GENERAL INSTRUCTIONS

HYDROGRAPHIC SURVEYS DIVISION

IN REGARD TO

INSHORE HYDROGRAPHIC WORK

OF THE

COAST SURVEY.

1878.

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1878.

Carefully study and strictly follow these

GENERAL INSTRUCTIONS

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INSHORE HYDROGRAPHIC WORK OF THE COAST SURVEY.

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1. The following general instructions must be observed by the hydrographic parties of the Coast Survey. The judgment of the chief of each party is the best guide in the arrangement of the detail's of the work, to be exercised under such general instructions as may tend to promote uniformity in the methods of working, and in presenting the results. The instructions will be presented under the heads of — I. THE PROJECTION; II. SOUNDINGS ; III. TIDES; IV. TIDAL CURRENTS; V. CURRENTS; VI. MISCELLANEOUS OBSERVATIONS; VII. PLOTTING OF WORK, ETC., DURING THE SEASON; VIII. SPECIAL OBSERVATIONS OF TEMPERATURE, ETC.; IX. OFFICE WORK.

I. THE PROJECTION.

2. As a rule there will be furnished from the office, with the instructions to chiefs of hydrographic parties, one or more projections,* upon a scale determined by the Superintendent, covering the area to be gone over in the hydrography. Upon these projections will be given the shore-line, if surveyed ; the positions of all triangulation-points falling within their limits, and of any objects or features, topographical or artificial, such as buildings, light-houses, forts, &c., which have been fixed by the plane-table or otherwise, and which may be useful in the execution of the hydrography. A triangulation point is indicated by a point inclosed in a triangle, thus, △; the point occupies the position of the exact center. All other points are indicated by dots inclosed in circles, thus, ⊙

* In the rare instances where the hydrography precedes the triangulation the sheets will be constructed upon rectangular co-ordinates.

3. Rules and tables for constructing projections will be supplied by the office as soon as printed. Should it be necessary for the party to make its own projections, application must be made to the Office for data with which to locate upon the sheets the triangulation-points. The data will be furnished in tabulated form as in the following example:

Station.	Latitude.	D.M.	Longitude.	D.P.	Distance.	To station.
	° ′ ″		° ′ ″			
Spar	34 02 29.96	830.6	77 52 48.17	1235.5	759.2	Fox.
					1623.1	Pilot.
Barrow	34 02 19.84	611.3	77 53 11.89	304.9	646.5	Spar.
					881.4	Fox.

4. In the above table the "D.M." and "D.P." are simply the stated seconds of latitude and longitude, respectively, reduced to meters, the parallels and meridians being projected upon the sheet for each minute. In the sixth column are given, in meters, the distances of each station from at least two other stations, to be used as checks in plotting.

5. There will be furnished from the office, with the projection (or with the data, as above), a description, and generally a sketch of each triangulation-point, showing the manner in which it has been marked, and the bearings and distances of any objects near at hand, by which its location can be found. For a full description of the objects used as surface, subsurface, and witness marks for preserving the locations of stations, see "Methods, Discussions, and Results of the Field-work of the Triangulation, by R. D. Cutts, Assistant, Coast Survey, 1877."

6. Great care should be exercised, when building signals over stations, not to disturb the objects used as marks, and in no case should that used as the *center* be moved in the slightest degree; this remark does not apply to a surface-mark over a subsurface center, as in some cases the surface-mark must be moved in order to expose the subsurface-mark, and thus make sure of getting at the true center. Should this be the case a plumb-bob must be suspended exactly over its center before moving it so that it can be replaced. The surface-marks, both center and witness, are often of perishable material, and if found rotted away should be replaced by similar objects, the greatest care being taken to preserve the same positions. A note should be made in the book referred to in paragraph 10, of any marks renewed, and a report of the same sent to the of-

fice. In the same book should also be recorded the condition in which the marks of each point are found, or if any are not found, the fact and the probable reason should be stated. Be particular to state whether the center and the witness-marks are found. It is thought that a witness-mark has occasionally been mistaken and used for the center.

7. It will often happen that many more points are given upon the projection than are needed for erecting hydrographic signals; this enables the chief of a party to use his judgment in selecting such as are best located for his work, or in case some of these are lost, to relocate them.

8. Before selecting stations for erecting signals, the chief of party should make a reconnaissance, carrying with him a tracing or, preferably a transfer, say upon stout c*artridge-paper,* of his projection. As soon as the points are chosen, search should be made for the exact locations of those first needed, and, if recovered, the signals erected over them. A shifting shore-line, traveling sand-dunes, the operations or maliciousness of men, &c., occasionally cause the disappearance of station-marks ; it will rarely occur, however, that some of the points cannot be recovered, and any two that are intervisible may be used as the extremities of a base for redetermining stations. It may be that the base is unfavorably located, is too short, or even too long, or that it lies in a wrong direction; these difficulties may generally be overcome by the establishment of intermediate points. A signal, or object used as such, will be fixed with sufficient accuracy for hydrographic purposes by obtaining lines of direction (commonly called "cuts") passing through it from two or more already established points. A cut is obtained, it need hardly be said, by measuring at any established point the horizontal angle between any other known point and the object to be fixed. The cuts should intersect upon the required point at an angle of not less than 30º nor more than 150º.

Erecting and fixing signals.

9. When the lines are not too long, ordinary poles answer well for *signals* to observe upon. Flags with contrast of colors, as black and white, red and white, red and green, or entirely white, or of one bright color, serve to increase the visibility of the signals. Experience has shown that the best signal to be used in a boat or vessel is the *Dutch flag*—blue, white, and red,

in horizontal stripes, or black in place of blue. The flattering of the flag will often attract the eye when the colors do not. The flag should be square, and should be slashed with a knife to make it useless for other purposes, so that it may not be stolen. When the lines are long, tripods built around the signal-poles afford good marks; the sides of the pyramids which are to be observed upon are covered with rough boards, a foot apart, from near the apex, half-way or more to the ground.

