoys. Bomb returns were received up to seventy seconds of time, which was the outer limit of the hydrography. Throughout the season, several of these sono-radio buoys operated as efficiently as shore stations. Due to the simplicity with which these buoys can be moved and installed wherever desired, it is believed that in the near future the need for shore stations will be lessened. There is, however, ever present the danger of dragging of anchors, non-operation or noisy installations so that it may be deemed necessary to have at least one or two shore stations in operation. The next season's work will naturally tend to solve this problem. With the new tubes of low voltage developed by Senior Chief Radio Operator Vincent, one set of batteries will successfully operate a sono-radio buoy the entire season. Too much credit cannot be given to him for whatever success was obtained by this vessel in using the sono-radio buoy.

* * * * * * *

Extract from Season's Report 1938 of Commanding Officer, U.S.C. and G.S. Ship LYDONIA, R. P. Eyman, H. and G. Engineer, U. S. Coast and Geodetic Survey.

The sono-radio buoys operated very well and most of the time returns were obtained from all three buoys. Velocity determinations appeared to be easier to evaluate and much more consistent at the beginning of the season and progressively worse during the season. Toward the end of the season the velocities appeared very erratic and a close study will have to be made to determine the best values and reasons for apparent deviations. It is my belief that adequate means of obtaining sufficient and accurate temperature measurements are not at present available. The use of the capsizing thermometer is time consuming and in too many cases uncertain, as apparent inconsistent readings would have to be repeated — many times with further inconsistencies. It would seem desirable also to make further intensive studies of the sound travel path through water to arrive at a workable formula for distances that appear to exceed the normal return of the first sound wave. In other words, the results of the past season seem to indicate that for distances up to about 25 seconds normal returns could be expected with very small bombs, whereas for greater distances returns often indicated a lower velocity or, probably what amounts to the same thing, the pick up of a second or later reflection of the sound wave.

A much more sensitive hydrophone could be used to great advantage. Many times a larger bomb would only give returns for a very short additional distance after failure of the l/4-pint bomb. Various types of hydrophone suspension were tried with a view to obtaining the best results with little or no apparent differences noted. One hydrophone was attached to the base of the buoy frame and others were suspended from 4 to 8 fathoms below the frame by both cable and chain with no noticeable difference in operation.

The matter of radio frequencies should be given further consideration with a view to obtaining separate bands for our own exclusive use. On two different occasions this past season we were

prevented from doing RAR for periods of from two to four hours due to almost continuous interference by Navy submarines operating out of New London and on many occasions for shorter intervals. In this matter also some thought has been given to the possibility of having separate frequencies for individual sono-radio buoys so that the returns could be controlled and definitely identified through separate receivers. This would permit the blocking off of buoys temporarily not desired due to poor or continuous operation, when near a bisetrix, or when a passing ship might be near one of the buoys. Three receivers would call for a redesign of the chronograph with probably three styli, one for each receiver, but it would seem that the results to be expected would far outweigh any difficulties in design and make-up.

The construction of the sono-radio buoys, both mechanically and electrically, would seem to be about all that could be desired at present. Their construction was rugged enough to withstand all but extreme weather conditions and at the same time they were comparatively easy to handle in planting and picking up. The electrical make-up was such that once adjusted and planted they needed no further attention except on very rare occasions until time for battery renewal after about 25 to 30 days.

FROM A LETTER TO THE ASSOCIATION BY LIEUTENANT L. C. JOHNSON, IN CAMP AT CAPE RUKAVISTIE, ALEUTIAN ISLANDS

"My season's assignment on the DISCOVERER has indeed been a unique one, - topography on the south shore of Unimak Island, using horses as means of transportation. It really works. This island, as you probably know, is especially hard to reach from the water side, due to heavy swells from the prevailing southerly seas. The camp is located at Cape Rukavistie, the only spot between Capes Lutke and Lazereff where a landing can be made, and then, only at certain times. My topo sheets run to about thirteen miles east and west of Rukavistie, and that is just about as far as one should plan to operate from a central camp. Even at that small distance it is necessary some of the time to spend some seven or more hours in the darling saddle in order to reach one end of the work. Then add a few more hours of topo and it really makes a day's work. On the other assignments of topo in the past, my only complaint came from tired dogs, bunions, corns, and calluses thereon but this, à la horseback, really brings in a new situation and the complaint level a little higher up. However, the horses have more than once proved their worth, and I am all for them, though how those cowboys in the story books ever wanted to dance at night is beyond me.

"The weather here this season seems to be about as bad as is possible, even for this locality. The usual procedure seems to follow a regular well laid plan; it blows like hell for two or three days from the northeast or the northwest, taking all the high fog from the Bering Sea to the Pacific, then it switches around in about ten or fifteen minutes and begins to blow from the southeast or the west of the south area, and in comes all the fog and rain and drizzle that went out over head in the past two days. This cycle seems never to cease, and what work is done has to be done quickly and in between, when there is a between".

GLACIER BAY

H. Arnold Karo, Hydrographic and Geodetic Engineer
Commanding Officer, U. S. Coast and Geodetic Survey
Motor Vessel WESTDAHL

Surveys in Glacier Bay were begun in the past year by the party under the charge of Lieutenant Karo, marking his second assignment in glacial regions, an unusual and interesting experience for an officer. In the previous year Lieutenant Karo conducted surveys in Taku Inlet, near famed Taku Glacier. This glacier is described by Lieutenant Morris, a member of the party, in the article beginning on page 44 of this issue. The following description of Glacier Bay is taken from Lieutenant Karo's season's report.

(Editor)

Glacier Bay, since its discovery, has been an area of wide scientific and general interest, presenting as it does, such a unique opportunity for studying and understanding recent glacial activity and the subsequent development of flora and fauna. Glacier Bay contains several interesting relics of ancient interglacial forests, and a wide variety of vegetation and wild life, which are gradually encroaching upon the former barren and desolate waste of ice and snow.

Regarding the discovery of Glacier Bay we find that Bancroft in his History of Alaska, in describing Vancouver's voyage, states that "Glacier Bay escaped observation although it almost faces the anchorage". John Muir, in speaking of Glacier Bay, says, "Glacier Bay is undoubtedly young as yet. Vancouver's chart,made only a century ago, shows no trace of it, though found admirably faithful in general. It seems probable therefore, that even the entire bay was occupied by a glacier". Both of which accounts lead one to believe that Glacier Bay, or its entrance, escaped the observations of Vancouver and his party.

However, the following account from Vancouver's "A Voyage of Discovery" would seem to indicate that Glacier Bay was indeed visited by a party under Mr. Whidbey on July 12, 1794, who found the bay blocked with ice a few miles from the mouth. - - - - "To the north and east of this point, the shores of the continent form two large open bays, which were terminated by compact, solid mountains of ice rising perpendicularly from the water's edge and bounded to the north by a continuation of the united lofty, frozen mountains that extend eastward from Mt. Fairweather. In these bays also were great quantities of broken ice, which, having been put in motion by the springing up of a northerly wind, were drifted to the southward, and forcing the boats from the northern shore, obliged them to take shelter around the northeast point of the above island. This made Mr. Whidbey apprehensive that the still apparent connected body of ice from side to side, would at length oblige him to abandon his researches by this route, unless he should find it possible to force a passage through this formidable obstruction".

In 1892 Mr. O. G. Hillman, while visiting Glacier Bay, found a carved wooden cheroot holder buried in the glacial mud of the Beardslee Islands. The holder is a delicately carved piece (see photograph), depicting the slaying of the dragon by St. George. A holder of this quality and apparent antiquity, is hardly one that

would have been used, by modern day visitors to Glacier Bay and could well have been lost by Mr. Whidbey, or one of the other officers, when they were exploring the waters of Glacier Bay as far as the ice conditions permitted at the time. In addition to which, Glacier Bay had had few visitors at the time this cheroot holder was found.

After leaving Vancouver's account of Glacier Bay - unnamed at that time - we have nothing further until 1869 when Kloh-Kutz, a Chilkat Chief, told Professor George Davidson that a large bay full of ice mountains was about "one snowshoe day's travel". Professor Davidson was very much interested in this reported bay full of ice mountains. But the visit of Ex-secretary Seward to the eclipse observatory prevented the full discovery of Glacier Bay that season by this great scientist who contributed so much to the geographic record and knowlege of the Pacific coast.

In 1877, Lieutenant C. E. S. Wood, U.S.A., visited Glacier Bay on a hunting expedition and camped in Geikie Inlet near what is now named Wood Glacier. He briefly mentioned it in a popular magazine article, but since he did not specifically describe, sketch, map, or name any part of the region, he is not credited with the discovery of Glacier Bay.

On October 25, 1879, John Muir, accompanied by Rev. S. Hall Young, entered Glacier Bay and is officially credited with its discovery through his explorations, maps, sketches and description. In 1880 Commander Beardslee gave it the name of Glacier Bay.

Some of the most vivid and colorful descriptions of natural phenomena and nature's grandeur were written by John Muir in his attempt to describe the wonders he had seen on this and other trips into Glacier Bay. - - - - "I've been wandering through a thousand rooms of God's crystal temple. I've been a thousand feet down in the crevasses, with matchless domes and sculptured figures and carved icework all about me. Solomon's marble and ivory palaces were nothing to it. Such purity of color, such delicate beauty! I was tempted to stay there and feast my soul, and softly freeze, until I would become a part of the glacier. What a great death that would be!"

After this tribute to the quiet and soul-satisfying grandeur and beauty he found in the ice fields and crevasses back from the face of the glacier, he pays tribute to the power and stupendous forces released by the glacier in the following:

"When a large mass sinks from the upper fissured portion of the wall, there is first a keen, prolonged, thundering roar, which slowly subsides into a low muttering growl, followed by numerous smaller grating clashing sounds from the agitated bergs that dance in the waves about the new-comer as if in welcome; and these again

are followed by the smash and roar of the waves that are raised and hurled up the beach against the moraines. But the largest and most beautiful of the bergs, instead of thus falling from the upper weathered portion of the wall, rise from the submerged portion with still grander commotion, springing with tremendous voice and gesture nearly to the top of the wall, tons of water streaming like hair down their sides, plunging and rising again and again, before they finally settle in perfect poise, free at last, after having formed part of the slow crawling glacier for centuries. And as we contemplate their history, as they sail calmly away down the fiord to the sea, how wonderful it seems that ice formed from pressed snow on the far off mountains two or three hundred years ago should still be pure and lovely in color after all its travel and toil in the rough mountain quarries, grinding and fashioning the features of predestined landscapes". And again - : "Seldom, if ever, do the towers, battlements, and pinnacles into which the front of the glacier is broken fall forward headlong from their bases like falling trees, at the water level or below it. They mostly sink vertically or nearly so, as if undermined by the melting action of the water of the inlet, occasionally maintaining their upright position after sinking far below the level of the water, and rising again a hundred feet or more into the air with water streaming like hair down their sides from their crowns, then launch forward and fall flat with yet another thundering report, raising spray in magnificent, flamelike, radiating jets and sheets, occasionally to the very top of the front wall. Illuminated by the sun, the spray and angular crystal masses are indescribably beautiful".

What a pity that this grand natural monument of past ages could not have remained in its entirety as John Muir saw it. Through the efforts of the Geological Society of America with the endorsement of the National Geographic Society, Glacier Bay National Monument was established February 25, 1925, covering an area of 1,164,800 acres containing the great tidewater glaciers. Although this area is now protected from the depredations of man (the effectiveness of which was somewhat lessened by the act of 1936 allowing mining operations under certain restrictions), those of nature herself have done much to destroy the grandeur that was once Glacier Bay's.

The glaciers, in most instances, have been receding over the past several decades. Inlets that were once completely filled with ice are now open to navigation. Some inlets, such as Muir, have an active glacier at their heads, which disgorge huge icebergs as they recede farther and farther up the fiords and inlets; these glaciers are slowly dying. Many have disappeared in their entirety. Some of the great ice fields are gradually disappearing and it is estimated that the great ice plateaus surrounding Muir Inlet, of which John Muir wrote such glowing descriptions, have decreased in thickness nearly a thousand feet. For the causes of this recession, we would have to go back years, in all probability - centuries. For the ice disgorged from the glaciers today, fell as snow on the high mountains surrounding Glacier Bay centuries ago. A factor contributing greatly to the rapid rate of recession of most of the glaciers in recent times was the earthquake of 1899 at Yakutat Bay. After this earthquake, Glacier Bay was filled with ice and it was impossible to enter the bay. Before the earthquake, Muir Glacier was an imposing sight, presenting a vertical wall of ice 200 to 300 feet high. After the earthquake when it was again possible to visit Muir Glacier, the face was very much broken up and uneven. The whole appearance was very much changed and several ledges of

rock were exposed which were not visible before.

Future climatic conditions may be such that these great ice fields will again be replenished, and with renewed source of supply, the glaciers will come to life and again push out into their inlets and may even again fill up the whole of Glacier Bay. This has happened more than once in the past and in all probability will happen again in the future.

It is estimated that the present period of recession began about 1735 to 1785, and that at the time Vancouver visited this area, the ice front had receded three to six miles from its maximum, which was approximately at the mouth of Glacier Bay. The date of the recession is fixed roughly by the age of the trees found on the moraine near the mouth of the bay.

The present recession has brought to light many interesting facts and an abundance of material for study. We find evidences and proof that at least on two different occasions there has been a major recession of the glacier fronts followed later by advances after a considerable period of time had elapsed. One period of contraction has been estimated at approximately 400 years for the area in the immediate vicinity of Muir Inlet, with the possibility of a much greater period of contraction for the lower bay - an estimate of 1,000 years having been made.

In following the recession of Muir Glacier up Muir Inlet, we find that the receding glacier has exposed to view, in the gravel banks along the shore of Muir Inlet, remains of forests preceding and contemporaneous with the deposition of the gravels forming the banks. In places the gravel deposits rest on glaciated rock surfaces. In one instance remains of old forests on two levels were noted. Nearby, low tide uncovered the remains of another forest, indicating a subsidence of at least 20 feet since the time when the forest grew on the shores of the bay. Also there is the possibility of three levels of forestation - or three periods of contraction. Some indication of moderate subsidence was noted near the entrance of Glacier Bay, although the evidences were too meager to warrant a positive statement.

When the detailed survey of Muir Inlet is completed, special note should be made of the forest remains encountered, their positions, elevations, etc., and all information that may be useful in the study of glacial advance and contraction. A wealth of material lies exposed to view and should provide one with an unlimited amount of data for study.

No information was collected this season relative to the availability of like evidence in Reid and Tarr Inlets. From the information obtained in 1936, it is believed that few if any forest remains will be encountered although forests may have existed in these inlets during the cycles of glacial contraction and recession. The shores of these inlets are composed of bare rock and are quite steep, and few deposits of gravel are to be found, so that it is entirely possible that the last advance of the glaciers in this area may have entirely uprooted and carried away any forests previously existing in these areas, leaving no trace of them at this time. When the detailed survey of this area is made, it is quite possible that more substantial evidence of the existence or non-existence of previous forestation of this area will come to light. Certain it is, that Reid and Tarr inlets now present a most barren and desolate picture - yet withall, one of austere grandeur - with

towering mountains, crags, and numerous glaciers cascading down the mountain sides, some reaching tide water. Much of this area is still in a state of unrest and landslides are not uncommon.

As our surveys of 1938 were confined to the area from Icy Straits up the bay to and including Berg Bay, little opportunity was available for more than a cursory examination and study of the interesting conditions noted above, which are to be found almost exclusively in the upper reaches of Glacier Bay. The extension of the surveys up Glacier Bay, should prove to be interesting and enlightening in the extreme, for there is no place where such a wealth of material for the study of glacial activity can be had with such little effort. And with the daily contraction of some of these glaciers, new fields and new data are constantly being exposed to view.

In closing, it might be added that the folk lore of the Hoonah Indians is that at one time the tribe made their home in Bartlett Cove. That, without warning, the ice came down on them so suddenly they were forced to flee, leaving all their belongings and even some of their sick and aged. Their village was totally covered with ice, forcing them to make their home elsewhere. The present site of Hoonah was chosen, Hoonah meaning "safe from the north wind".

Until the advent of the Bilby Steel Towers, the cost of triangulation in areas of flat terrain and high timber was prohibitive because the tall wooden towers were difficult to erect and could not be used a second time. Consequently, first-order traverse, which was never thoroughly satisfactory as a method of control, was frequently substituted for the triangulation.

In 1927, portable steel towers, manufactured after a design by Chief Signalman Jasper S. Bilby, (retired) U. S. Coast and Geodetic Survey and named Bilby Steel Towers, were adopted and have proved so satisfactory that practically no first-order control is now established by traverse. Some of these towers have been used at as many as 200 different stations.

A recent letter from Major M. Hotine, Royal Engineer, Ordnance Survey Office, Southampton, England, expresses his appreciation of the towers. His letter reads in part as follows:

> "We have just completed among other work this season, the primary observation for our new triangulation in the Eastern Counties of England. The country here is so flat and enclosed that we had to use Bilby Steel Towers at 34 of the main Stations, to say nothing of several secondary stations surrounding such Steel Tower Stations, which we thought it advisable to observe at the same time as the primary work. You may be interested to know that these admirable Steel Towers were entirely satisfactory; and that we were very deeply impressed with the conception, design and construction of these Towers".

RECOVERIES BY OLD MAPS AND NEW PHOTOGRAPHS

Thomas M. Price, Jr., Assistant Cartographic Engineer
U. S. Coast and Geodetic Survey

For recovering those tough old stations, barely described, referenced to the smokehouse, and not looked for since the dark ages when they were established, don't forget about the Coast Survey's collection of original old topographic map drawings, if the triangulation station is within charted areas.

No doubt, many make use of bromide copies of the old topographic surveys when searching for an old station, but also there are probably many officers who are not aware of the advantage which is given by having in hand one of these large scale maps on which the old station is represented in proper relation to surrounding detail of that date. Where the description of station is inadequate, or changes have ruined the value of the description, it will frequently be found that the old map makes an excellent adjunct to the customary control index chart. Since the chart is usually on a smaller scale, and has been stripped of minute land features, it does not offer the assistance that the old map does in referencing one's position to nearby detail.

Even where the surrounding features have changed so much that it is no longer possible to recognize on the ground the fence line, the old road, or anything else that appears on the old map drawing, still there is hope for recovery if the station is really wanted. Air photographs of the area may be available. If so, the chances are ten to one that the old fence line, the former road, and the cultivated patch shown on the old topographic map, but no longer visible to one on foot at the spot, can be distinguished on the photograph from the air. By making the scales the same, and superimposing the old map, on which the station is plotted, onto the air photograph, matching common detail, the station can be closely transferred to the photograph.

The station will thus be located in relation to present features at the site appearing on the air photograph, and will be much more readily found, or more obviously lost. It will put the station in a close enough position so that the "12 inch redbud tree" used as a witness mark in 1901 may still be identified. If the object of the search is "Yellow House, west chimney, 1912, n.d.", it will be possible to tell which of several nearby houses (all, or none, of which may now be yellow), is the one to get serious about. Or, if there are no houses at all to be seen, it will indicate where in the underbrush to look for the ruins.

Errorless radio direction finding is claimed for a new special antenna which, with a device, has been developed by experts in Paris. The apparatus, which is operated much more easily than the long-range type direction finder, uses short waves, and precludes all possibilities of error in bearings. It can be installed anywhere and is not affected with night error.

ELECTROMAGNETIC HYDROPHONES,

or

"MAGNETOPHONES"

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

"Necessity is the mother of invention" and one of the difficulties of radio acoustic ranging was the noise which developed in the cable from the hydrophone to the shore station, due to leakage, since a small current was necessary in the cable to operate the carbon button of the hydrophone. The carbon button itself, also produced some electrical noises, called drying or burning, especially if the applied voltage was too high. It was desirable, therefore, to have some method whereby an electromotive force would be generated in the hydrophone itself, by the bomb sound, without the use of auxiliary voltages.

Back in the days when minds were working on these ideas there were several kinds of loud speaker units on the market. One type was meant to be used with a horn, in which the currents from the radio receiver caused a diaphragm to vibrate and set air in motion; another type was built to be fastened to a thin sheet of wood, such as the sounding board of a piano, and cause the board itself to vibrate. The inertia of the unit caused the board to vibrate more than the unit itself. This was called a piano unit and apparently was more common in the West than on the East Coast. Nathaniel Baldwin of Salt Lake City built very good units of both types. While each of these instruments had been designed to produce sound when currents of electricity flowed through their magnetic windings, it was also true of each, that if the movable part were vibrated an electric voltage would be generated in its windings.

In any design of instrument in which the volume decreases with pressure, it is necessary to avoid any construction in which the voltage generating element is fixed to one part of the container and has the movable part actuated directly by another part of the container. This is because the voltage generating element would be either crushed or rendered inoperative when the entire instrument is lowered into the water and the external pressure begins to deform the container. To avoid this in the case of the rubber hydrophones with the carbon microphone button an "inertia type" mounting is used. In this the button is mounted so that the pin of the unit is attached to the diaphragm of the container. The heavier portion tends to stand still so that the front and back plates of the button alternately approach and recede, thus changing the pressure on the carbon, altering its resistance. This type was used in the Navy hydrophones and in the hydrophones used with the Type 312 fathometer. The Baldwin piano unit, when used as a loud speaker, is the inertia type mounting, and it was this type of instrument which Senior Chief Radio Operator Almon M. Vincent used when he designed, on the Ship GUIDE in about 1928, the first magnetophone used in radio acoustic ranging.

The container was simply a large dipper or stew pan, about seven inches in diameter, borrowed from the galley. A Baldwin speaker unit was soldered to the bottom and a brass plate soldered over the top. The wires were brought out through the side by using the brass tube of a Navy hydrophone as a stuffing box. This tube was soldered into the dipper. A bicycle tire valve was also sold-

ered into the side so that it could be tested for leaks by air pressure.

Figure 1 gives an idea of the appearance of this historical instrument. The unit is now broken loose from the bottom, which served as a diapnragm, so that it is no longer serviceable, but it served its purpose in the early days and forms the basis of all the West Coast designs of magnetophones since that time.

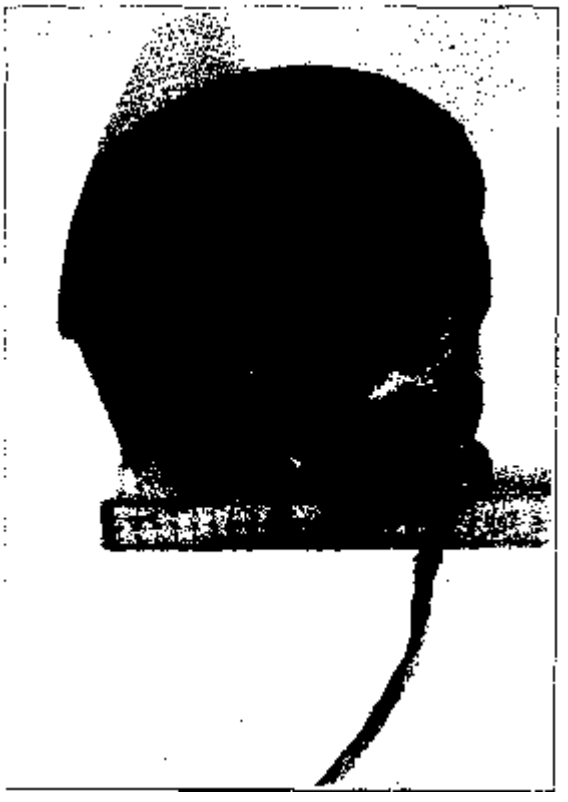


Fig. 1
Vincent Type Magnetophone
Original Model

Meanwhile, on the Atlantic Coast, the writer had been working on a magnetophone utilizing the other type of Baldwin loud speaker unit. Direct connection of the unit to the external diaphragm was avoided by using air as the connecting link. When the diaphragm of the case is vibrated by the bomb signal, the internal air vibrations are communicated, through a hole in the middle, to the diaphragm of the unit in the rear portion. Figure 2 shows the parts of the magnetophone. At the left is the diaphragm with a flange which fits loosely in a groove in the base, shown at the right. When the rubber gasket is placed in the groove and the diaphragm bolted tightly to the base so that the metal surfaces at the edge touch each other, the rubber gasket is sufficiently compressed to form a watertight joint. Only a small air space is left between the diaphragm and the base so that if the water pressure is great, the diaphragm will be forced against the base and will not be distorted. The loud speaker unit, shown next to the diaphragm, is screwed into a threaded hole in the middle of the rear side of the base, and finally, the rubber plug is inserted in the tubular portion, the tyrex connecting cable passing out through the middle of the plug. The threads for the speaker unit are left a bit loose so that slow changes of air pressure will be equalized in the front and rear portions, while sudden impulses actuate the speaker diaphragm.

This magnetophone case is made entirely of rolled brass, the back tubular portion being sweated to the base with soft solder, as shown on the working drawing, Figure 3. After assembly in the Instrument Division the cases are tested with an air pressure of 15 to 20 pounds to find any leaks. During this test a thick plate is clamped over the diaphragm so that it will not be permanently bulged.

There were lots of headaches in its early development. One

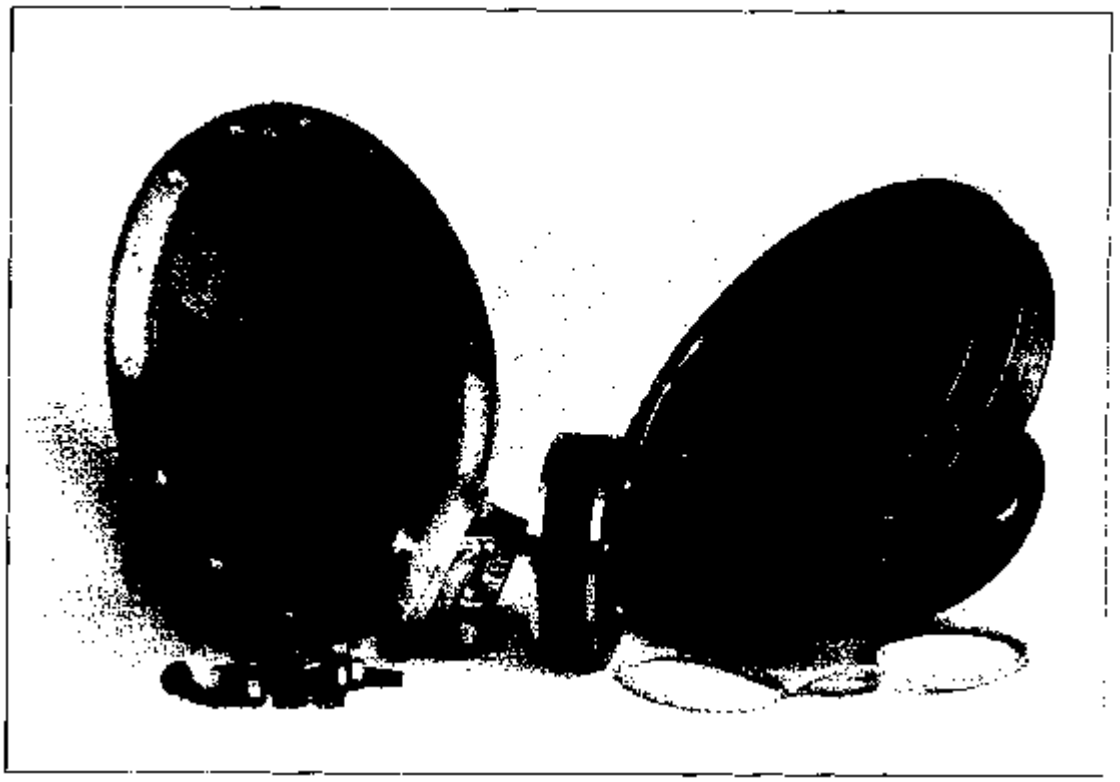


Fig. 2. Parts of Dorsey Type Magnetophone

looks at it and naturally asks, why not use a brass casting? And that is just what was used at the beginning. From a wood pattern some castings were made at the Washington Navy Yard on a hurry-up order. Never thinking of the casting leaking, the diaphragm was soldered in as well as the back and the tyrex cable was brought out the side through a stuffing box. No one suspected but that it would be watertight and serviceable for long periods, but the brass casting leaked almost like a sieve. Solder was applied, with some benefit, and later on the cases were dipped in melted tin, but even then they were not entirely tight.

The first tests were made on the Launch ECHO, attached to the Ship LYDONIA, in September, 1929, to determine the feasibility of radio acoustic ranging using launches for station ships. The original model from the GUIDE was also tested and proved to be slightly more sensitive. Both were tested in comparison with a carbon button hydrophone, which was much more sensitive than either magnetophone. This, however, soon showed its inferiority when the distance between the LYDONIA and ECHO necessitated more amplification. The carbon noises in the hydrophone then became greater than the bomb signal while the magnetophones would still give good returns.

With the troubles of leakage through the brass castings, it was natural that several different methods were proposed to make something better, and on the LYDONIA, Engineers S. N. Davis, now Chief Engineer of the Ship EXPLORER, and J. W. Smith, designed and built magnetophones from 6-inch tobin bronze shafting. A hollow cup was turned in the shafting, leaving the metal 3/8 inch thick. The speaker unit was inserted from the front, attached to a collar, so that the air could go through the center to the speaker unit as

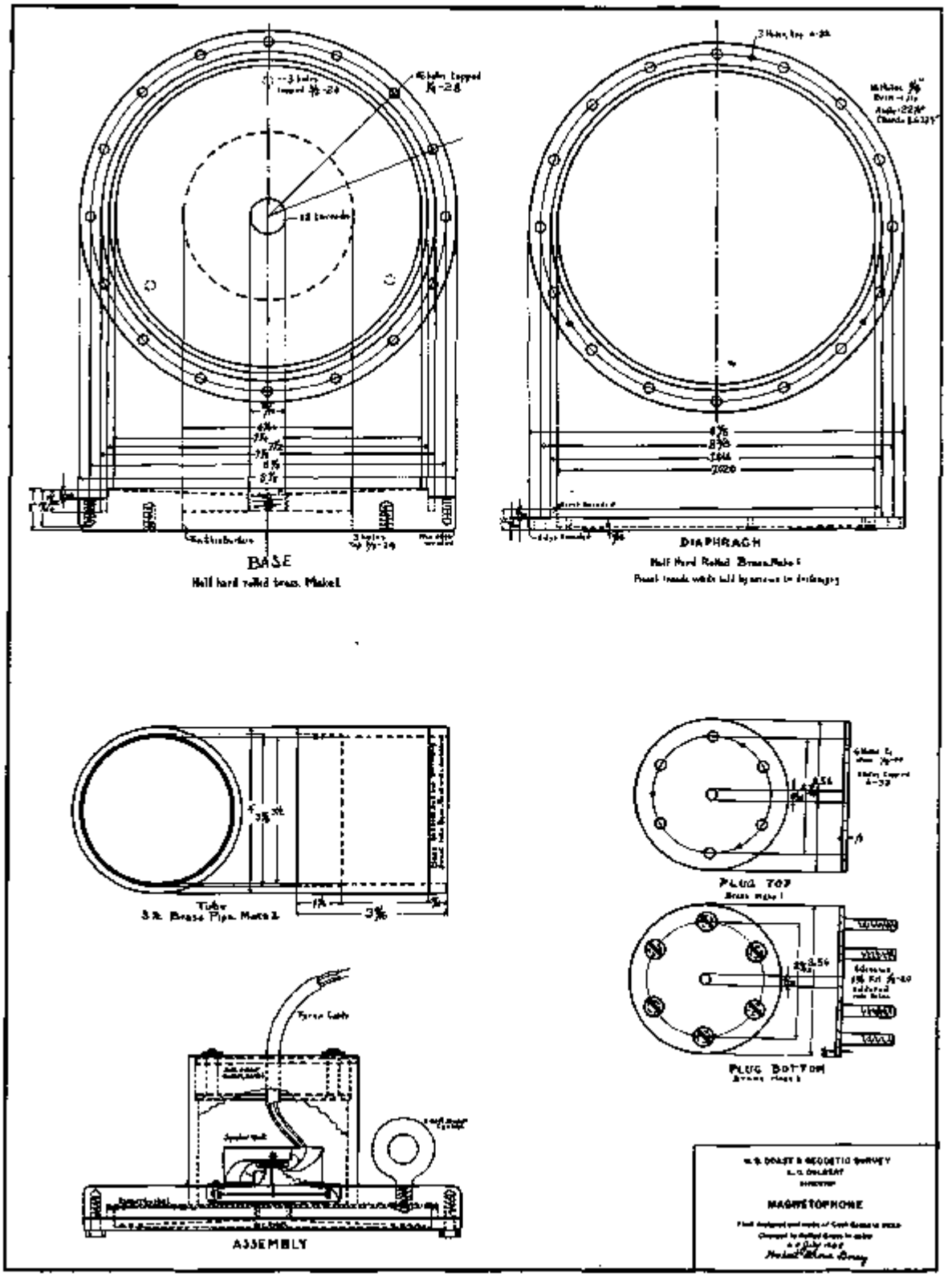
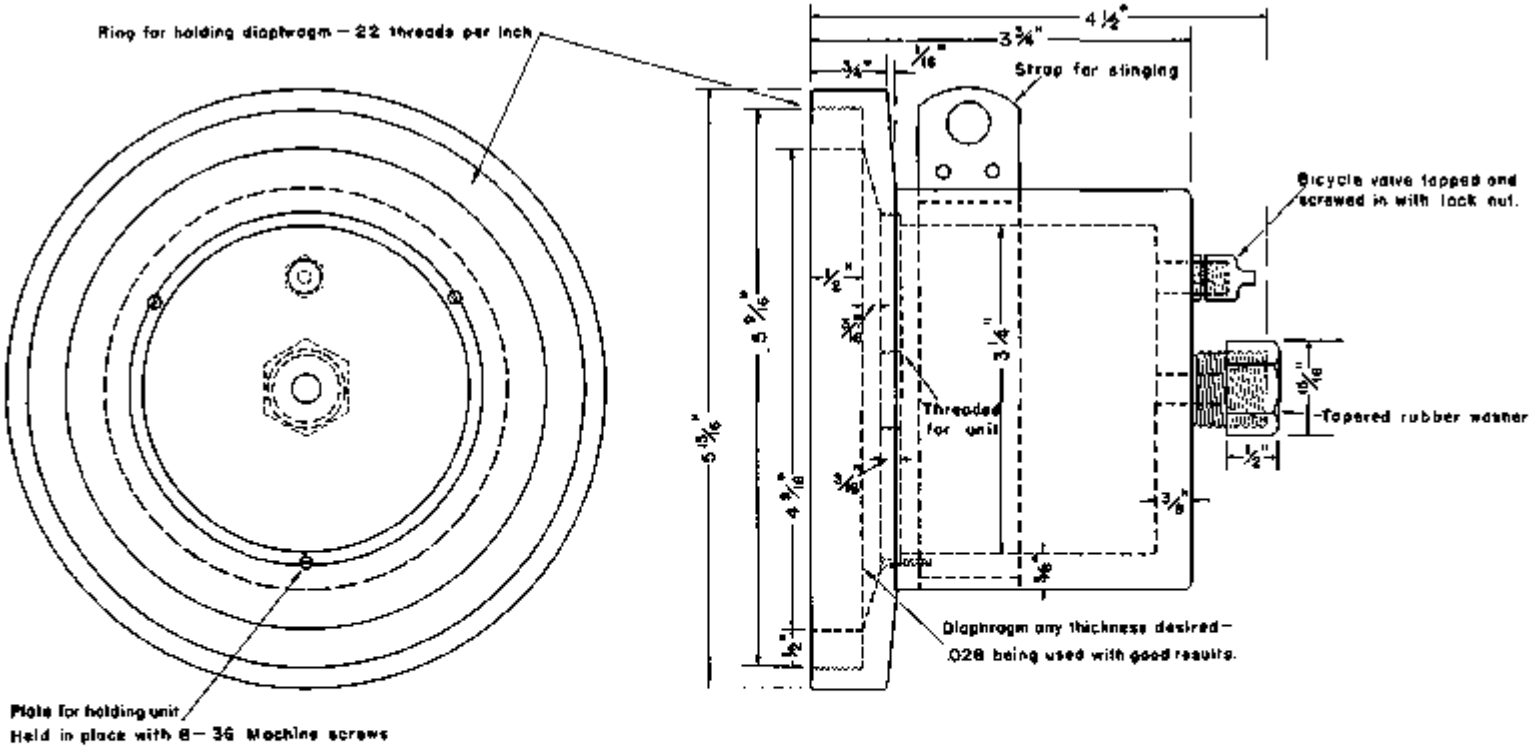

BASE
Half hard rolled brass. Makes 1
DIAPHRAGH
Half Hard Rolled Brass Make 1
Tube
3 ft. Brass Pipe. Make 2
PLUG TOP
PLUG BOTTOM
ASSEMBLY
MAGNETOPHONE

Figure 3.