They should be *whitewashed,* if showing against woods or dark ground; and *blackwashed,* if showing against the sky or light ground.

Drift-wood, where it is to be found, small trees and saplings cut from the woods, and barrel-staves for boarding up, will be found to serve a good purpose in building signals, and will save lumber and transportation. Where two signals are near enough to each other, or so similarly located that one may be mistaken for the other, they should be varied in form and appearance so as to prevent the possibility of mistake. It must be remembered that the danger of mistaking a signal is much increased when it is seen by reflection. In order to save both time and material in boarding up and white or black washing a signal, the directions from which it will need to be visible should be kept in view. Light-houses, beacons, spires, prominent chimneys, the apexes of the gables of buildings, flag-staffs, lone trees, isolated rocks, and many other objects, natural or artificial, will, if conveniently located, serve an excellent purpose as hydrographic signals ; and if any such occur which are not already upon the projection, they should be "cut" in and plotted. An object may also be fixed by the *three-point problem by* occupying its center; in such case, as a check, three angles, or even a *round** of angles, should be measured if possible.

10. It is generally intended that the work of triangulation should so far precede the hydrography that the use of the signals by the triangulation-parties should have terminated before they are required by the sounding parties. Sometimes, however, this is not the case, and then the tripods for sounding should be erected independently of the triangulation-signal, not touching it in any part, and the slats being so arranged as to allow a view of the cone, the upper third and base of the pole if a

* By a round of angles, is meant a set composed of the angles between consecutive pairs of objects around the circle to the starting-point; it will be understood that one object is common to each two pairs.

signal with a pole in the ground, or if a tripod-signal, to allow a view of the crotch of the tripod and of all above it. As the wind often causes these boarded tripods to lean, a sufficient interval should be left between them and the signal to prevent their touching in such a case. It is understood that the axis of the sounding-signal should be the same as that of the triangulation-signal. Careful descriptions of all the signals should be made and recorded in the book, to be entitled "Descriptions of signals."

11. Triangulation by vessels, or buoys, when desirable, will be the subject of special instructions.

Naming signals.

12. A signal, which is erected exactly upon a triangulation or other previously-fixed point, should bear the name already given to that point. If *near* but not exactly *upon* an old point, either give a new name to the signal or the old name with "No. 2," or the date, as "*Spar* No. 2," or "*Spar* '78." In giving new names to signals, those, if possible, should be selected which are suggested by the locality, the appearance of the signal, or by any incident which happens when it is being built; this in in order to impress the names upon the memory. Short names are best.

Angle-books.

13. All angles taken for fixing signals must be entered in an angle-book, which, together with other note-books, will be furnished from the office on requisition by the chief of party. The angle-books are arranged for recording both the angles observed for locating signals and those taken from stations on shore for fixing, from time to time, the positions of a vessel or boat when sounding. (See paragraph 32 a.) In recording for the former purpose, the columns headed "Time" and "No.," respectively, may be disregarded. The following should be carefully noted at the beginning of each set of observations, viz: 1st. The locality; 2d. The date; 3d. The name of the observer; 4th. The instrument used; 5th. The name of the recorder. The columns should be filled as per heading. In the column of remarks should be named with each set of angles the object or objects to be fixed by those angles. The words "ditto" and "same" should never be used in making entries. If angles taken at any one station, or for fixing any one point, have to

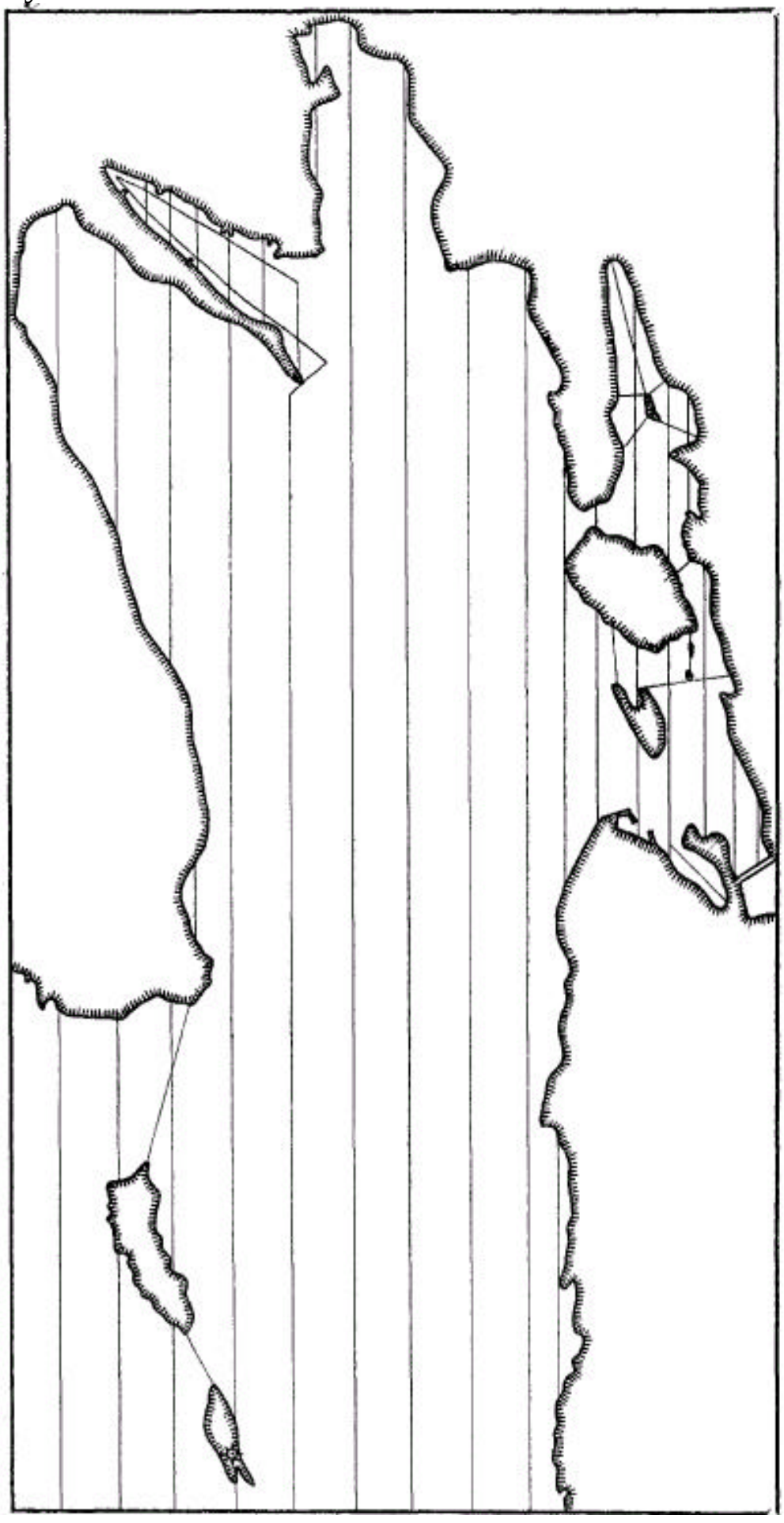
be carried over to a new page, the name should be repeated in its proper column and the word "continued" added. This saves much time to the draughtsman and computer in using the records. *It should be the study of each officer to make every page of his note-books as complete and clear as possible in information, so that no referring back will be necessary.* There are very wide differences in this respect among the books of different parties as received at the Office.

14. In running lines of soundings it occasionally happens that a new signal has to be established. In such a case the angles observed may be entered, with notes giving their object and the *name* of the new signal, in the sounding-book, but they should be transferred to an angle-book upon returning to the vessel. When sounding in boats, the foremast of the vessel may frequently be used to advantage as a station, care being taken that she is anchored with a short scope, and that the direction in which the vessel swings is noticed; if a long scope is used, great care must be taken in reference to the last-named observation.

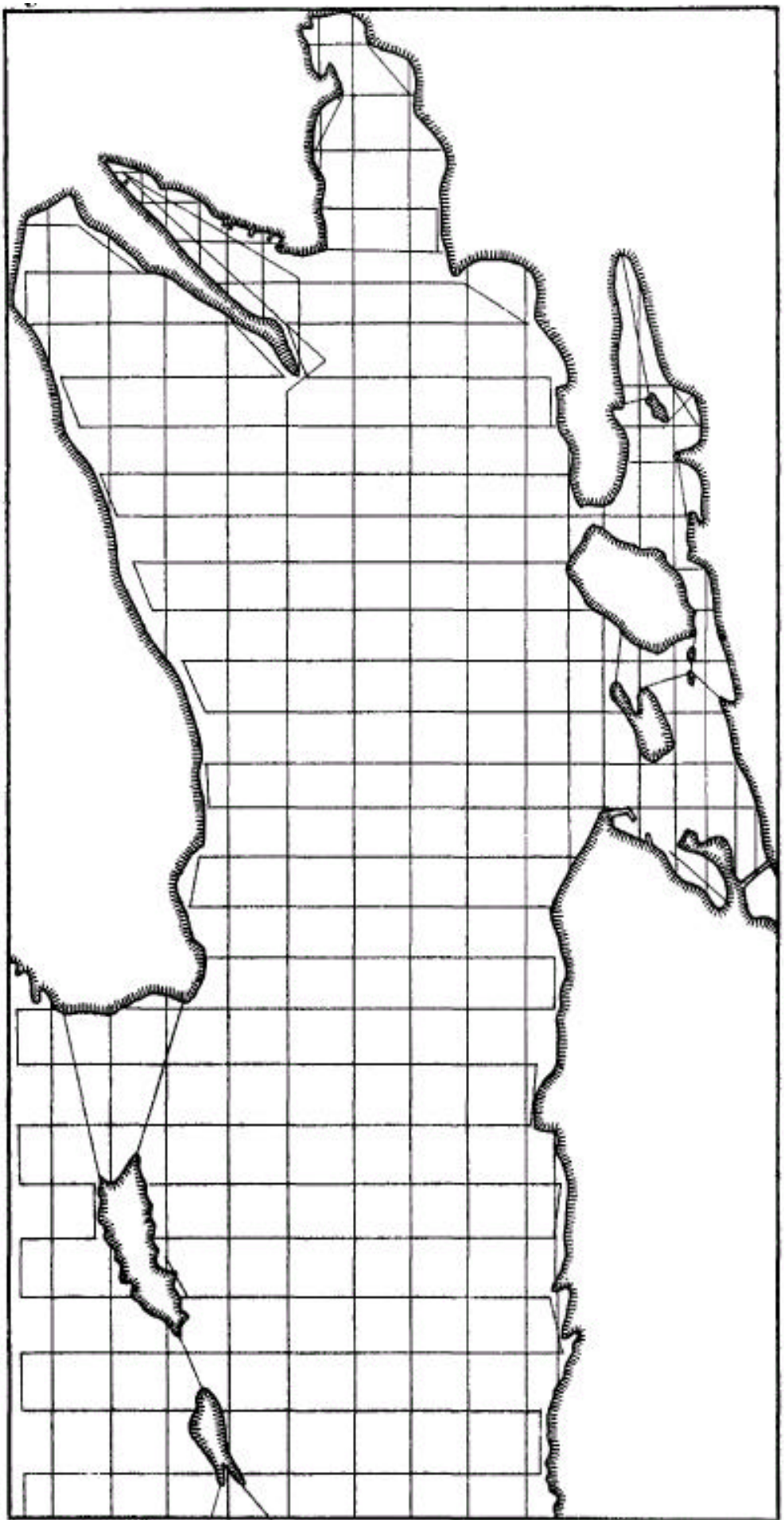
II.—SOUNDINGS.