U. S. COAST AND GEODETIC SURVEY
L. O. COLBERT DIRECTOR

MAGNETOPHONE

DESIGNED & MADE OF
6" TOBIN BRONZE SHAFTING
BY S. N. DAVIS & J. W. SMITH
SHIP LYDONIA, 1930

Figure 4.

in the Dorsey type. The front was then closed with a phosphor bronze diaphragm 0.028 inch thick, white lead being used on the edge and the diaphragm clamped in place with a large circular nut. The designers stated that two days were required to make the magnetophone and that the material cost about $15.00. (Figures 4 and 5).

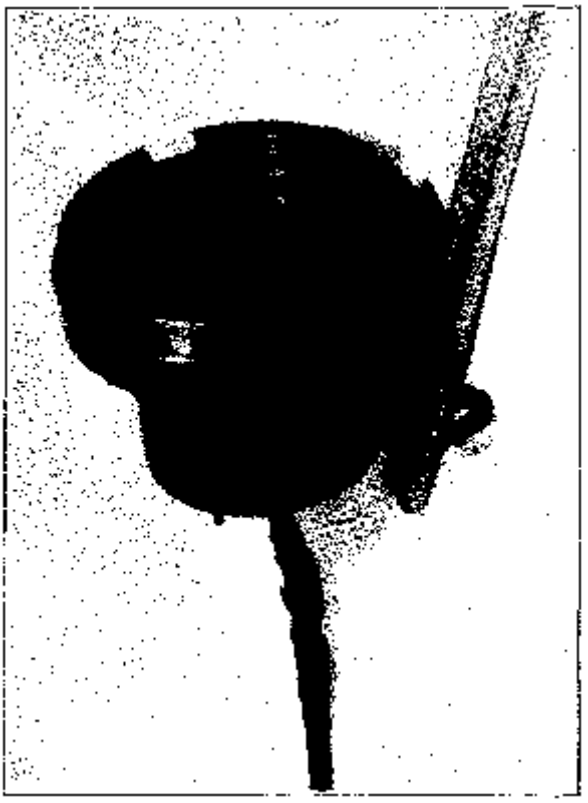


Figure 5. Davis Type Magnetophone

Several of this type were made up and used, primarily on the Ship HYDROGRAPHER, until displaced by the Dorsey type after the latter were made of rolled brass and free from leakage troubles.

It is not easy to get comparative tests of different types of hydrophones without the expenditure of considerable time, and as rivalry continues between the commanding officers of the different ships to increase the miles of hydrography per season, it becomes more and more difficult to beg time for experimental work in the field. Comparative tests were made at the laboratory, however, on four different magnetophones in March, 1936. The hydrophones were tested, one at a time, in a tank of water in a court of the Commerce Building, each in turn being placed at the same distance from an aperiodic magnetophone used as a sound producer. This was excited at the different frequencies from a beat frequency oscillator through a microvolter so that a constant input voltage could be maintained for all frequencies. Preliminary work was done in the daytime to make sure of the method, but because of interference from building noises the final measurements were made at night. These curves are plotted with frequencies as abscissas and decibel losses in amplifier as ordinates. This means that a high voltage amplifier, flat from 30 cycles to 50,000 cycles, was connected to the output of the magnetophone with a meter across the output of the amplifier and the amplifier gain control varied until a constant value was obtained on the output meter. A precalibration curve of this amplifier then made it possible to plot the curves in decibels, thus making a true comparative test of all four magnetophones.

A Vincent type magnetophone, shown in Figure 6, had been sent to the office from the Ship GUIDE and its curve is shown in Figure 7. The Davis type, whose curve is shown in Figure 8, had been used on the HYDROGRAPHER. Two of the Dorsey type are shown in Figure 9; the full line curve shows the results of the test from one constructed in the laboratory, and the dashed line curve from one used on the LYDONIA.

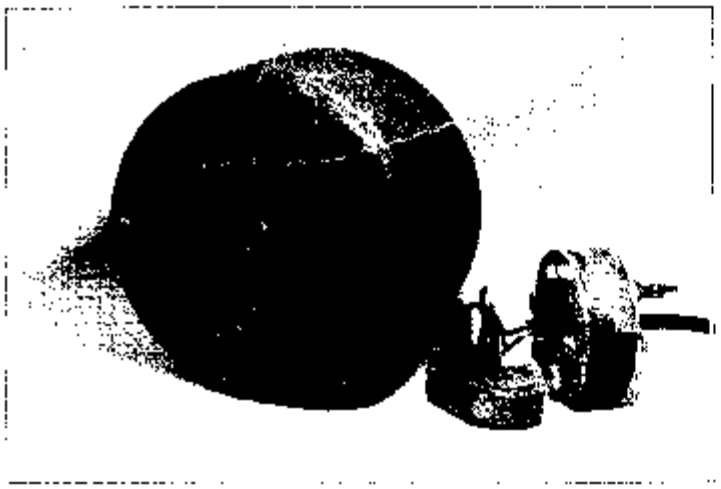


Fig. 6. Vincent type magnetophone with speaker unit.

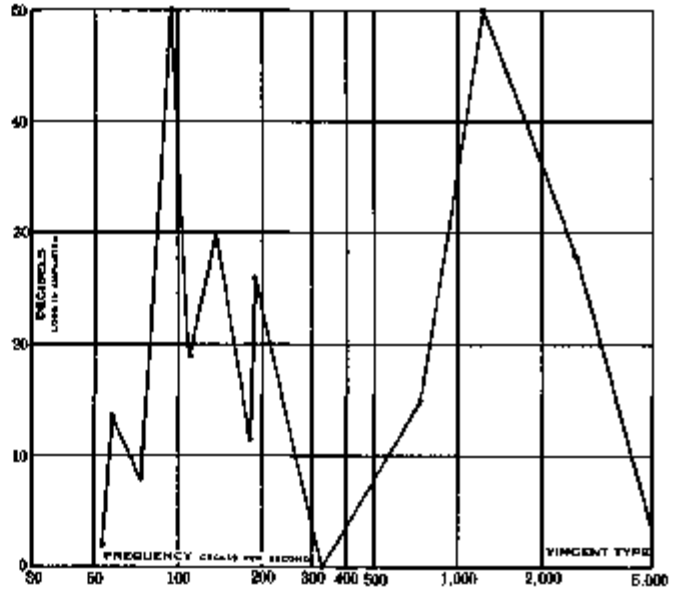


Fig. 7.

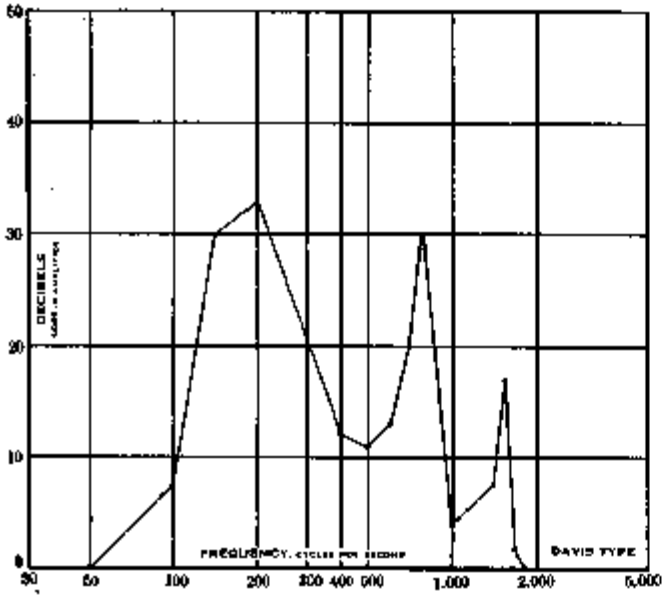


Fig. 8.

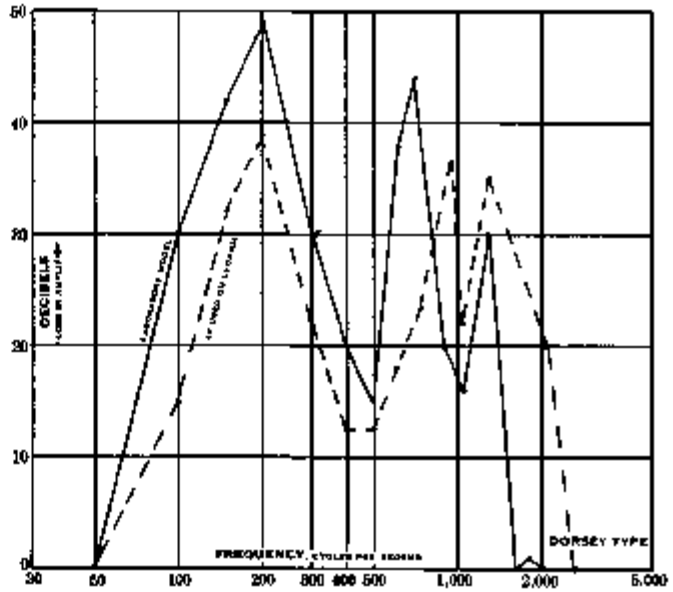


Fig. 9

It will be noticed that the West Coast type shows greater sensitivity up to 100 cycles than the East Coast type. This is considered a great advantage by the writer who believes that the really effective part of the bomb signal is just a compressional wave and that any so-called bomb frequencies are produced by reflections from surface and bottom and such frequencies as may be introduced by the receiving apparatus. It is a well known fact in acoustics that a single sound, such as a hand clap or pistol shot, made in front of a flight of steps will be reflected as a musical note of definite frequency depending upon the vertical distance between steps. Near Earnshaws Shipyard at Manila, P, I., the impulses from a gasoline engine were reflected from corrugated sheet iron buildings as distinct whistling notes. It is easy to imagine, by analogy, that reflections from surface water waves in subaqueous acoustics might produce different pitched notes with different lengths of swell. Evidence that the lower frequencies are more effective than the higher ones, is shown by putting a capacitance of one to four microfarads across the input of the amplifier which will cut out frequencies above about 300 and also considerable water noise, but will still give as good bomb returns as without the capacitance. For the same reason it is quite probable that the high sensitivity of the Vincent type at 1250 cycles is useless in this magnetophone.

There are two probable reasons for the high sensitivity of the West Coast type at low frequencies; first, the low natural frequency of the air cavity inside the drum of the magnetophone case and, second, the low natural frequency of the speaker unit when held by its stem.

It will be noticed that the three curves in Figures 8 and 9 have three humps of high sensitivity coming somewhere near the frequencies of 200, 800 and 1500 cycles per second. Since the same type of speaker unit is used in each, it seems probable that these humps are due to the unit itself. The much thinner diaphragm of the Davis type does not add to the sensitivity, for the Dorsey type has a thicker diaphragm but larger area which probably produces the greater sensitivity. Since sounds readily go through the steel hull of a ship, the writer believes that the thickness of the diaphragm has little to do with the sensitivity.

In the case of all radio acoustic ranging apparatus, as well as in echo sounding, experimental work is being continued in an effort to achieve still better results. Captain F. H. Hardy, Commanding Officer of the Ship GUIDE, on which Senior Chief Radio Operator Vincent is serving, describes, in a letter dated August 2, 1938, the latest types of Vincent magnetophones. They are illustrated in Figure 10, and described as follows:

- A -

A bakelite container, cylindrical in form, has the following outside measurements:

Diameter	3"
Length	4"
Thickness of cylinder	3/16"
Thickness of end	1/4"
Thickness of cap	1/4"

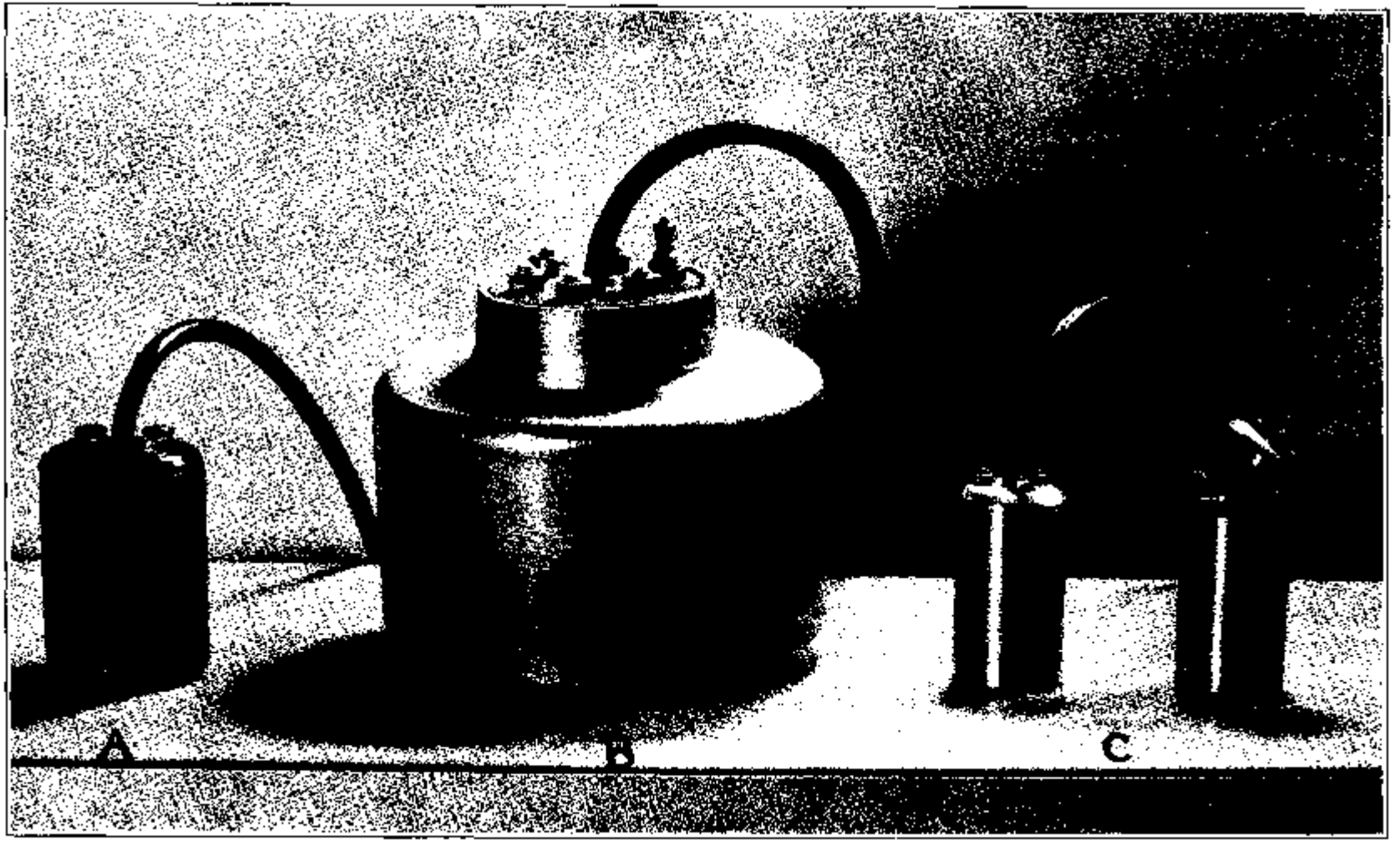


Figure 10.

This container accommodates both the Alnico (aluminum-nickel-cobalt) speaker and the small telephone sound powered units. The seal consists of 5/8" rubber compressed by four 1/4" - 20 machine screws.