15. The depths of water are given upon the marine chart not only for the purpose of indicating to the navigator the hidden dangers which he must avoid, but also to reveal those general characteristics in the configuration of the bottom, which may enable him, by casts of the lead, to recognize his position or the course that he is making. With this twofold object in view, the hydrographer should so plan out his work that the exact positions and magnitudes of the dangers may be made to appear, and also the undulations of the bottom. If the dangers are rocks, sunken wrecks, or other abrupt obstructions, he will make their examination a separate study from the general survey; but where these dangers consist of alluvial shoals he may develop them in connection with a general system of gauging over the entire field, using the lead and line or pole as the land-surveyor uses his level and rod to measure elevations and depressions, and arranging his courses very much as the land-surveyor would do in *contouring* a country. There are several systems for running lines of soundings by which the surface of the bottom can be economically and thoroughly developed, each to be used in accordance with the character of that surface and the minuteness of the work required. Several of these are here given.

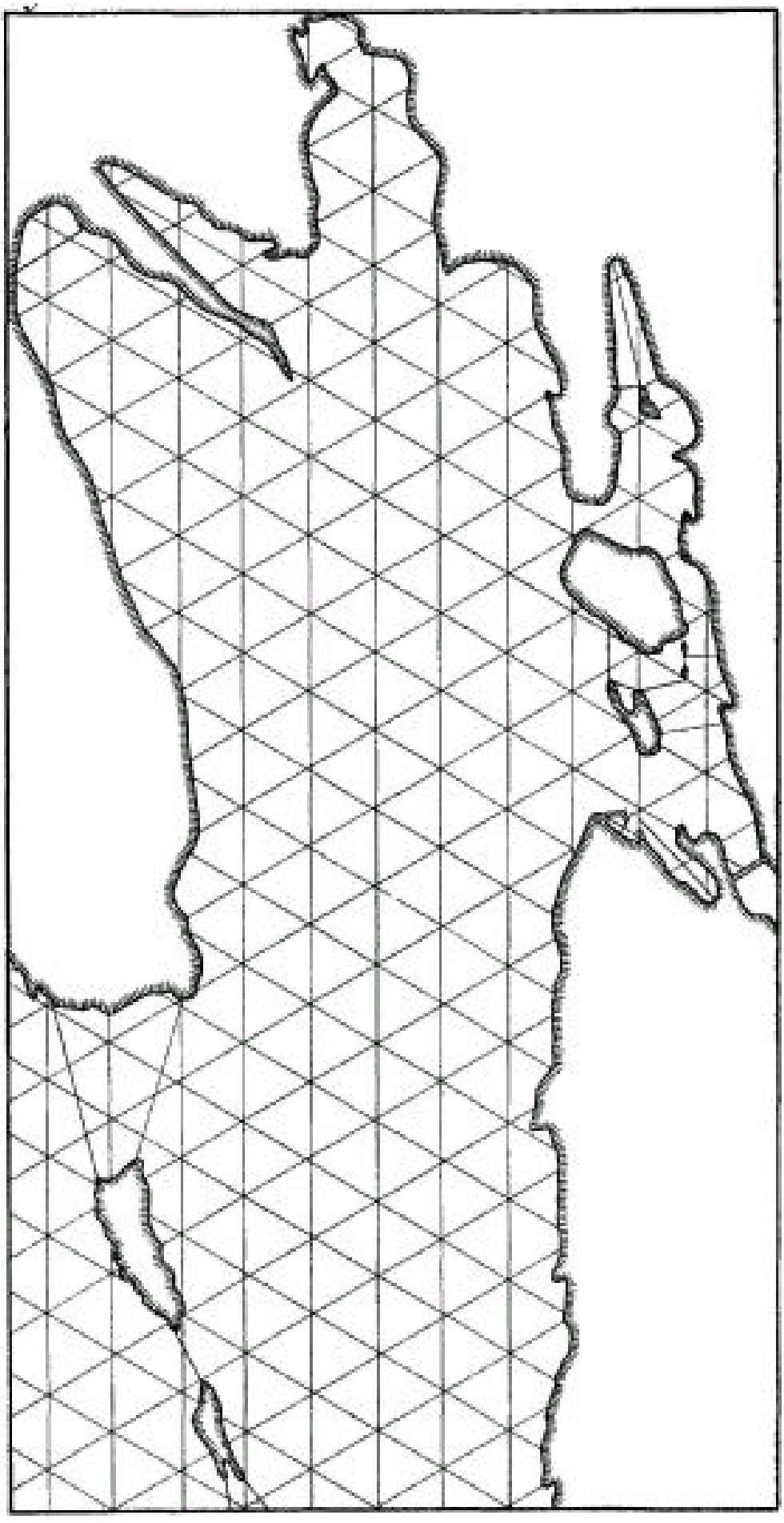
System a



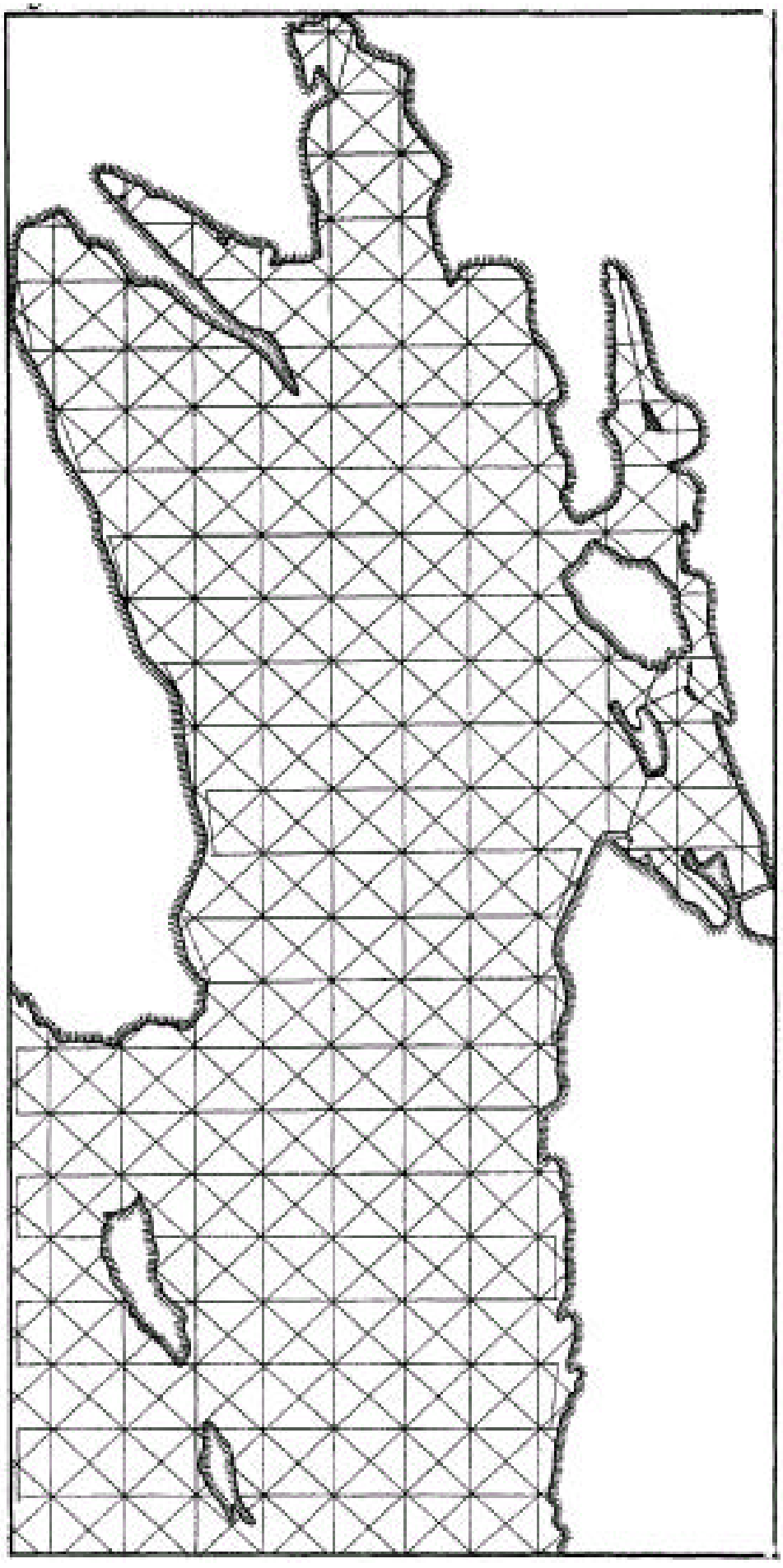
System b.



System c.



System d.



a. The most simple is a set of lines normal to a coast, direction of a stream, or line of shoal, at such distances apart as the locality may require.

b. A system of lines normal to the coast or general direction of a bay, river, &c., with another system at right-angles to these: the first giving the longitudinal slope and irregularities, the second giving cross section. This system cuts the field into rectangles, and is often used.

c. A system of double lines, running each at an angle of 60° to the line of the coast or 30° to the general direction of the river, bay, &c., making angles of 60° or 120° with each other, with another system, parallel to the coast, or normal to the direction of the river, bay, &c., crossing the first system of lines at their intersections, so that each of the angles at the point of intersection would be equal to 60°; all the triangles thus formed by the intersecting lines being equilateral triangles. This system will give the best results with the fewest lines, and has been successfully used. (See plate.)

d. The system *b*, with another similar system at an angle of 45°; the two systems having common points of intersection. This system divides the space into right-angled triangles, and has been used successfully where minute work is required with large plans.

16. The judgment must be exercised as to the system to be used at any given locality, the distance of the lines from each other, and hence the size of the spaces not occupied by soundings, so as to omit no important determination. In the system *a*, there are no means by which the position of the soundings can be verified; in the system *b*, these positions are verified at the intersected points of two lines; in the system *c*, of three lines, in the system *d*, of two lines and of four lines.

17. In very large plans for expensive improvements of very irregular reefs, other systems, still more minute, in which a sounding is determined upon almost each square foot, are used. No one general system of lines is sufficient for the development of every irregularity of bottom or of spaces between islands ; therefore special systems of lines must be used.

18. In making a reconnaissance, or in making a rough survey of an unimportant water-way, zigzagging may be resorted to in order to save time; but, even in this case, *the alternate courses should be normal to the stream in order to furnish cross-sections.*

19. The best test of the sufficiency of the data supplied by a

hydrographic survey is to ascertain if the curves can be drawn for all depths, without leaving doubt as to their directions anywhere. For purposes of navigation, it will be sufficient, generally, that these curves should be traced for every fathom up to three fathoms; the determinations to the farther depth of five fathoms aiming to be good to fractions (say tenths) of a foot. Beyond this depth, greater latitude, is allowable; fractions of a fathom, or half fathom, or even whole fathoms, in deep-water work, taking the place of fractions of a foot. In particular cases, when the figure of the bottom is very irregular, it may be desirable to draw half-fathom curves, or even curves, to every foot of depth, within the limits before stated. Observations made expressly for the purpose have shown that, in the smooth water and moderate depths of harbors, the difference between lines of soundings at their crossings should not exceed, in depths of 15 feet and under, two-tenths of a foot; between depths of 15 and 30 feet, three-tenths; 30 and 48 feet, five-tenths; between 48 and 72 feet, three-fourths of a foot; between 72 and 96, one foot and a half; and between 96 and 150 feet, two feet. In the sea-depths the limit of error should not exceed 1 per cent. With proper care and close attention, these limits of error are quite attainable.

20. As the direction of the line which is possible depends upon the direction and force of the wind, the currents, and the qualities of the vessel, the problem is to run such lines as may be practicable under the circumstances of the case, and as may best exhibit the form of the bottom; increasing the *number of casts* on a line, and of *lines* in a given space, with the general slope and irregularity of the bottom at a given depth, and with the shoalness of the water up to the limit of depth of, say, six feet in approaching a shore, or three feet upon a detached shoal. The test referred to in paragraph 19 becomes of the more importance that so much must be left to judgment in the matter.

21. *Diagrams* of the work laid out, corrected to represent the actual working, will be an aid to the chief in planning or reviewing work, and to his subordinates in executing it.

22. When shoals or slopes are run by zigzags, crossing the horizontal curves nearly at right angles, these lines should in every case be intersected by others in the general direction of these curves.

The lines upon the edges of shoals, run both in the direction of the curves and normal to them, should be executed with

extreme care, and under favorable circumstances as to slackness of current, smoothness of water, &c., as a *small* error in *position* on the steep slopes of shoals gives a *large* error in *depth.*

23. The directions of the lines which it is desirable to run having been determined, the *frequency* of the *casts* to be made depends, of course, upon the greater or less irregularity or greater and less slope of the bottom. The casts should be so frequent as to give the fraction of a foot, half-fathom, or fathom, according to the depth of the water (paragraph 19).

24. When the *bottom* is *rocky,* or when detached rocks are known or suspected to occur, the precautions in sounding should, of course, be much increased. Information should be obtained from all available sources, especially from charts or books, from the oral information of pilots, fishermen, or ship-masters, and every place where rumor has even supposed a rock or shoal to exist should be examined. The method of trolling for rocks should, in such cases, be resorted to, using the deep-sea line in a single boat, or a sunken line, net, or chain, with two boats or vessels. An inclined rod, or bars of iron or copper, with one end-piece at right angles to the rod, might be used with advantage in trolling; one end of the rod being attached near the bow of a vessel or boat, and the cord being attached near the other extremity, so as to pass at right angles to the rod, from near its lower end, to the stern-sheets of the boat or any convenient part of the quarter-deck of the vessel; several such rods might be worked from the vessel at the same time by attaching them to outriggers. In sweeping, always do so in the direction of the dip of the strata, which can be generally determined by the adjacent rocks above water. The line or chain is more apt to catch against the steep than along the sloping side. When a reef or shoal is found, its limits should be determined as carefully as possible, and it should be examined very thoroughly for projecting rocks. Rocks and reefs which appear on a cursory examination to be detached are often connected, and it is desirable that the connection should be traced. The rocky features of the land will often afford useful hints to guide in these determinations.

Whenever the soundings on a line indicate a shoal or reef, the spot should be subsequently visited and thoroughly developed. A sounding showing even but very little less than the average depth should be regarded as the indication of a possible shoal, much more so when two such shoaler soundings are

found on contiguous lines; the space between them should be carefully sounded by zigzags, going far enough each way to cross the lines already run, keeping in mind the irregular outlines often assumed by shoals. Too much care cannot be exercised in executing the particulars of this and the following paragraphs.

SPECIAL DEVELOPMENT OF REEFS, SHOALS, BARS, AND CHANNELS.

25. In running lines to determine a reef with a single high point or surface, a buoy is generally placed on the highest point, and radial lines run from this; but it is obvious that this gives a very imperfect idea of the shape of the reef, as the lines diverge rapidly from each other. New lines should be introduced, therefore, between the first radial lines as they recede from the buoy. If the reef has more than one high point, several buoys placed upon them will give the means of laying out upon a diagram and of executing by sounding, a regular plan of work which will show the peculiarities of the reef, multiplying the soundings where the slopes are steep or the irregularities great.

Minus Soundings.

26. All shoals and flats bare at low water should be sounded over at or near high water, and the heights above the plane of reference given just as are the depths below that plane. These heights will be plotted on the chart as *minus soundings, i.e.*, the heights in figures will be plotted with the minus sign before each. It is obvious that the minus soundings will be obtained by subtracting the actual soundings from the amount of tidal reduction (*i.e.*, the height of the water above the plane of reference) at the moment of each. In general, whenever a sounding is less than the amount of reduction at the same moment, the difference should be plotted as a minus sounding. Until the work is sufficient to execute a model of the reef, it cannot be considered sufficient for any minute purpose, though it may be adequate to general purposes of navigation.

27. When the survey of a shoal or rock is finished, care must be taken to note upon the spot all ranges, bearings, and marks which lead over it, or close to it, on every side. Lines of soundings should be run on all ranges that may be used for marking channels.

Channels and bars.