- B -

The standard type of aluminum magnetophone container developed by this vessel in 1927 is shown at B. This type is being used with good results for shore station installation. It has sufficient buoyancy to remain suspended in the water without the use of supplemental buoys. Its dimensions are as follows:

Diameter	8-1/4"
Length	5"
Thickness of cylinder	3/16"
Thickness of diaphragm	l/4"
Thickness of end	1/4"
Diameter of opening	4"
Length of collar	1-1/4"

The inside of the cover is grooved with deep threads to give additional friction to the rubber seal. This container will accommodate all types of magnetic as well as Rochelle salt units. A tire valve is provided for the purpose of introducing air pressure to equalize the water pressure outside the container. This is necessary because of the light construction of the container.

- C -

Open and closed views of a small container being used in connection with sono-radio buoys are shown. Its dimensions are as follows:

Diameter	1-7/8'
Length	3-1/2'
Thickness of cylinder	l/8"
Thickness of cap and end	l/4"

This container accommodates only the small telephone sound powered units and the small crystal vibration pickups. It has been made up in steel, bakelite and aluminum, and bored out of solid rod rather than made from tubing. This makes a much stronger construction. The aluminum containers have been submerged to 150 fathoms without collapsing, while the steel ones are practically unbreakable. The latter have been subjected to 6,600 pounds per square inch external pressure without failure.

Attention is particularly directed to the improved type of seal cap used on the containers in A and C. It will be noted that the cap is provided with a flange which prevents the seal from being forced inward by water pressure. This type of cap permits the use of soft gum rubber for a seal. This improvement is of most value for hydrophone installation in deep water.

The average sensitivity of the small hydrophones is greater than the large ones, B, except at the diaphragm resonance frequency which is above the bomb frequency range and is of little value. The compactness of the former is such that it permits a simplified installation for sono-radio buoy work and allows a wide depth range.

Commander O. W. Swainson, former Commanding Officer of the Ship PIONEER, has suggested that "B" could be much easier handled and secured for operation if it had a handle or lug attached to the side or cylindrical part. Many different hydrophones were built on the PIONEER, under his command, one type being built of boiler plate, 1/4 inch thick, and about 2 feet in diameter, the cylinder being 8 or 10 inches long. The same type of speaker unit was used and the sensitivity seemed about the same as the Vincent type. I believe careful comparative measurements might show a greater sensitivity for the larger area of diaphragm.

The Dorsey and Davis types of magnetophones were developed on East Coast vessels and continue in use on this and the Gulf Coasts. Those of the Vincent type are preferred on the West Coast. When the latter types have been used on the East Coast the feeling seems to be that the bomb signal has been unduly prolonged. One disadvantage is that if roughly handled, while the unit is in place, the unit may be broken loose while the East Coast type has no such disadvantage.

Taken altogether, all of these magnetophones have given excellent results and will continue to do so and operators on each coast will probably use the type with which they believe they can get the best results.

We have followed with interest the program of modernization of the fleet of H. M. Naval Surveying Service as described in the last few annual reports of the Hydrographer of the British Admiralty.

The keel of H. M. Surveying Ship STORK was laid June 19, 1935 and the vessel began survey work abroad in the fall of 1936. The ENDEAVOUR was commissioned on January 15, 1937 for service on the New Zealand Station. Other ships which were to be completed by the close of the calendar year of 1938 were the GLEANER, JASON, FRANKLIN, SCOTT, AUCKLAND, PELICAN and RESEARCH. Five of these last named will replace the Ships BEAUFORT, FLINDERS, KELLETT, FITZROY and HERALD. The AUCKLAND is an additional vessel over the number formerly employed on survey work and the RESEARCH is a non-magnetic vessel designed to carry on the world wide magnetic work on which the United States vessels GILLESPIE and CARNEGIE were once engaged. This vessel displaces about 770 tons, is rigged as a brigantine and equipped with an auxiliary diesel engine. Mr.. W. J. Peters, a retired member of the Carnegie Institution of Washington, who at one time commanded the CARNEGIE, was associated in an advisory capacity with its construction.

WHITEWASH SIGNALS

L. W. Swanson, Junior Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Along the northern coast of California the bluffs in many places consisted of crumbling dirt or rotten rock. Ordinarily, bluffs are ideal for whitewash signals, but on these the whitewash could not be brushed on due to the condition of the surface. Many wooden signals, requiring considerable time and material, were built in this area.

It was finally decided that if some method of spraying the whitewash could be used, the construction of many of these wooden signals could be eliminated and the time and labor of signal building reduced. A three-gallon brass garden spray was purchased locally. This spray consisted of a brass tank, the top opening of which is very little smaller than the diameter of the tank. Air pressure is maintained by means of a pump which fits into the center of the tank at the top. A piece of rubber hose about two feet long is attached to the side of the tank near the top, and attached to the other end of the hose is a piece of brass tubing with a nozzle which is used to control the size and quantity of the spray. In signal building it was found that this sprayer could be used more efficiently by replacing the short hose with a length of about 20 feet, and the nozzle was replaced by a lever nozzle which produced a fan-shaped spray or solid stream. A piece of copper window screening was used in the top of the tank when filling the container in order to prevent lumps of unslaked lime from getting into it. The whitewash used was made in the usual manner from pulverized unslaked lime. The spray gun was carried on a packboard which could be placed on the ground during operation, the 20 feet of hose allowing mobility to the operator. Ordinarily one man pumped to keep the pressure up, while another man sprayed.

Signals could be placed much higher on the bluff than usual due to the fact that the gun would spray approximately 20 feet into the air; one filling of the tank (approximately 2-1/2 gallons) sufficed for the average signal; rough and irregular surfaces were well coated with whitewash, and there was no waste or spilling of the whitewash. In places not easily accessible, the tank could be filled on the beach and pumped to the proper pressure, and then carried by means of the packboard to the desired location, leaving the operator's hands free for use in climbing. In some cases the tank could be left on the beach, the nozzle man climbing up 10 or 15 feet with the hose and then spraying a signal 10 or 15 feet above him. However, in this instance full pressure is necessary, requiring continuous pumping by the man remaining on the beach. The tank was cleaned at the end of each day's work, which kept the whitewash from clogging the hose and valve.

No doubt some may think that this method is impracticable, and that too many things may go wrong with the apparatus. The proof of the pudding is in the eating, however, in spite of the skepticism of various members of the party it did work and its use is recommended. After a season's experience the writer believes that a considerable saving in time, labor and material can be effected in the whitewashing of rock or earth signals, and that a much whiter signal is obtained due to more complete coverage of the ground by means of this method than by the ordinary brush method.

Where signals were whitewashed on dirt bluffs and it was believed that they would be needed the following season, they were marked by galvanized iron pipes driven into the bluffs. This method of marking them temporarily was considered satisfactory as the pipes could be easily found the following season.

It is recommended that each whitewash party, using the equipment described, carry several spare piston cup-type washers, a screw-driver and a pair of pliers. The valve at the bottom of the pump should be examined from time to time. With these simple precautions, there should be no difficulty in keeping the spray gun in first-class working order at all times.

I have been informed that the spray gun above described was used this past season and was found to be mechanically in good condition.

The following is an excerpt from a personal letter received recently by Lieutenant Swanson from an officer who used the equipment described above for signal building during the past (1938) season.

(Editor)

"We used the spray gun almost all the time, and with our previous experience about cleaning it, etc., it proved to be a howling success. I recall that signal "Sale River" where you put the whitewash on red hot the previous year and several coats, I think, was in good shape this year. The whitewash was blown off a little on the south side, but on the north side it was intact and still looked and stuck on like stucco. The gun was used again to retouch the rocks as well as the constructed signals".

A recent article in The Engineering News-Record by Mr. George D. Whitmore, Maps and Surveys Division, T. V. A., Knoxville, Tennessee, describes a paint spray gun, devised by Mr. Paul Morris, Chief of a survey party, in which the pressure is obtained by carbon dioxide gas generated from dry-ice.

The pressure tank consists of an 8-quart household pressure cooker, fitted with a safety valve set to open at 25 pounds pressure and divided into two chambers by a grill. About 10 pounds of dry-ice is placed in the upper chamber and the tank sealed tightly. Gas continues to generate until the ice reduces in size below six pounds. When an accelerating agent, consisting of any liquid of low-freezing point, such as kerosene, is necessary, this is placed in the lower chamber and the tank tilted until the liquid touches the ice.

The device does not appear as practicable as Lieutenant Swanson's method for whitewash signals, but it is believed it could be used advantageously on shipboard during overhaul periods in port where dry-ice could easily be obtained.

EXTRACTS FROM THE BULLETINS OE THE BUREAU OF MARINE INSPECTION AND NAVIGATION

VENTILATION OE MOTORBOATS

Any compartment or space in which a motor is located, particularly the lower portion and bilges, should be provided with ventilation effective to remove possible accumulation of flammable or explosive vapor. Tank compartments should be similarly ventilated when practicable. To meet this requirement, the following is recommended: Where motor and/or tanks are in closed compartments, permanently open and adequate inlet and outlet ventilation ducts extending to the bilges should be installed; two inlets leading to the wings at one end of the compartment and two outlets from the wings at the opposite end.

Where motors and/or tanks are not in closed compartments, at least one such duct should be installed in the fore part of the boat and one in the after part. Inlet ducts should be provided with cowls or equivalent fittings.

Where feasible, it is also recommended that outlet ducts be fitted with wind-actuated self-trimming or rotary exhauster heads or that power-operated exhausters be installed in each outlet duct. If exhausters are used, motors shall be installed outside of the ducts and as high above the accommodation flooring as practicable. They shall be run for at least 5 minutes before starting any engine. Size of vents should be approximately proportional to the beam of the boat with 2 square inches of aggregate vent area per foot of beam as a minimum.

OPERATION OE MOTORBOATS

Attention is called to the hazard involved in the handling of gasoline. An atmospheric concentration as low as 1-1/4 percent is practically odorless, but is sufficient to create a mixture which may be exploded by a slight spark. Such explosive vapor may travel a considerable distance from the point of leakage. Gasoline vapors are heavier than air and will not escape from low lying pockets, such as bilges or tank bottoms, unless drawn or forced out. A recently emptied gasoline tank is in its most dangerous condition. The following precautions are recommended, therefore, in order to reduce the fire and/or explosion hazard:

(a) All gasoline connections shall be tight.

(b) Care shall be taken not to expose gasoline in closed spaces through, spilling, drawing off, storage, or use in any kind of cleaning, no matter how small the quantity.

(c) Ventilation as adequate as possible shall be insured by attention to all arrangements therefor, both before starting and while running.

(d) Naked lights, however small, shall not be carried into compartments where gasoline vapor may be present.

(e) The entire boat, and especially the engine compartment, shall be kept clean and free from flammable rubbish, loose oil and grease, and dirty waste or rags. Clean waste and rags shall be kept in metal-lined lockers or containers. Similar receptacles shall be provided for waste and rags coated with oil, paint, remover, or polish; but such accumulation shall be kept to a minimum by frequent disposal ashore.

(f) If fueling, before tank fills are opened or gasoline brought on board, all engines, motors, and fans shall be shut down, galley fires put out, and all doors, ports, windows, and hatches closed. On completion, after hose or cans have been removed, any spillage shall be wiped up and the boat opened. If practicable, it shall remain open for at least 5 minutes before starting any engine or motor or lighting a fire. No smoking shall be permitted during a fueling operation.

(g) In order to guard against a possible spark during fueling operation, nozzle of the hose or can shall be put in contact with the fill pipe or funnel before starting to run in gasoline and this contact shall be kept until the flow has stopped.

NOTE.-- There is a serious hazard from static discharge unless this rule is observed.

(h) Lockers in which oiled clothing is carried shall be cool and well ventilated on account of the danger of spontaneous combustion.

(i) Paint and varnish removers are generally highly flammable and particular caution should be exercised during use of such to see that there is ample ventilation and no open lights, fires, or smoking.

Frequent flushing and cleaning of bilges is recommended Drain outlets should be fitted in the bottom of the hull and particular attention paid to securing complete drainage thereto and to the bilge pumps sections in order to facilitate this operation, either hauled out or afloat. From standpoint of fire hazard, it is highly desirable that bilges of machinery and fuel tank spaces should be separated from bilges of accommodation spaces by bulkheads as tight as practicable--i.e., of double diagonal wood, steel plate, or equivalent construction.

USE OF LIFE LINES AT SEA

Investigations have shown that insufficient attention is paid to the use of life lines during heavy weather, especially on cargo vessels. Life lines should be installed fore and aft and athwartships on decks exposed to the sea during heavy weather for the safety of the crew who must pass along these decks when engaged in the ordinary routine of the vessel. These life lines, supplemented by bowlines, are even more essential when the crew is engaged on exposed decks on work of an emergency nature.

It is suggested that masters and mates of cargo vessels survey their vessels to ascertain where these life lines can best be run and secured, and that they keep in the emergency lockers short bowlines equipped with sharp hooks which can be readily adjusted to such life lines. The use of these devices will give the crew greater protection when engaged in emergency operations such as securing boats or other articles of equipment which have come adrift owing to excessive rolling when vessels are hove to.

ASTRONOMICAL DETERMINATIONS IN CENTRAL AMERICA*

R. W. Woodworth, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

Geodetic activities, in connection with the demarcation of the Republic of Guatemala's boundaries with the adjoining Republics of Honduras and El Salvador, were begun several years ago under the direction of Sidney H. Birdseye, Chief of the two Boundary Commissions charged with these projects.

Execution of the first-order boundary triangulation arc, now extending from the Atlantic to the Pacific along the 400 kilometers of generally mountainous country comprising Guatemala's southerly frontier, called first for the establishment of a provisional datum based on one or more accurately determined geographic positions and azimuths. These conditions were met by the establishment of two astronomic stations in 1935 by Lieutenant J. P. Lushene, U.S. Coast and Geodetic Survey, under whose direction the Guatemala-Honduras first-order boundary arc was accomplished. One station was located at the Atlantic end of this triangulation, the other near the common juncture of Guatemala, Honduras, and El Salvador.

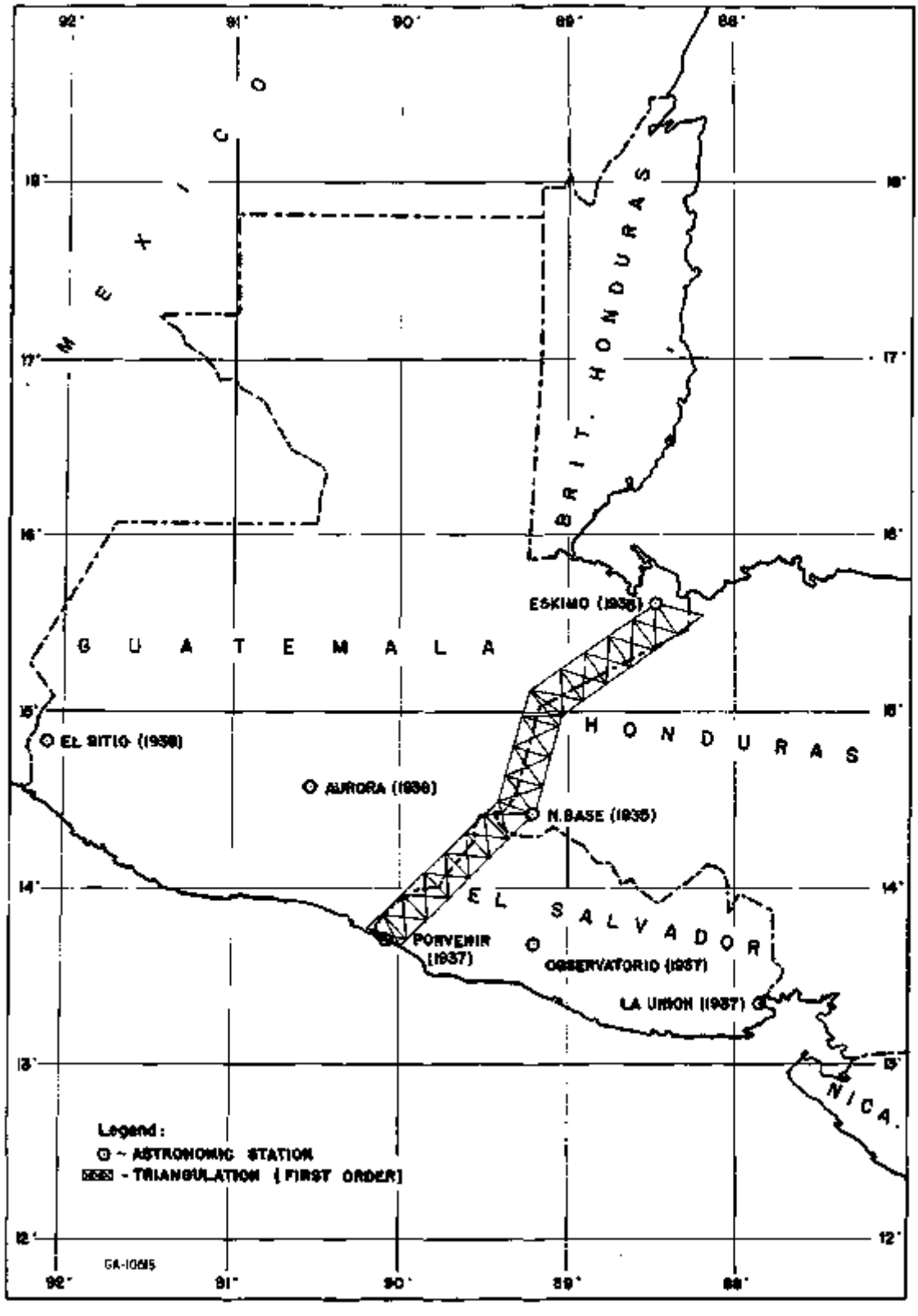
These two astronomic positions, although of high accuracy in themselves, are affected by such "deflection from the vertical" as is caused by the gravitational pull of surrounding mountain masses. Lacking the necessary topographic maps for an accurate delineation of the extremely rugged country it was not possible to compute deflection corrections for either astronomic position. The closure of 12".9 in Latitude and 11".4 in Longitude, obtained through the interconnecting first-order triangulation (in itself practically unaffected by deflection), supplied a measure of relative deflection which was applied in part to the southerly astronomic station. This corrected position was adopted as the provisional datum for adjustment of the triangulation arc. The northerly astronomic determination served thereafter only as a Laplace azimuth station used to correct the twist of 3".97 accumulated in the triangulation.

This adopted position of the point, in Honduras near its juncture with Guatemala and El Salvador, known as the Ocotepeque Datum, together with the adjusted Atlantic-Pacific arc of first-order triangulation based upon it, furnishes a series of excellent position-length-azimuth bases for future expansion of precise horizontal control through all the Central American countries in the form of triangulation arcs necessary for the control of interior or of boundary surveys.

To furnish the Laplace azimuth station required to adjust the Guatemala-El Salvador section of the interocean are was the reason for the request by the Comision Mixta de Limites, through the United States Department of State, that the Coast and Geodetic Survey determine Latitude, Longitude, and Azimuth at one triangulation station of the Pacific base net for this arc.

The writer was assigned this detail and sailed from New York City on April 17th, 1937. Actual observing was commenced May 5th at a station located on the Pacific coast just east of the Guatemala-El Salvador frontier. Following the completion of this determination four additional stations were established at the requests of the governments of Guatemala and El Salvador.

* paper read before the American Geophysical Union, April 27, 1938.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M E X I C O
BRIT. HONDURAS
G U A T E M A L A
H O N D U R A S
E L S A L V A D O R
NICA.
ESKIMO (1938)
EL SITIO (1938)
AURORA (1936)
N.BASE (1935)
PORVENIR (1937)
OBSERVATORIO (1937)
LA UNION (1937)
Legend:
- ASTRONOMIC STATION
- TRIANGULATION (FIRST ORDER)
GA-10615

This class of work required only a small station party, consisting of an observer, recorder, general handyman, cook and helper. With a small advance party to handle monumenting, construction, and camp establishment it was possible for the station party to commence observations their first night in camp. The abilities and close cooperation of the three principal assistants - Recording Engineer Mejia (R.P.I.-'18) for El Salvador, Recording Engineer Sarti (M.I.T.-'18) for Guatemala, and Constructor Ordonez- were largely responsible for the successful completion of the 1937-38 astronomic determinations, the majority of which were necessarily obtained under decidedly adverse conditions of weather.

Until late October and the cessation of the rainy season the party journal notes only 12 percent of the nights (during which all night "watches" were maintained) as even possible for astronomic observing. The two stations occupied during the rainy season averaged 72 days each. The remaining stations, although occupied during the dry season and averaging but 15 days each, were considerably affected by local conditions of weather, only one in the lowlands of northwest Guatemala permitting a practically uninterrupted observing program. This station was completed in nine nights. In many respects the mile-high Guatemala City station was rendered the most difficult, as a result of the fast-scudding mountain clouds that prohibited observing 80 percent of the nights during December and January, and the very heavy night dews which caused weakening of the low-voltage transit circuits and necessitated frequent removal of lens condensation.

Nights were cool even at the lowland stations, and days at these locations were rendered quite comfortable under the high-peaked palm-leaf thatches of the quickly erected "champas".

Minor earth temblors, of frequent occurrence at the two northerly stations in El Salvador, fortunately did not occur during the periods of observation. The sensitive stride levels of the Bamberg gave evidence of the slightest "shake".

Transportation presented few problems inasmuch as all but the first station were directly accessible by rail, truck, or ox-cart. The last-named, plus mules and dugout transport along the beach and five tidal crossings enroute to the first station resulted in the total immersion of the party's short-wave receivers. Hence the rather important element of time was obtained by star observations entirely until a replacement radio was received from San Salvador.

First-order triangulation will carry position and length from the precision of a first-order base line over considerable distances with practically no loss in accuracy save for the tendency of small systematic angular errors to impart a twist to the arc. To correct this is the prime function of the Laplace azimuth, an astronomic azimuth adjusted for the astro-geodetic longitude difference and derived from astronomic stations located six to eight figures apart along the triangulation arc.

For the foregoing purpose, in connection with international boundary surveys, the following accuracy criteria were used:

A Longitude probable error not to exceed 10 feet.
An Azimuth " " not to exceed 0".3
A Latitude " " not to exceed 10 feet.

To obtain these measures of precision under field conditions calls for an astronomic transit instrument readily portable, with sufficient weight for stability, yet not so massively constructed that flexure enters unduly into the observing of stars at varying altitudes. For this purpose the Coast and Geodetic Survey has found a Bamberg Broken Transit, of approximately 200 pounds weight, an excellent instrument for both Latitude and Longitude observations. It is a fixed base type, equxpped with 1".3 stride levels, with magnifications from 44x to 96x. Its micrometer eyepieces are readily transferable for the observation of Latitude or Longitude, the former readings being taken and recorded directly to 0".1 of arc, the latter being transmitted electrically for chronograph registration.

The Bamberg Transit is mounted either on top of a heavy concrete pier as for the recent Central American work, or on a knock-down, braced, aluminum tripod as is the usual practise for occupancy of the short-period Laplace stations in the United States. It is then carefully placed in the meridian within 1" of arc and held there for the duration of the observations by means of plaster-of-paris secured base plates, one of which permits a slow-motion adjustment in arc. On a concrete pier mount it is very seldom found necessary to correct the original meridian placement, even for as long a period as a two-month station occupancy.

For Latitude, the Horrebow-Talcott method of equi-altitude stars is used, in which is measured the small difference of meridional zenith distance of a north and a south star culminating at approximately the same time. This method is particularly accurate in that refraction error is practically eliminated. Star pairs are obtained from Coast and Geodetic Survey star charts and the Boss catalog, using magnitudes between 3 and 7 with a 65x eyepiece.

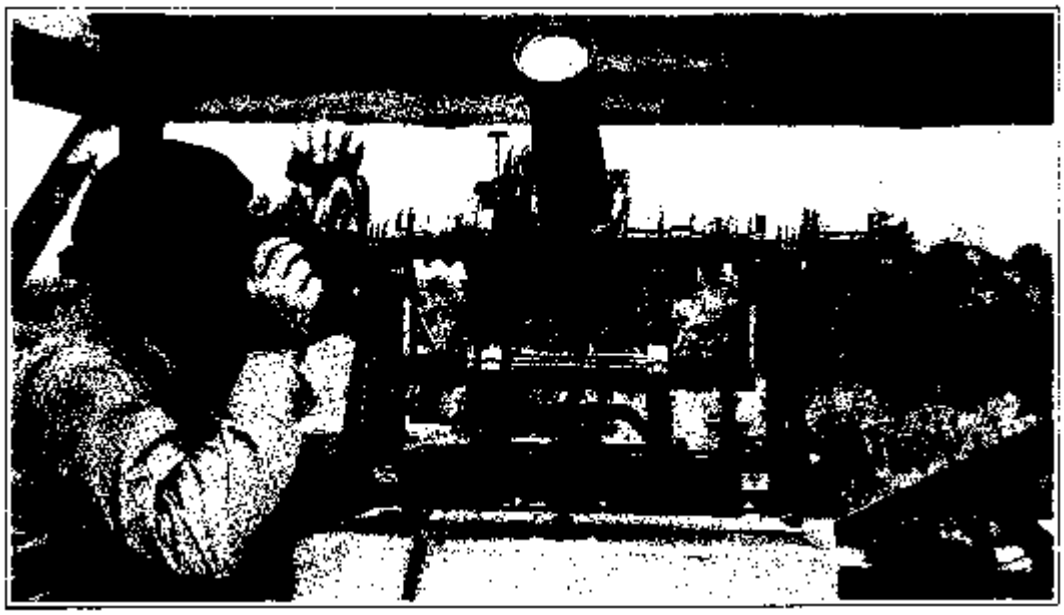
Two nights of 12 pairs each will usually yield the accuracy required, but it is desirable to observe a slightly greater number of pairs for each of three nights, thus obviating possible constant night errors due to atmospheric conditions.

Although actual star pointings must be secured with extreme precision, sidereal time to 0".5 is sufficiently accurate for purposes of latitude computation. Daily radio-chronometer comparisons with U. S. Naval Observatory time signals give a continuous chronometer correction.

Having obtained the required number of latitude observations a skilled astronomic observer is assured of satisfying the accuracy criterion. Hence it was possible to speed field operations by having all latitude computations made directly at the Washington Office of the Coast and Geodetic Survey.

For the five 1937-38 Central American astronomic stations the mean probable error for all latitude determinations was 0".04 of arc, or 4 feet in distance.

For Longitude, dependent upon accurate simultaneous comparison of local sidereal time with that of the Naval Observatory at Arlington, Virginia, through the medium of short-wave time signals, the Bamberg Transit is supplemented by special battery-operated recording apparatus consisting of a shortwave code receiver, a 2-stage amplifier, a constant-rate sidereal chronometer, and a recording chronograph.



Bamberg Broken Transit Used For Precise
Latitude and Longitude Determinations

Latitude and Longitude Installation At
Station "El Sitio"

Two sets of Longitude observations obtained on two different nights will usually suffice, but on this special work five sets over three nights were required under the project instructions.

A single longitude set consists of observations on from six to ten time stars obtained just prior to the recording of a Naval Observatory time signal, after which immediately follows a similar group of time star observations. True local sidereal time of the Observatory signal recorded is derived with 0ˢ.001 accuracy from these observed time stars, which also establishes the chronometer rate during the observing period. Therefore a longitude can be obtained as the difference of the simultaneous sidereal times at the field astronomic station and at the center of the Naval Observatory clockroom.

Only American Ephemeris 10-day stars, with magnitudes from 2 to 6 and of small zenith distance, are used for time observations. With the approximate latitude (within 1' of arc) and local sidereal time as finder arguments a star to be observed comes into the telescope field about 1-1/2 minutes prior to its meridian passage. Its bisection is held by a movable hair, the gear-train for which also actuates an agate and platinum contact drum for the electrical transmission of definite intervals of the observed star time. From 10 to 20 contacts are made prior to the star's culmination with the instrument direct, and are followed by a reverse order repetition of the identical contact after culmination with the instrument reversed. Thus the observed time of culmination becomes the mean of any pair of direct and reverse contact breaks as recorded on the chronograph sheet. Scaling 10 pairs of breaks per star yields 0ˢ.01 accuracy for a single star. The time mean of the six to ten stars in each half-set permits 0ˢ.001 accuracy for the local sidereal time determination.

The chronograph sheet records two second breaks of the sidereal chronometer against which the star breaks are scaled for time. Using double speed to permit closer scaling the Naval Observatory signal is recorded in a similar manner, and from 10 to 40 breaks are used to derive a 0ˢ.001 mean.

Amplifier and relay settings are maintained as constant as possible throughout each longitude set to obviate variable lags in the circuits.

Longitude is computed in the field and allowance made for possible set differences due to the then unknown values for sending lag at the Observatory.

For the five 1937-38 Central American astronomic stations the mean of observed star time residuals was 0ˢ.025 with a maximum of 0ˢ.09 for a single star. A mean probable error of 0ˢ.005 of time was obtained, or approximately 7 feet in distance. This value,together with the latitude value, deals with observational accuracy only since it was not possible to correct for deflection from the vertical.

For Azimuth observations a Parkhurst 9-inch direction theodolite, equipped with a quick-finding star pointer, was used. This instrument was stably mounted on a 3-meter stand, carefully protected from wind, and observations taken over clear lines to an azimuth mark, of about the same elevation, at least two miles distant. No trouble was experienced save for the one azimuth line

necessarily observed just inshore from the Pacific beach, on which surf-haze caused considerable flaring and walking of the signal light pointed on. Polaris only was observed on from 16 to 24 positions on each of three nights. Half-second sidereal time sufficed.

Azimuth was computed in the field, using the best available values for the station latitude and longitude. It is possible to obtain a rapid derivation of both within 2"0 of arc.

The mean probable error obtained from the five 1937-38 astronomic station azimuths equalled 0"14 of arc.

Field computations were checked and the final computations completed by mathematicians at the Washington Office of the Coast and Geodetic Survey.

At the Pacific Coast astronomic station of the inter-ocean triangulation arc the astro-geodetic differences were very small except in latitude. This latitude discrepancy indicates that the adopted provisional datum of 1935 may be too far north, but it was felt that no change in the original datum should be considered until several more astronomic determinations are obtained and until accurate large-scale topographic maps are available for the computation of theoretical deflections at all astronomic stations. Such additional stations would necessarily be connected by first-order triangulation to the present arc. Actually, however, the slightly improved datum to be expected, even with these other stations and theoretical deflection values, still might not warrant changing the 1935 datum, which in itself will serve all practical purposes of expansion through Central America until the accomplishment of a first-order connection between the present Central American arc and the North American Datum through the 98th meridian Mexican arc. With this connection a reality, all Central American triangulation could be placed on a fully corrected horizontal datum.

Upon completion of the astronomic station at the Pacific end of the Guatemala-El Salvador frontier, work was taken up on the four additional stations requested by the individual countries. These were desired to furnish the Laplace azimuths essential to the triangulation control of the complete aerial-cadastral surveys contemplated. Incidentally the same astronomic stations were strategically located for possible future use; (1) when the triangulation connection to the North American Datum is undertaken, and (2) should a precise delineation of the El Salvador-Honduras boundary be desired. Two of the stations also established exact astronomic positions for the meteorological and seismological observatory at Guatemala City and for the seismologieal observatory at San Salvador.

With a single exception all were located to permit the ready measurement of an adjoining first-order base line. Astronomic stations were established, and permanently monumented, at San Salvador, in the central part of El Salvador;La Union, in southern El Salvador near the end of the Honduras frontier; Guatemala City, in the south-central part of Guatemala; and El Sitio, on the Guatemala-Mexico frontier near the Pacific coast. With these, together with the three astronomic stations on the inter-ocean arc, El Salvador has sufficient Laplace control for the two or three more triangulation arcs necessary to establish basic control for any interior mapping. One such arc could also serve for precise

demarcation of the El Salvador-Honduras boundary. The astronomic station at La Union, on Fonseca Bay, might possibly be of some use in connection with any future boundary survey of the Honduras-Nicaragua frontier now in dispute.

The five astronomic stations in and adjacent to Guatemala will furnish sufficient Laplace control for that portion of the North American Datum connecting arc crossing that country. Together with such astronomic positions of secondary accuracy as have been determined in British Honduras along its westerly and southerly frontiers and those now being established by the Fairchild Aerial Surveys to control their mapping operations in northern Guatemala, there will be possibly sufficient astronomic position data to supply a measure of horizontal control for interior surveys.

It is to be hoped that the considerable advance made and the local interest aroused in precise geodetic control through the efforts of Honduras, Guatemala, and El Salvador may continue in their own and the adjoining Republics of Central America, in order that these countries may achieve the complete and accurate network of first-order control so essential to the proper mapping and development of their natural resources.

AIR PHOTOGRAPHS IN HYDROGRAPHIC SURVEYING

George M. Marchand, Jr., Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

An incident which occurred during the surveys along the northern coast of California, conducted by the Ship GUIDE, served to demonstrate the practical use of air photographs in hydrography.

An uncharted breaker was reported by the wire drag party to be approximately three-fourths mile south of False Cape Rock near Cape Mendocino. Since the weather was thick at the time, the party was unable to fix the position of the breaker. When the weather cleared, the area was investigated by running a series of sounding lines spaced 50 meters apart but not a single indication of shoaling was obtained, the general depths being from 9 to 12 fathoms.

It was assumed from this that the wire drag party was off their reckoning and that the breaker must have been close inshore. However, at a later date, some air photographs of the locality were obtained which had been taken at very low tide during a heavy northwesterly swell. These photographs showed what appeared to be a breaker near the reported position and two additional breakers about one-fourth mile to the northward.

A rough compilation of the area from Steamboat Rock to the vicinity of False Cape Rock was made and the breakers located on celluloid by radial plot. These positions were transferred to the hydrographic boat sheet and the exact locations, as obtained from the photographs, examined by the hydrographic party. The search revealed a rock covered by only 10 feet of water near the place reported by the wire drag party and the two breakers to the northward were found to be caused by two rocks, covered by 10 feet and 19 feet of water respectively.

CONSOL OIL FOR RUST PREVENTION

Leroy P. Raynor, Hydrographic and Geodetic Engineer
U. S. Coast and Geodetic Survey

At the suggestion of Boatswain Ralph E. Crosby, who had noticed its successful use on a fleet of decommissioned vessels in New Orleans, Consol Oil was used during the 1937 overhaul period for reconditioning the Ship HYDROGRAPHER'S anchor cables instead of by the usual method of scaling. The oil was applied by utilizing a half section of a 50-gallon drum. This was partially filled with Consol Oil and the cables allowed to soak, in sections, for about four minutes. After draining for a short period, the cables were returned to the locker with no further work on them.

During the field season, which began about two months later, it was the practice to alternate the port and starboard anchors, using one only on each 10-day trip to the working grounds. The cable not being used was sprinkled with a gallon or so of Consol Oil by allowing it to drip from a punctured paint can suspended in the chain locker.

When the cables were hauled out in the next overhaul period (January, 1938) their condition was surprising. The outboard shots, which had been used for anchoring, were practically free from rust. Those shots which had remained in the locker during the season were covered with a light scale which was easily removed by wire brushing. Four men, working three days only, were able to clean and paint the 240 fathoms of cable, in addition to hauling it out on the dock and returning it to the locker, certainly a great saving in the time usually required for conditioning anchor cables.