28. The development of channels when the depths in the fairway are less than five fathoms, and that of *bars*, if there are any, which obstruct the fairway, are of the utmost importance, and should receive the close personal attention of the chief of party. After the lines are plotted and the curves drawn in, he should carefully trace out each channel, and assure himself that no soundings are missing needed to show exactly how much water can be carried throughout its whole extent, causing extra lines to be run where there is the least room for doubt. Should he find indications of a bar, he will cause a further examination to be made to develop its form and extent, and to make sure of having found the least depths upon it. The first will be accomplished by running several lines close together in the direction of its general trend, spreading upon either side from deep water to deep water, and running transverse lines where there seems to be any break in the bar, until all doubts are removed.

The least water will be determined by going over the whole bar with a sounding-pole. This last work need not necessarily be recorded if no depth is found less than that already obtained; but a note should be made in the sounding-book, giving the character and extent of the examination. Notes of this kind should always be so full and explicit as to convince a stranger of the sufficiency of the work. Make also a note as to breakers, if any, upon the bar, giving their extent, with what winds they occur, at what stages of the tide they make and cease, and how nearly and from what directions they may be approached. It is in matters like those detailed in the last two paragraphs that the skill and judgment of the hydrographer are most required and best exhibited.

Sounding leads, lines, and poles.

29. It is unnecessary to say anything in regard to the usual sounding *leads* and *line*. A pole must be used instead of the line when sounding in shoal water (fifteen feet or less), and when the bottom is muddy, a disk may be placed upon the lower end of the pole to prevent it from sinking below the surface of the bottom. The line and pole must be conveniently marked to meet the conditions of accuracy noted in paragraph 19.

The length of the line should be ascertained from time to time, especially when beginning to use it for the day, in the

middle, and at the close of the work, by reference to a measured length upon the gunwale of the boat or upon the vessel; and the comparisons should be recorded in the note-book, to be used in reducing the results, if necessary, and if not, as records that the comparisons have been made.

Character of the bottom.

30. The *character* of the *bottom* should be ascertained so often as to test its changes; the specimens being brought up by one of the instruments contrived for the purpose. Such specimens as are characteristic of the bottom should be carefully preserved, the places where, and dates when, they were obtained marked; and when obtained, or subsequently, they should be placed in small quarter-ounce wide-mouthed vials, with marks referring suitably to the place and date of procuring them. Their appearance should be described when wet, and afterward when dry. Each specimen-bottle should bear a label of the approved form, giving all the particulars in regard to the place were it was obtained. One set of specimens should be selected corresponding to the different kinds of bottom noted, and serving as types in the nomenclature. For instance, a set of specimens should be selected as representing coarse sand, fine sand, coarse gray sand, fine gray sand, coarse sand and shells, fine sand and black specks, pebbles, &c. *It is designed to classify these specimens so as, if possible, to trace the formations along the coast in which particular kinds of soil occur ; also to submit them to microscopic examination.* The information, therefore, in regard to them should be as minute as possible ; and, especially, it should be recollected that the navigator will see them when wet, and that they may change their appearance in drying so that the original aspect may not be restored by again wetting them. Apparatus for bringing up specimens of bottom will be furnished from the office.

31. The judgment of the chief of the party will decide when the work of sounding is to be executed from the *vessel* or *in boats*, or both, and the number of boats to be worked, and similar questions.

Locating lines of soundings.

32. There are three methods in common use for locating the lines of sounding, so that they may be plotted accurately upon the chart. Of the three methods, that by ranges is the most

ready, especially for sounding in boats for short lines, where the taking of angles may be dispensed with. By the use of a watch, making the soundings by intervals of time, and timing the whole distance, great accuracy may be obtained. The observations of angles, from the boat or vessel, upon three signals (the *three-point problem),* is perhaps the most useful method for general purposes. The frequency of the measurement of angles will depend upon the importance of, and the supposed accuracy with which the line can be run, and the use of the watch will reduce the number of measurements necessary. When sounding in boats, the foremast of the vessel may frequently be used to advantage as a station, care being taken that she is anchored with a short scope, and that the direction in which the vessel swings is noticed; if a long scope is used, great care must be taken in reference to the last-named observation.

a. In work along the coast, in deep water of harbors, or where the currents are strong, it is convenient to place two observers at *shore-stations,* as upon light-houses or temporary tripods, to measure angles upon the vessel, while for verification the angle at the vessel is also measured. The signals for observation are generally given from the vessel by dropping a flag. Along the coast, the signal at the mast-head of the vessel is often easily distinguished even when the shore-stations cannot be seen from a convenient place of observation in the vessel. In certain cases, the measurements of angles should be made at stated times; the watches of the observers and the vessel being frequently compared, and their rates allowed for. (See paragraph 52, *et seq.*)

Instruments.

b. In all measurements of angles, *reflecting-instruments* have hitherto been used, and especially, as being the most portable, the sextant. Simple *theodolites,* graduated to half-minutes, have been found very useful for measuring angles from shore-tripods or from light-houses. These are commonly known as *hydrographic theodolites.*

Record of soundings.

33. Printed forms for registering soundings are issued from the office, bound, like those for angles and tides, in books of a width of one-half the sheet. Special attention is called to the

headings of the columns and other memoranda, and the greatest care should be taken to make all entries as complete as possible. It should be borne in mind that *only such work is accepted at this office as can be plotted from the data furnished by the party, and without the assistance of any member thereof.* Many things which are perfectly clear to an observer, having the work fresh in his memory, may not be so apparent to a stranger; therefore the necessity of making complete notes with each day's work, and recording everything which would aid a stranger in thoroughly comprehending the subject.