The chain locker bilges were also found to be in excellent condition, indicating that the oil which had drained from the cables had been effective in preventing the formation of rust. This led to the use of the oil in other places about the ship, particularly those difficult of access such as the bilges under the ice-box. So far, its use has been very successful, although about 10 to 20 days are required to remove scale.

Gonsol Oil is manufactured by the Intercoastal Paint Company with offices and factories in Baltimore, Maryland, and East St. Louis, Illinois. Its use is recommended on other ships, particularly for conditioning anchor cables.

On returning to the working grounds, after the hurricane of September, 1938, Lieutenant Commander Eyman of the Ship LYDONIA found that one of the sono-radio buoys had gone adrift during the storm and could nowhere be seen. He began firing TNT bombs and the lost buoy responded on the chronograph tape, indicating that it had drifted some 25 miles. After a few experimental courses, the LYDONIA headed in the proper direction and by continually firing bombs found the buoy with little difficulty.

TOPOGRAPHY IN GLACIER BAT

Extract from 1938 Season's Report of H. Arnold Karo,
Hydrographic and Geodetic Engineer
Commanding Officer, U. S. Coast and Geodetic Survey
Motor Vessel WESTBAHL

The survey of the lower part of Glacier Bay was not without its compensations, however. The local name for Point Gustavus is Strawberry Point and investigation readily shows why it is so called. Thousands and thousands of strawberry plants (and almost an equal number of bear tracks), covered the point, although few berries were obtained this season due to the continued cold and rainy weather. It is reported that in summers when good weather prevails, the strawberry crop is most prodigious. Wild strawberries are found along the shores of Glacier Bay as far as the party worked this year although the crop was very poor due to unfavorable weather. However, a few tasty feasts of berries were gathered and proved a welcome change of diet. From all reports, the topographic party usually managed to take their noonday lunch in the center of a favorable strawberry patch. While it was not admitted by them, it is believed by the remainder of the party that their taste for strawberries was the cause of their skirmish with a black bear, which fortunately, ended in a draw.

On this particular day the party was working in the bight south of Berg Bay - a particularly choice location for the elusive berry. Seeing the rodman waving frantically and hearing him shouting to hurry up with the rod readings, the rest of the party were at a loss to understand this sudden burst of activity on his part. After each rod reading he would literally run up the beach to the next point, and would again wave frantically and beseech the topographer to hurry and read the rod. He was rodding toward the plane table setup and as he rounded the point and approached closer, the reason for all his agitation was soon apparent; for rounding the point about a hundred yards astern of him, was a black bear of no mean proportions! Each time the rodman stopped to give a reading, Mr. Bear stopped still and stood upright, almost in imitation. When the rodman started up the beach, after him came Mr. Bear on all fours.

This strange game of tag or "hare and hounds" was most amusing to the party gathered around the plane table. Closer and closer came the rodman and after him the bear. It soon became apparent that Mr. Bear was bent on a thorough job of investigating these strange creatures who had apparently interrupted his feast of strawberries. Having no firearms, the party armed themselves with the axe and stood their ground, although ready to take to the boat if necessary. The rodman reached the party and on came Mr. Bear. Brandishing the axe and clubs and letting forth blood curdling yells, the whole party gave a good imitation of a headhunter's dance. In spite of this unholy din, it looked as if a Kit Carson act was called for or else that discretion should be the better part of valor and the entire party would have to retreat to the boat. Just as the party was about to abandon its position, the bear turned around and lumbered off, having approached to within thirty yards of the party.

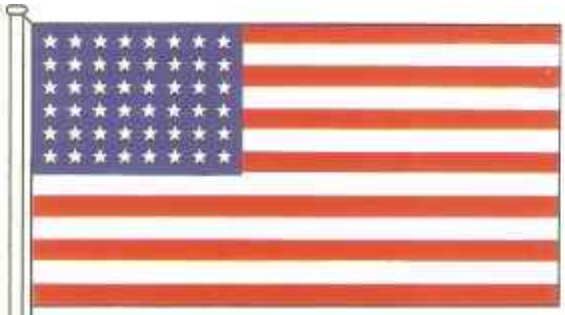
Many bears were seen by the parties at various times and some of the hydrographic signals were destroyed by them. Tripod signals having red cloth on them seemed to be the big attraction as several of these were destroyed. Bears were seen along the beach on several occasions, presumably eating strawberries, and one spent the entire day wandering up and down, retiring to the brush only when attempts were made to photograph him and appearing again as soon as the photographers returned to the ship.

Bear tracks and wolf tracks are in evidence wherever one lands on the beach and the howling of wolves on the mainland and on some of the Beardslee Islands was not uncommon. Woodchucks or groundhogs of extremely large size were found in many sections. Hair seals are found in large numbers and it is reported that the natives still make sealing expeditions up Muir Inlet and into Beartrack Cove for their supply of seal skins, et cetera. The Beardslee Islands are the nesting place for eider ducks, and many geese, ducks and other water fowl are to be found in the lower parts of Glacier Bay. These geese are said to be native of this area and closely resemble the Canadian Honker.

I know of no other place where the sight of one or more whales is a daily occurrence. During the entire time spent in Glacier Bay this season, if visibility permitted, we saw at least one whale each day and at times as many as four or five, often approaching within a few yards of them in the course of our work. At times they seemed most playful and on more than one occasion various members of the party saw them leap clear of the water and come down with a resounding crash, throwing spray a hundred feet or more in the air, apparently from mere exuberance of spirits, for no trace of killer whales was seen at the time. At times they would be close inshore on the reefs, apparently "scraping the barnacles off their bottoms".

Crabs abound in the waters of the bay and more than one feast of this delicious seafood was enjoyed by the entire party. A small amount of commercial crab fishing is carried on, as well as halibut fishing. While anchored at night in Berg Bay, thousands of shrimp, attracted by the lights, were seen swimming around the ship.

FLAGS USED BY U. S. COAST AND GEODETIC SURVEY



NATIONAL ENSIGN

Flag No.	Hoist	Dimensions
6	8.94'	Hoist of Flag 1.0
7	5.14'	Fly of Flag 1.9
9	3.52'	Hoist of Union $\frac{7}{13}$
10	2.90'	Fly of Union .76
11	2.37'	Width of Stripe $\frac{1}{13}$

UNION JACK

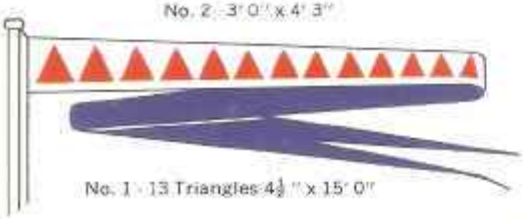
Flag No.	Hoist
6	4.81'
7	2.77'
9	1.90'
10	1.56'
11	1.28'

SECRETARY OF COMMERCE
No. 1 7' 6" x 10' 6"
No. 2 3' 0" x 4' 3"

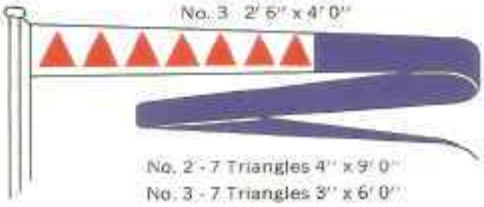
ASST. SECRETARY OF COMMERCE
No. 1 7' 6" x 10' 6"
No. 2 3' 0" x 4' 3"

DIRECTOR'S FLAG
U. S. COAST & GEODETIC SURVEY
No. 1 7' 6" x 10' 6"
No. 2 3' 0" x 4' 3"

SERVICE FLAG
U. S. COAST & GEODETIC SURVEY
No. 1 7' 6" x 12' 0"
No. 2 5' 0" x 8' 0"
No. 3 2' 6" x 4' 0"



No. 1 - 13 Triangles $4\frac{1}{2}$" x 15' 0"



No. 2 - 7 Triangles 4" x 9' 0"
No. 3 - 7 Triangles 3" x 6' 0"

PENNANTS
U. S. COAST & GEODETIC SURVEY

PROPOSED ASSIGNMENT OF OFFICERS FOR FIELD SEASON, 1939
DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

OCEANOGRAPHER

Borden, F.S., Comdg.
Meaney, C.D., Exec.
Smith, P.A.
Latham, E.B.
Kirsch, E.H.
Lushene, J.P.
Mathisson, J.C.
Bull, J.C.
Deck Officer
Deck Officer
Deck Officer
Okeson, F.E.
Gile, K.R., Eng. Off.

HYDROGRAPHER

Mattison, G.C., Comdg.
Raynor, L.P., Exec.
McCarthy, E.R.
Baum, E.C.
Lewey, E.B.
Weber, P.A.
Clark, C.W.
Stirni, J.W.
Deck Officer
Deck Officer
Sawyer, E.M., Eng. Off.

LYDONIA

Eyman, R.P., Comdg.
Karo, H.A., Exec.
Bose, J.C.
Brittain, J.H.
George, C.A.
Riddell, F.A.
Deck Officer
Overton, R.C.
Jones, C.R., Eng. Off.

GILBERT

Thomas, C.M., Comdg.
Schanck, C.A.
Bryant, F.J.

MIKAWE

Gallen, F.L., Comdg.
Ricketts, M.G.
Brown, E.B., Jr.
Ulm, K.S.

SURVEYOR

Schoppe, R.L., Comdg.
Egner, C.A., Exec.
Smook, J.M.
Roberts, E.B.
Thorson, A.C.
Partington, J.C.
Bowie, John, Jr.
Thurmond, J.D.
Oliver, H.J.
Reed, C.R.
Tucker, W.R.
Sturmer, D.E.
Healy, R.W.
Wetzel, J.W., Med. Off.
Zimmerman, E.G., Eng. Off.

DISCOVERER

Jones, G.C., Comdg.
Bean, G.L., Exec.
Boothe, G.E.
Hubbard, L.S.
Doran, P.C.
Paton, H.A.
Johnson, L.C.
Burmister, C.A.
Gibbens, V.M.
Jarman, J.T.
Tryon, R.H.
Moore, G.W.
Soule, F.J., Med. Off.
Davis, S.N., Eng. Off.

PIONEER

Horne, R.D., Comdg.
Odessey, H., Exec.
Sammons, J.C.
Grenell, S.B.
Pfau, R.L.
Fish, G.R.
Bolstad, R.C.
Laskowski, J.
Ellerbe, J.C.
Jackson, W.R.
Lariviere, E.W., Eng.Off

WESTDAHL

Rigg, B.H., Comdg.
Nelson, G.A.
Deane, W.F.

GUIDE

Eickelberg, E.W., Comdg.
Shaw, Chas., Exec.
Bernstein, E.H.
Rowse, R.C.
Marchand, G.M.
Hicks, E.F.
Conerly, H.G.
Chenworth, C.F.
Schoene, C.A.
Weidlich, W.
Seymour, F., Eng. Off.

PATHFINDER

Pierce, Chas., Comdg.
Porter, W.R., Exec.
LeFever, C.
Morris, G.E.
Leary, W.J., Med. Off.

New EXPLORER

Sobieralski, A.M.
Insp. of Const.
Peters, J.H., Asst.
Insp. of Const.
Greer, W.E., Eng. Off.

E. LESTER JONES

Wilder, L.C, Insp. of Const.

WIRE DRAG

Rittenburg, I.E., in charge
Chovan, W.J.
Stohsner, E.E.
Applequist, H.C.

COMBINED OPERATIONS

Columbia River

Scaife, W.M.
Sanders, I.T.
Wagner, C.J.
Waugh, J.E., Jr.

Intracoastal Waterway
(Gulf Coast)

Anderson, G.L.
Garber, H.F.
Tribble, J.C, Jr.

AIR PHOTO SURVEYS

Baltimore

Swanson, L.W.
Jones, J.N.
Gilmore, R.A.
Jones, E.L.
Russell, W.C.
Wardwell, A.L.

St. Johns River

Sipe, R.J.
Fortin, H.O.
Gossett, F.R.

COAST PILOT
(Atlantic Coast)

Crosby, K.G.

WASHINGTON OFFICE

Rude, G.T.
Cowie, G.D.
Campbell, H.B.
Peacock, F.L.
Senior, Jack
Reading, O.S.
Witherbee, M.O.
Bond, J.A.
Tison, J.C., Jr.

UNASSIGNED

Warwick, H.C.
Deily, E.A.
Healy, H.J.
Wennermark, M.E.

LIGHTHOUSE SERVICE

Norfolk

Finnegan, H.E.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY (cont.)

FIELD STATIONS

New York	Maher, T.J.	Seattle	Hardy, F.H.
Boston	Moore, R.R.		Rubottom, I.R.
New Orleans	Graham, L.D.	Honolulu	Heaton, E.O.
San Francisco	Lukens, R.R.	Manila	Siems, F.B.T.

The field parties of the Division of Hydrography and Topography will operate during the 1939 field season in the following localities:

HYDROGRAPHER - during the first part of the season along the west Gulf coast from latitude 27° to the mouth of the Rio Grande, and the remainder of the season eastward from the vicinity of Pensacola.

The OCEANOGRAPHER and LYDONIA in the area between Montauk Point and Nantucket Light Vessel.

The GILBERT on Nantucket Shoals, in cooperation with the OCEANOGRAPHER, and in Nantucket Sound.

The MIKAWE along the north shore of Nantucket Sound.

The WESTDAHL in Glacier Bay, Alaska.

The SURVEYOR and PIONEER in the Aleutian Islands, westward from Umnak Island.

The GUIDE will complete surveys along the California coast early in the season and then take up surveys in Bering Sea, eastward from Unimak Pass.

The DISCOVERER will continue operations along the south coast of the Alaska Peninsula eastward from the Sanak Islands.

The Pacific Coast Wire Drag Party will operate as an independent unit on St. Georges Reef and along the coast from Bodega Bay toward Point Arena.

The PATHFINDER off the west coast of Palawan and in the South Sulu Sea area.

The St. Johns River air photographic survey party will continue work on the St. Johns River.

The party in the Florida Keys will complete the survey of the Keys and take up work in the Intracoastal waterways along the Gulf coast in the vicinity of Apalachicola.

The air photographic survey party at Baltimore will continue work in Chesapeake Bay and along the north shore of Nantucket Sound.

The Columbia River party will complete triangulation on the Columbia River and the coastal arc from the mouth of Columbia River to Grays Harbor and then take up revision surveys in Willapa Bay.

DIVISION OF GEODESY

WASHINGTON OFFICE	FIELD	FIELD	FIELD
Garner, C.L.	Ratti, A.P.	Quinn, F.B.	Morton, J.S.
Hemple, H.W.	Woodworth, R.W.	Bernstein, P.L.	Sheridan, E.H.
Bainbridge, W.H.	Hoskinson, A.J.	Lovesee, G.W.	Beyma, C.J.
	Knox, R.W.	Stewart, A.N.	Konichek, D.H.
NEW YORK COMPUTING OFFICE	Aslakson, C.I.	Earle, R.A.	Taylor, P.
	Johnson, F.G.	Jeffers, K.B.	Martin, W.N.
Gibson, W.M.	Shelton, G.R.	Mast, G.C.	Seaborg, H.J.
Natella, F.			
Hecht, M.A.			

DIVISION OF CHARTS	DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY	DIVISION OF TIDES AND CURRENTS	DIVISION OF PERSONNEL AND ACCOUNTS
Adams, K.T.	Heck, N.H.	Whitney, P.O.	Luce, R.F.
Green, C.K.	Swainson, O.W.	Malnate, W.F.	
Durgin, C.M.	Cotton, H.A.	Marshall, R.A.	
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, 1937 - June 30, 1938

Locality	Project H.T.No.	Ship or Party No.	Chief of Party	Hydrography: Sounding Lines Mi.	Hydrography: Area Sq. Mi.	Hydrography: Soundings No.	Topography: Shore Line Mi.	Topography: Area sq. mi.	Triangulation: Length of Scheme Mi.	Triangulation: Area sq. mi.	Triangulation: Geo. Pos. No.	Tides & Cur.: Tide Sta.	Tides & Cur.: Cur. Sta.	Tides & Cur.: Mag. Ent.	Tides & Cur.: Mag. Det.
Nantucket Sound	217	61.	G. M. Thomas	44	2	2,412	18.0	4.0	6	6	2	2			1
Atlantic coast of Long Island	207	EX.	R. P. Eyman	2,843	1,184	28,594						1			1
Coast of N.J.	207	LX.	J. Sailer	4,197	2,387	37,902						1			
Coast of N.J.	207	61.	R. P. Horne	1,640	854	89,791									
Coast of N.J.	207	60.	E. W. Burden	4,447	1,919	37,044									
N.J. Inland Waterway	208	MX.	L. D. Graham	1,828	56	58,848						13		40	
Chesapeake Bay	215	MX.	F. L. Dallas	516	24	52,210						4		2	
Chesapeake Bay	215	A.P. 1	L. W. Swanson				258.0	140.0	30	74	48				
Chesapeake Bay	215	A.P. 6	S. S. Grendall				95.0		4						
Inland Waters Va. & N.C.			E. E. Finnegan	396	26	13,743	3.0		29	92	35	3		9	1
Inland Waters Va. & N.C.	215	A.P. 6	S. S. Grendall				237.0	390.0							
St. Johns R. Fla.	216	MX.	L. D. Graham	737	39	39,958						4		11	
St. Johns R. Fla.	146	A.P. 3	E. A. Petop				387.0	257.0							
Fla. Keys	185	S.P. 1	E. R. McCarthy	5,201	193	71,549	400.5	124.5	8	13	2	12	2	24	10
Tex. Coast	214	MX.	C. G. Matthews	15,821	11,685	145,536	98.0	46.0				7		2	29
Vin. of Santa Barb. Isl., Cal.	187	61.	E. H. Campbell	4,618	3,642	33,993									1
Coasts of Wa. Ore. & Oregon	204	60.	F. H. Jardy	3,314	2,732*	19,838	102.4	4.0	8	14	5	6		4	9
San Francisco			R. P. Larsen								21		5		
Columbia R. Ore. & Wash.	201	S.P. 3	R. M. Smith	1,531	43	47,010	169.0	30.0	30	49	281	21		18	3
Puget Sound	223	WX.	H. A. Karo	256	80	4,149	10.0	48.0				1	1	2	9
Stephens Passage	225	WX.	H. A. Karo	581	47	12,888	34.3	380.0	6	31	13	1		3	3
Xifin Cove & Glacier B.	211	WX.	H. A. Karo	136	18	4,359	27.8		12	34	28	3	1	9	
Sumner Str. & Wrangell Hbr.	211	XX.	G. C. Jones	1,050	73	21,386	105.3	46.6	25	43	40	5			4
Sitka Hbr.	220	XX.	G. C. Jones	8	18**	2,141	24.6	9.1	16	31	64	8		2	3
Goodnews Bay Alaska		Spec.	R. W. Kenk	16	1	482			2	2	13	1		3	1
Gulf of Alaska	218	PI.	R. D. Horne	453	6,380	973									
Gulf of Alaska	194	67.	A.W.Soderstrom	2,457	24,530	2,180									
Gulf of Alaska	203	61.	R. L. Schoppe	1,809	24,280	3,315									
Alaska Peninsula	208	31.	R. L. Schoppe	6,701	5,480	84,876	91.1	158.8	22	63		4	1	6	3
Aleutian Isl. Alaska	176	30.	A.W.Soderstrom	4,053	1,514	28,000	135.0	505.0	95	995	63	4	1	6	8
	219		R. P. Horne												1
P.I., East Coast Mindanao			T. J. Maher	3,674	596	50,317		28.0							
P.I., Davao Isl.			T. J. Maher	17	3	198									
P.I., Whale Hook			T. J. Maher	19	3	199									
P.I., Cole Bl. & Pete			T. J. Maher	28	4	454									
P.I., Alice Channel			T. J. Maher	79		826			43	475	10				
P.I., Tawitawi Bay, Sulu			T. J. Maher						30	30	26				
P.I., Dahican Bay, Luzon			T. J. Maher	45	2	1,647									
P.I., Mambulao & Manta Grul			T. J. Maher	139	14	7,345			6	35	35				
			Totals	87,188	34,425	848,250	2,612.6	1,887.2	366	1,954	458	98	12	150	89

* Includes 255 square miles of Wire Drag.
** Includes 18 square miles of Wire Drag.

OFFICERS ATTACHED TO SHIPS AND PARTIES DURING THE YEAR

1. DISCOVERER:	R. L. Schoppe, Com'd'g, R. R. Moore, J. M. Smook, C. Pierce, L. S. Hubbard, L. C. Johnson, J. Bowie, Jr., I. T. Sanders, C. A. Burmister, V. M. Gibbens, C. LeFever, E. C. Baum, E. B. Lewey, I. R. Rubottom, J. C. Tribble, Jr., J. E. Waugh, Jr., H. J. Seaborg, K. R. Gile, and F. J. Soule.
2. EXPLORER:	G. C. Jones, Com'd'g, L. C. Wilder, R. J. Sipe, E. O. Baum, J. C. Ellerbe, H. O. Applequist, J. E. Waugh, W. Weidlich, and S. N. Davis.
3. FATHOMER:	H. C. Warwick, Com'd'g, C. Pierce, K.G. Crosby, H. J. Healy, C. A. Schanck, M. E. Wennermark, J. W. Wetzel, W. J. Leary, and G. W. Hutchison.
4. GILBERT:	R. D. Horne and C. M. Thomas, Com'd'g, J. P. Lushene, and C. A. George.
5. GUIDE:	F. H. Hardy and O. W. Swainson, Com'd'g, C. Shaw, W. D. Patterson, E. H. Bernstein, I. E. Rittenburg, W. H. Bainbridge, W.E. Malnate, G. M. Marchand, W. J. Chovan, L. W. Swanson, R. C. Bolstad, M. G. Ricketts, H. F. Garber, K. S. Ulm, E. E. Stohsner, H. G. Conerly, C. A. Schoene, and F. Seymour.
6. HYDROGRAPHER:	F. S. Borden and G. C. Mattison, Com'd'g, L. P. Raynor, G. L. Anderson, P. C. Doran, V. M. Gibbens, F. R.Gossett, E. B. Lewey, J. N. Jones, K.B. Jeffers, R. A. Gilmore, J. T. Jarman, P. Taylor, C. W. Clark, J. W. Stirni, G. W. Moore, and E. M. Sawyer.
7. LYDONIA:	J. Senior and R. P. Eyman, Com'd'g, E. O.Heaton, M. O. Witherbee, T. B. Reed, C. M. Thomas, G. E. Boothe, J. O. Bose, S. B. Grenell, E. F. Hicks, J. C. Bull, A. L. Wardwell, F. J. Bryant, R. C. Overton, F. E. Okeson, and C. R. Jones.
8. MIKAWE:	L. D. Graham and F. L. Gallen, Com'd'g, G.W. lovesee, J. C.Partington, E. B. Brown, E. L. Jones, and R.H.Carstens.
9. OCEANOGRAPHER:	H. A. Seran and F. S. Borden, Com'd'g, R.P.Eyman, M. O. Witherbee, H. Odessey, C. M. Thomas, T. B. Reed S. B. Grenell, P. A. Smith, E. B. Latham, E. H. Kirsch, J. H. Brittain, J. P. Lushene, J. C. Mathisson, E. F. Hicks, J. C. Bull, C. F.Chenworth, F.E. Okeson, and W. E.Greer.
10. PIONEER:	H. B. Campbell and R.D. Horne, Com'd'g, R. R. Moore, J. M. Smook, W. M. Scaife, J. C. Sammons, R.J.Sipe, L.S. Hubbard, R.L. Pfau, G. A. Nelson, W. R. Porter, G. R. Fish, R. C. Bolstad, M. G. Ricketts, W. R.Scroggs, and E. W. Lariviere.
11. SURVEYOR:	A. M.Sobieralski, Com'd'g, G. L. Bean, W. F.Malnate, John Bowie, I. T. Sanders, G. A. Kelson, J. D. Thurmond, H. J. Oliver, John Laskowski, F. A. Riddell, J.C. Ellerbe, J. C.Tison, W.F. Deane, W. R. Tucker, D. E. Stunner, R. W. Healy, W. J. Leary, J. W. Wetzel, and E.G. Zimmerman.
12. WESTDAHL:	H. A. Karo, Com'd'g, G.E.Morris, and R. D. Konichek.
Shore Party No. 1:	E. R. McCarthy, Chief, J.C.Mathisson, and P. A. Weber.
Shore Party No. 3:	R. W. Knox and W. M. Scaife, Chief, C. J. Wagner and C.R.Reed.
Air Photo Party "A":	J. C. Partington and L. W. Swanson, Chief, E. L. Jones, and W.C. Russell.
Air Photo Party "C:	S. B. Grenell, Chief, E. B. Latham, J. P.Lushene, G.C. Mast, J. C. Bull, A.L. Wardwell, and C.F.Chenworth.
Air Photo Party "B":	H. A. Paton, Chief, H. O. Fortin, F.R.Gosaett, and W.C. Russell.
Special Party:	R. W. Knox, Chief, and F. A. Riddell.
Liaison Officers:	Fifth Lighthouse District - H. E. Finnegan. Sixth Lighthouse District - B. H. Rigg.
Field Stations:	Manila, P. I., T. J. Maher; Boston, E. B.Roberts; New York, C. A. Egner; New Orleans, G. C. Mattison and L. D. Graham; San Francisco, R. R. Lukens; Seattle, O.W.Swainson and R.W; Knox; Honolulu, T. H., J. H. Peters; San Juan, Puerto Rico, E. A. Cotton.
Washington Office:	G. T. Rude, Chief of Division; R. F. Luce, Assistant Chief; F. B. T. Siems and R. F. A. Studds, Chief, Section of Coast Pilot; F. G. Engle, J. Senior and R. F. A. Studds, Chief, Section 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; E. H. Kirsch, and J.S. Morton.

DIVISION OF TIDES AND CURRENTS

Summary of Statistics - 1938

P. C. Whitney, Chief of Division

R. C. Rowse

Tide Survey - Sacramento and San Joaquin Rivers

Tide stations occupied	8
Number of bench marks leveled to	85

R. A. Marshall

Tide Survey - Connecticut River

Tide stations occupied 7

Tide station inspection and reconstruction, Atlantic and Gulf coasts

Tide stations established	4
Tide stations inspected	17

Other Field Activities of Division

Tide stations occupied for general purposes	75
Tide stations occupied for hydrographic surveys	70
Long period current stations occupied	4
Short period current stations occupied	21
Number of bench marks leveled to	702

DISTRIBUTION OF PARTIES AND STATISTICS

GEODESY - FISCAL YEAR 1938

Chief of Party	Locality	Length of Scheme	Area
		Miles	Sq. Mi.
	TRIANGULATION FIRST ORDER		
C. D. Mastay	Amsterdam Avenue base net, New York	6	2
	Vicinity of New York, N.Y.	10	2
	Hudson River, N.Y. to Hudson, N.Y.	150	1,650
	Baltimore County, Md.	22	140
F. G. Fridsen	Soil-Conservation Area, Utah, Colorado, and Wyoming	495	13,150
	Great Basin net, Nevada	13	50
	Virgin River area, Utah and Arizona	180	6,000
E. H. Tryon	Connecticut-Rhode Island boundary; Connecticut and Rhode Island	43	340
	Hartford to Torrington, Conn.	84	500
P. A. Earle	Colquitt, Ga., to Laurel Hill, Fla.	145	1,450
A. G. Thorson	Earthquake investigation: Mariposa, Calif.	16	80
	Palmdale, Calif.	16	70
	Gorman, Calif.	24	190
	TRIANGULATION, SECOND ORDER		
E. A. Earle	Arcadia to Fort Ogden, Fla.	17	190
	Lake Okeechobee to Fort Myers, Fla.	70	190
	Highlands to Francis, Fla.	80	600
	Darrobelle, Fla., to Gotgrit, Ga.	80	720
	Early to Cambellton, Fla.	60	600
G. I. Ashenden	Lower Merion Township, Pa.	10	50
F. G. Johnson	Soil-Conservation area, Utah, Colorado and Wyoming	950	22,550
	BASE LINES, FIRST ORDER		
C. D. Mastay	Amsterdam Avenue, New York	4.0	- - -
H. T. Gainbridge	Lomita, Ark. (remeasurement)	8.8	- - -
	TRAVERSE, FIRST ORDER		
A. C. Thorson	Earthquake investigation, Mariposa, Calif.	14.0	- - -
	RECONNAISSANCE, FIRST ORDER TRIANGULATION		
C. D. Mastay	Amsterdam Avenue base net, New York	4	2
M. A. Tacht	Vicinity of New York, N.Y.	10	2
M. L. Strahan	Colquitt, Ga., to Mobile, Ala.	880	2,695
G. I. Ashenden	Montgomery County, Md.	22	140
Wm. Hemsetter	Soil-Conservation Area, Utah, Colorado and Wyoming	495	13,150
	Virgin River area, Utah and Arizona	180	6,000
E. E. Johnson	Earthquake investigation: Cajon Pass, Calif.	9	12
	Whitewater, Calif.	7	10
	Morongo, Calif.	11	44
	Whittier, Calif.	9	36
	Inglewood, Calif.	10	50
	Palmdale, Calif.	16	35
	Gorman, Calif.	24	100
	Mariposa, Calif.	18	80
H. B. Parker	Greenville, Ala., to Cuthbert, Ga.	95	950
	Rockford to Sheffield, Ala.	55	550
	Fredericktown to Success, Mo.	95	950
	RECONNAISSANCE, SECOND ORDER TRIANGULATION		
J. S. Kilby	Elwood, Kans., to Kinsley, Colo.	220	2,200
H. E. Moore	Highland to Francis, Fla.	40	400
P. J. Bryant	Arcadia to Fort Ogden, Fla.	17	170
C. I. Ashenden	Lower Merion Township, Pa.	10	50

Chief of Party		Length of Scheme	Area
		Miles	Sq. Mi.
	RECONNAISSANCE, SECOND ORDER TRIANGULATION (Cont.)		
Wm. Hemsetter	Soil-Conservation area, Utah, Colorado, and Wyoming	950	28,500
	Grantsville-Tooele area, Utah	43	900
O. S. Rivold	Weber River area, Utah	113	2,925

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
O. J. Lacy	California	325	---	325
F. R. Quinn	Colorado	100	247	347
	Idaho	75	101	176
	Montana	---	454	454
	Nevada	4	39	43
	New Mexico	5	11	16
	Utah	44	259	303
	Wyoming	---	119	119
K. D. Carters	Louisiana	261	---	261
	Mississippi	50	---	50
O. I. Ashenden	Maryland	53	7	60
	Virginia	---	215	215
	Totals	917	1,382	2,299

ASTRONOMICAL OBSERVATIONS

Chief of Party	State	Number of determinations: Latitude	Longitude	Azimuth
R. W. Woodworth	Guatemala	2	2	2
	El Salvador	3	3	3

GRAVITY OBSERVATIONS

Chief of Party	State	Number of determinations: New	Other
O. I. Ashenden	Alabama	15	---
	Florida	18	2
	Georgia	13	---
	North Carolina	7	1
	South Carolina	1	---
	Virginia	1	1
C. A. Schenck	Connecticut	5	---
	Massachusetts	12	1
	New Hampshire	1	---
	New Jersey	6	---
	New York	9	1
	North Carolina	5	---
	Pennsylvania	17	1
	Rhode Island	4	---
	Virginia	11	---
A.F. Robinson	North Carolina	11	---
R.M. Woodworth	North Carolina	2	---
	Totals	140	7

SUMMARY OF STATISTICS

Geodesy - Fiscal Year 1938

Activity	Miles
Triangulation:	
First order	1,149
Second order	1,347
Base lines, first order	15.8
Reconnaissance:	
First order	1,317
Second order	1,487
Leveling:	
First order	1,838
Second order	2,796
Gravity determinations	136
Traverse, first order	14.4
Total	9,589.2

DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY

Summary of Statistics - 1938

N. H. Heck, Chief of Division
E. W. Eickelberg, Assistant chief of Division to July 31, 1938
0. W. Swainson, Assistant Chief of Division from August 1, to December 31, 1938
J. H. Peters, In charge Honolulu Magnetic Observatory
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

Magnetics

Field Determinations

Chiefs of Magnetic parties - S. A. Deel, F. P. Ulrich, R. R. Bodle

Magnetic Parties	
No. of Declination Determinations	50
No. of Horizontal Intensity and Dip Determinations	20
Geodetic Parties	
No. of Declination Determinations	336
No. of Horizontal Intensity and Dip Determinations	0
Hydrographic and Topographic Parties	
No. of Declination Determinations	109
No. of Horizontal Intensity and Dip Determinations	5
Special Magnetic Parties	
No. of repeat stations - declination only	26
No. of horizontal intensity stations	1
No. of repeat stations - all elements	16
No. of Magnetic Observatories in operation	5

Seismology

Earthquakes reported	435
Seismological instruments in use:	
Accelerographs	42
Displacement meters	6
Weed seismographs	11
Tiltmeters	4
Shocks recorded, strong motion instruments	9
Vibration observations made	250
No. of Teleseismic stations in Operation	18
No. of stations reporting to Science Service for immediate determination of epicenters by Coast and Geodetic Survey	25
Epicenters reported to Science Service	43
Deep well acoustic stations 2	

TEE CHART DIVISION

The commissioned personnel during the 1938 fiscal year consisted of:

Chief of Division	L. O. Colbert to April 12, 1938
	K. T. Adams.from April 15, 1938
Assistant Chief of Division	K. T. Adams to April 14, 1938
	C. K. Green from April 21, 1938
Chief of Field Records Section	C. K. Green to April 20, 1938
	T. B. Reed from April 21, 1938
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 15 new nautical charts, of which six were of the 1:40,000 scale Intracoastal Waterway Series, completing this series.

The printing of new editions for 123 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 latter being the first two of a new series. The printing of 48 new editions of previously published aeronautical charts.

The issue of aeronautical charts in 1938 was seven percent greater than in 1937, and that of nautical charts was five percent greater. These increases are all the more remarkable when it is considered that the 1937 issues in both cases were new yearly records.

The total number of impressions made on the printing presses was 7,099,304 far exceeding the largest previous year in 1936, which was 5,594,204.

June 20, 1938.

U. S. COAST AND GEODETIC SURVEY

Field Memorandum No. 1 (1938)

MEAN HIGH WATER LINE IN MARSH AND OTHER SWAMP AREAS.

The instructions contained herein supersede paragraph 43, page 9, of the Topographic Manual, Special Publication No. 144, and other previous instructions as regards the delineation on planetable and air photographic surveys of the mean high water line in marsh, mangrove, and cypress areas.

In the remaining paragraphs of these instructions the term mean high water line refers to the line of intersection of the mean high water plane with the ground.

In marsh, mangrove, and cypress or similar swamp areas, the mean high water line is generally obscured by the vegetation and will not ordinarily be located. In these areas the outer edge of the vegetation visible above mean high water is charted as the shoreline and shall be located on the planetable and air photographic surveys in lieu of actual mean high water line. The outer edge of vegetation shall be shown on all planetable and air photographic surveys by a fine solid black line, which shall be distinctly lighter and readily distinguished from the actual mean high water line on fast land which shall be shown by the standard weight solid black line. Refer to Figures 1, 2, and 3.

The change from the heavy to the light line shall be made abruptly, as illustrated, and not by tapering off at the end of the heavy line.

In cases where the outer limits of marsh or mangrove are so broken and scattered at mean high water that they cannot be well defined by a light line, the limits shall be shown by symbols only as at (A) in Fig. 1 and Fig. 3. This condition will be found frequently in marsh but infrequently in mangrove.

When the question arises as to whether a particular area of marsh or mangrove shall be shown with the line or by symbols only, the criterion shall be its appearance to the navigator. If it presents a fairly definate edge at mean high water it should be shown with a line.

Referring to Fig. 1, at (A) and (B) the marsh has a gradual slope with no definite berm or edge. At mean high water the outer section is mostly flooded with only scattered tufts of grass showing. The interior section at (B) is higher and shows as solid marsh.

The line of change from (A) to (B) is indicated approximately by the difference in symbols. It need not be surveyed but shall be sketched approximately in order to show the character of the marsh.

Referring to Fig. 3, at (A) the mangrove is low and scattered. The change to the area of thick mangrove is not well defined and no line is shown.

The symbol at B represents low scattered mangrove growing outside of a well defined edge of dense mangrove.

The condition illustrated at B is found more often than that at A.

At C the mangrove is low and scattered but the line is shown to define a mud area which has a berm or edge slightly higher than the interior

and covered only at higher tides. At ordinary tides the only water entering the interior is by seepage. This condition has been noted only in a limited area of the Florida keys.

The edge of high ground at the back of the marsh, mangrove and cypress areas shall be indicated by symbols only, as illustrated in the examples, and not by a fine line.

Each survey showing marsh, mangrove or cypress areas shall carry the note "The light line around the marsh (mangrove or cypress) defines the outer limits of vegetation visible at mean high water. The mean high water line (intersection of the plane of mean high water with the ground) is shown only on fast land and is represented by a heavy solid line." This note will, ordinarily, be stamped or printed on the surveys in the office and need not be lettered by the field party unless called for in the instructions for the particular project.

Open mud areas in marsh and mangrove as at D, Fig. 1, and at E, Fig. 3, shall be labelled so as not to be confused with areas of high ground. The mud symbols need be shown only where the label will not be sufficient to show the conditions as at D, Fig. 3. In this case, the mud symbol is needed to show the change from the mud flat to higher ground. No mud symbol is needed at D, Fig. 1, or at E, Fig. 3, as the mud area is bounded by the marsh or mangrove symbol.

Low water areas of mud and sand shall in general be shown with the dotted line and labelled without filling in the symbol, as illustrated in Fig. 1 and Fig. 3. The symbol need be filled in only where the label will not be sufficient to show the conditions.

Care shall be exercised to include on the surveys the small sections of mean high water line similar to that shown at A, Fig. 2.

As regards the air photographic surveys, sufficient field inspection shall be made to insure the correct delineation of mean high water line and limits of vegetation. In many areas the field inspection may be made at any stage of the tide. In indefinite areas, as illustrated at A, in Fig. 1, sufficient inspection shall be made at or near mean high water for correct interpretation of the photographs.

Descriptive notes shall be lettered on the plane table surveys and on the air photographic survey overlays to indicate the character of vegetation, composition of low water areas, etc. Descriptive notes are particularly important where the conditions are not readily interpreted from the map symbols alone.

L. O. Colbert.

Director.

M-585

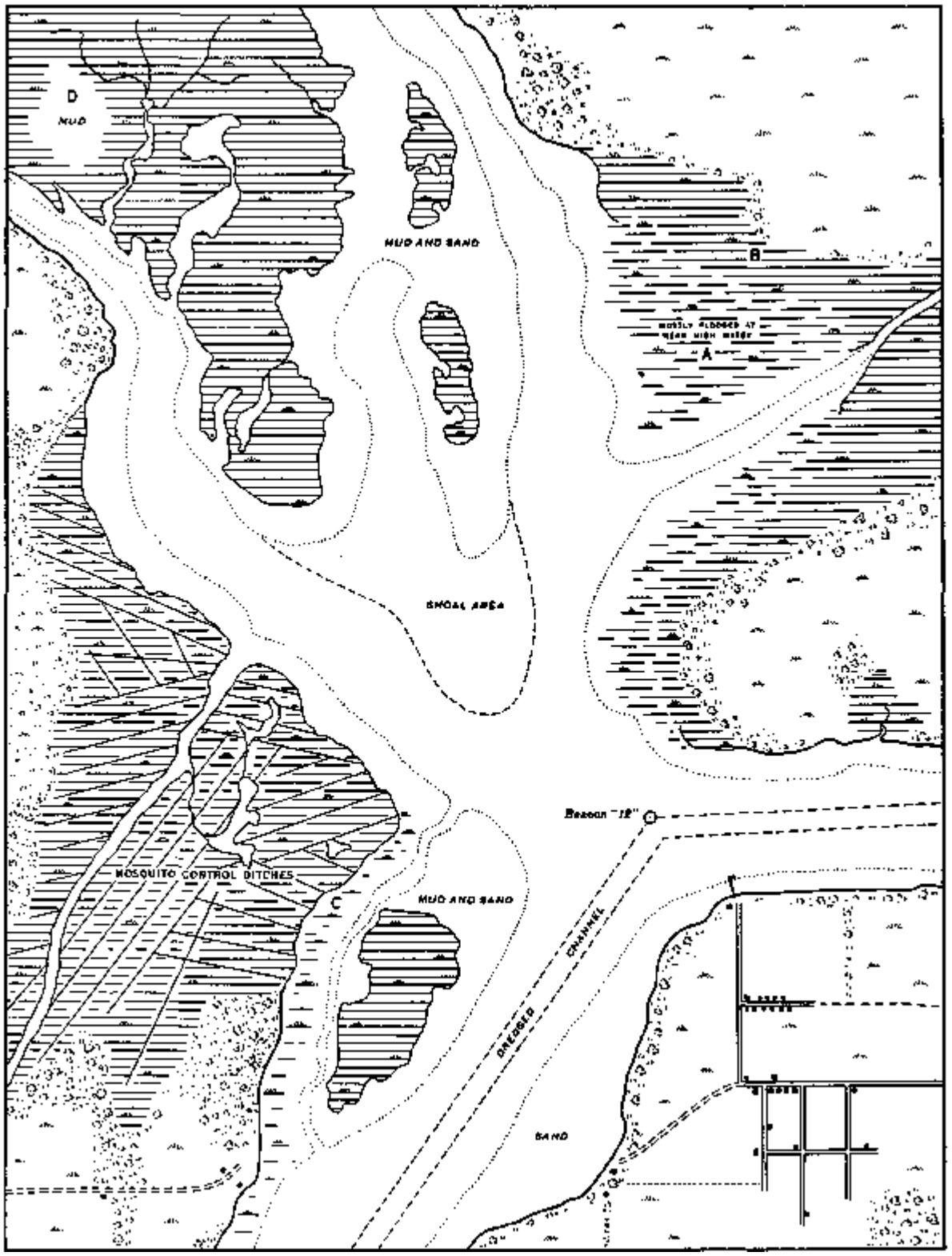


FIG. 1 The light line around the marsh defines the outer limits of vegetation visible at mean high water. The mean high water line (intersection of the plane of mean high water with the ground) is shown only on fast land and is represented by a heavy solid line. The change from the heavy to the light line is made abruptly and not gradually. At (A) no line is shown as the outer section of the marsh is mostly flooded with only scattered clumps of grass showing at mean high water. The symbol at (C) represents short grass (mostly flooded at high water) growing outside of a well defined high marsh.

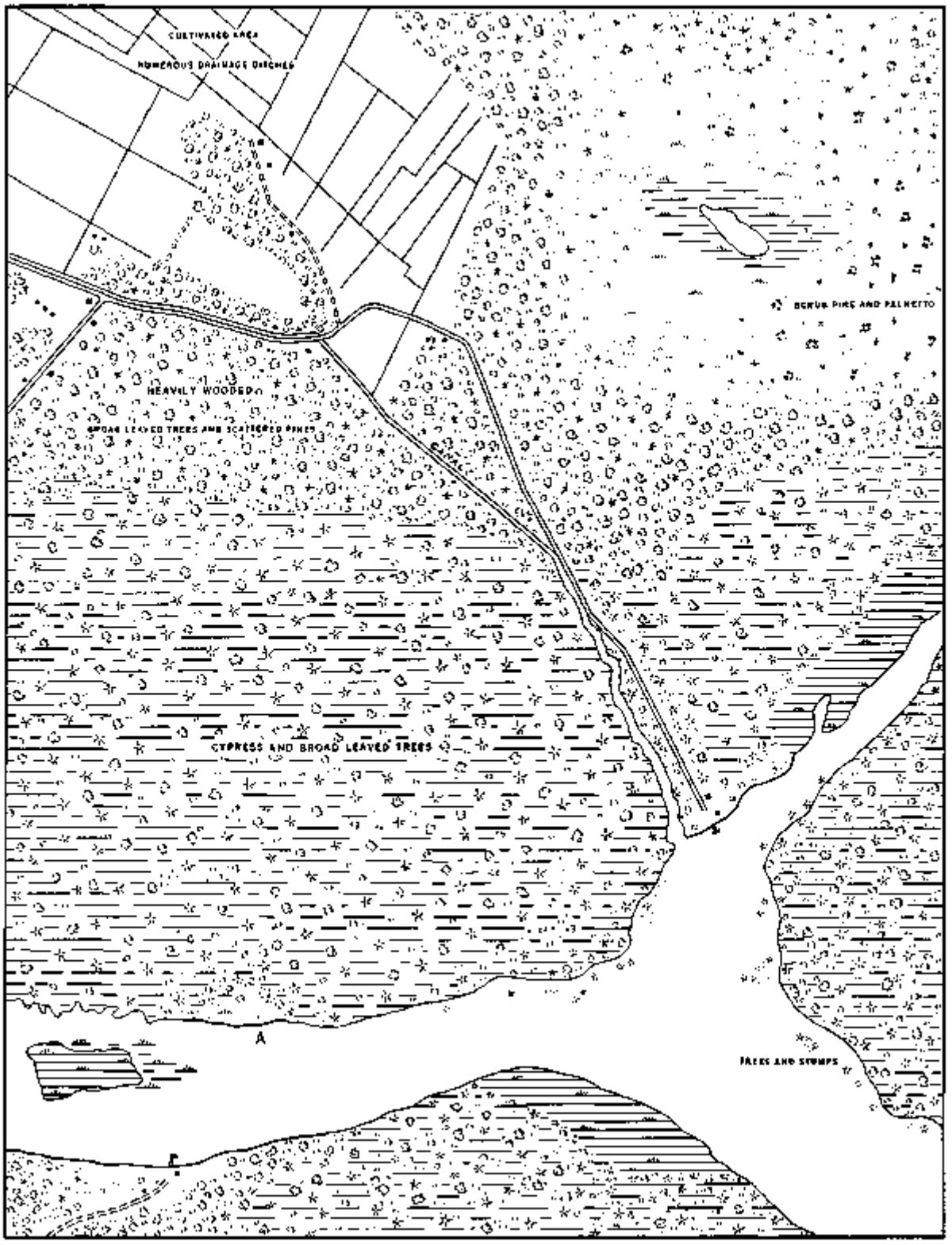


FIG. 2 The light line around the cypress and marsh areas defines the outer limits of vegetation visible at mean high water. The mean high water line (intersection of the plane of mean high water with the ground) is shown only on fast land and is represented by a heavy solid line. The change from the heavy to the light is made abruptly and not gradually.

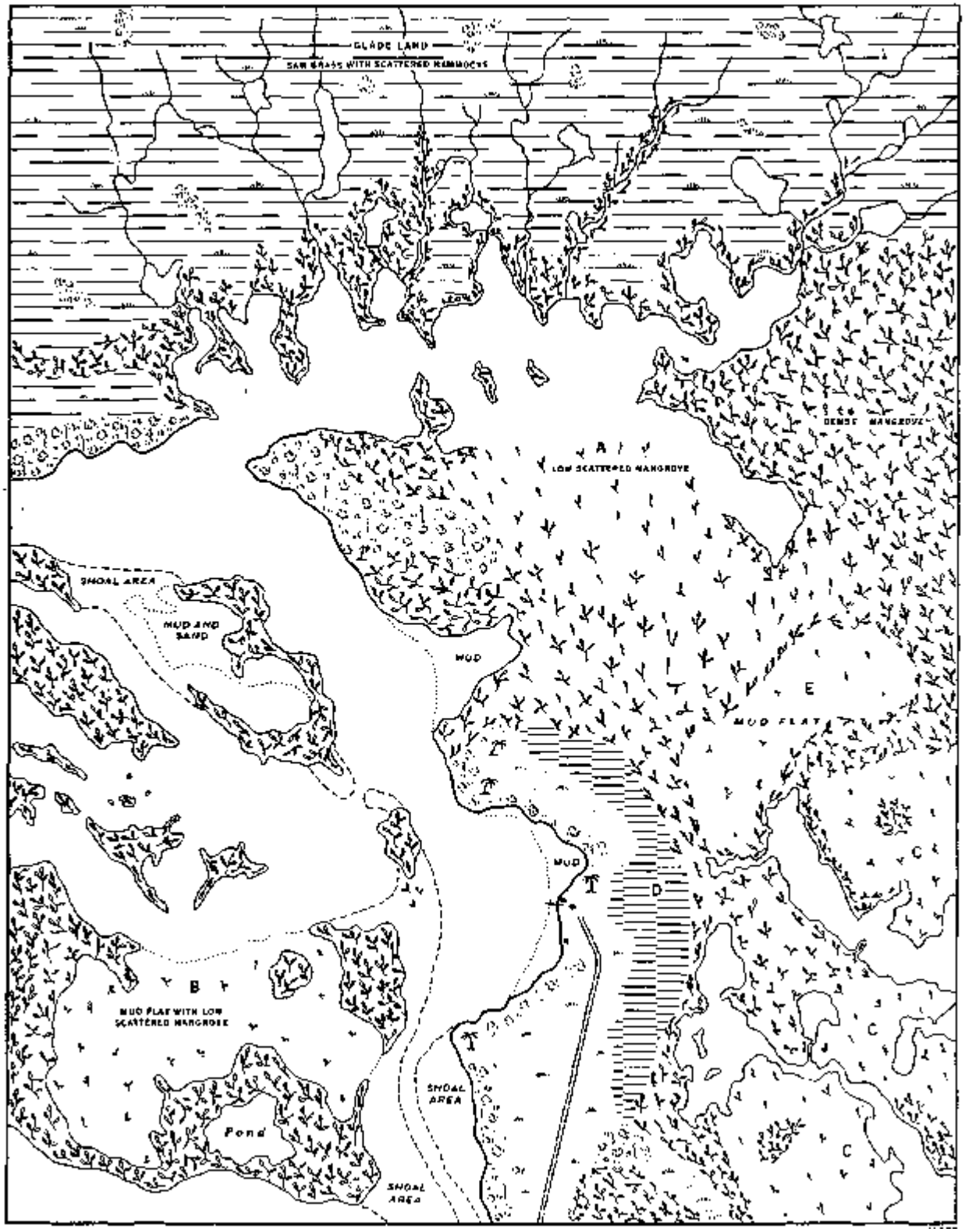


FIG. 3 The light line around the mangrove defines the outer limits of vegetation visible at mean high water. The change from the heavy mean high water line on fast land to the light line is made abruptly and not tapered off. No line is shown at (A) as the mangrove is scattered with no definite edge. The symbol at (B) represents low scattered mangrove growing outside of a well defined edge of dense mangrove. The mud symbol is shown at (D) as otherwise the mud area would not be defined. The symbol should be omitted where the mud can be indicated by a label without the symbol as at (B) and (E).

September 2, 1938.

FIELD MEMORANDUM No. 2 — 1938
UNITED STATES COAST AND GEODETIC SURVEY

PHOTOGRAPHS

The demand in recent years for photographs illustrative of the work of the Bureau, for use in talks, magazine and newspaper articles, and for Bureau publications, makes it necessary that new-photographs, even of old subject matter, be added to the Bureau's files.

Accordingly, officers are directed to submit photographs of field activities, particularly actual survey operations, whenever opportunities are afforded. It is requested, also, that personal photographs, taken in the past, be examined and those submitted which might be of value. Negatives, rather than prints, are desired for better reproduction. After register of a negative, prints may be ordered by reference to the register number.

In taking photographs an effort should be made to obtain sharp, distinct outlines and decided contrasts. A photograph of an instrument or a machine should include a person standing nearby to show relative size. Photographs intended for illustrations in the Coast Pilots should be taken from a position where the view would most likely be of use to a mariner, such as making a landfall on an established route. In a region where the coast may be approached with safety, distinctive features which can be identified during low visibility are especially useful. The photographs in this case should be taken close to the feature.

Complete history of a photograph is provided for on form 623-A, "Photograph History." Each submitted negative should be accompanied by this form with items 3, 4, 5, 6, 7, 8, and 13 accomplished. Particular care should be taken to see that the descriptive title is sufficiently comprehensive to leave no doubt regarding any feature of the photograph. In the case of photographs for Coast Pilot illustrations, the title should include a statement of the distance of the feature and the direction in which it is seen; for example, "Cape St. Elias, looking westward, mag., 15 miles distant."

The negatives or duplicate prints of illustrations for a season's or special report should be submitted separately so that the report will not be mutilated by removing the photographs for register.

L. O. Colbert,

Director