34. *In every case the original notes are the only authentic record of work. Duplicates are required of all original hydrographic notes.*

35. At the beginning of each day's work should be entered, in the sounding-book, the names of the observers, recorder, and leadsman; and should any of these be relieved during the day a note should be made in the column of remarks at the time it occurs. If there are two observers, state which takes the right-hand and which the left-hand angle.

a. At the head of each page give, 1st, the locality; 2d, the name of the vessel or boat employed; 3d, year, month, and day of the month.

b. In the column headed "Time," should be given at the top of each page, and opposite each note of position, including those of the beginnings and ends of lines, the hours, minutes, and seconds, as shown by the watch or boat-clock; and in the same column, between each two positions, the intervals at which soundings are taken. If soundings are taken at irregular intervals—as for example on the slope of a shoal—note the minutes and seconds at each cast.

c. The column for soundings, it will be observed, has two subheads, viz: "Fathoms and feet," and "Feet and tenths." If the soundings are being recorded in fathoms and feet, a line should be drawn through the words "feet and tenths," and *vice versa*.

d. The columns headed "Reduction for tide " and "Reduced soundings," respectively, are filled subsequently.

e. The character of the bottom should be noted at the head of each new page, and at each change reported by the leadsman, making the entry opposite that of the sounding at which the change was observed.

f. In the column headed "Angles and ranges" are to be

recorded all angles and ranges taken from time to time to locate the vessel or boat together with the names of the objects observed upon, the entry to be made in each case opposite that of the sounding taken at the same time, and a check made opposite the sounding itself; or if the angle or range is taken between two soundings, place the check just above the second to show the fact.

36. Positions, whether by *angles*, *ranges*, or merely by *time*, are numbered in one series for each day's work; the number is inclosed in a symbol like that for square root.

37. Angles are recorded by writing, first, the names of the right-hand and middle objects, and the angular distance between them, then the names of the middle and left-hand objects and their angles, thus:

√ *Spar to Barrow.*
27° 13'
Barrow to Top.
53° 18'

NOTE.—The word "*to*" should be used between the names, and not "*and*," as the right-hand object is reflected to the left-hand object.

38. A range is indicated by writing upon the same line the names of the two objects in transit and to the right of them three *zeros* with a line drawn through them, thus:

Spar and Stub, ~~0 0 0~~

which means that *Spar, Stub,* and the vessel or boat are, at the moment, in the same straight line.

39. An angle and range taken simultaneously, give, probably, the best determination of position (with the possible exception of intersecting ranges). The entry should show whether an object on the right was reflected to the objects in range, or whether the objects in range were reflected to one to the left, thus :

Spar to
Barrow & Top, ~~0 0 0~~
29° 15'

or

Spar & Stub, ~~0 0 0~~
to
Top
34° 48'

The names of the objects observed upon should be written out for each position, when even the same objects are used for consecutive positions. The not uncommon practice of writing "ditto" or "same" instead of repeating the names of signals is very objectionable.

40. In the column of remarks should be stated, as well as it can be described in words, where each line begins (the lines being numbered consecutively for each day); the course steered in running the line; any change of course at the time it occurs; the force and direction of the wind; the state of the sea, whether rough or smooth; the force and direction of the current, if any; the bearing and estimated distance of any object passed by the boat, and which is plotted on the projection; where the line ends, and any other information which will facilitate or check the plotting of the work.

41. The direction in paragraph 27 to examine at least three times a day the lead-line should be carefully attended to, and a note made showing whether it is found correct, or, if not, how much shrinkage upon one fathom, upon two fathoms, upon three fathoms, and so on up to the greatest depths recorded since the last previous trial of the line.

42. If a pole is used, state the fact at the beginning of each day's record.

43. As a matter of convenience, the sounding-books used by the vessel and by each boat should not be interchanged. Each boat will require at least two books, so that one may go out while the other is in the hands of the draughtsman.

Lettering the day's work.

44. To save space in plotting upon the sheet, each-day's work is known by a letter; the vessel and each boat should have a separate series, distinguishing them by using capitals for the vessel, and lower-case letters of different colors for the boats; these distinctions to be preserved in the books, on the sheets, and in the table of statistics. For convenience of reference all the letters used in each book should be given on the outside of the covers; much time is thus saved for the draughtsman.

Running the lines.

45. The signals being established, or a sufficient number of them for immediate use, and *the tide-gauge set up,* the next

step is to begin the lines of soundings. The judgment of the chief of party will be required in so laying out the work with reference to the anchorage of the vessel, and in shifting the anchorage to suit the work, as to give the least distances to be passed over in going to and returning from work, not only to prevent loss of time, but to save coal if steaming, and the strength of the men if pulling. Having determined, with reference to the state of the tide, wind, sea, &c., where the line is to begin, the vessel or boat is placed at that point. The observers, recorder, and leadsman take their places; the officer in charge will tell the recorder what note to make for fixing the beginning of the line. For example, "line No.1 begins 10 meters from shore, abreast signal 'Spar' running south;" or, "line No. 1 begins at √, 30 meters from shore, running east." It is always desirable to fix by angles the beginning of a line, but when from being under a high bank, or for any other reason, the signals are not visible for the purpose, some other note should be made, as above, and angles taken as soon as it can be done. The leadsman will get a cast, the recorder will note the time, and the vessel or boat will start.

Sounding at fixed intervals.

46. As a matter of convenience, as well as to insure accuracy in plotting, the soundings should be taken at fixed intervals of time, the intervals to be determined by the officer in charge; they will of course have to vary with the depth of water. When the depths are changing very rapidly—as for example, upon the slope of a shoal—it may not be possible to sound at fixed intervals; in such a case the time of each cast should be recorded. (See paragraph 35 *b*.) It is generally the case that many more soundings are taken than can be plotted on the sheet, which is desirable, as we are thus enabled to select the characteristic soundings, and if at any time it is required to replot the work on a larger scale the extra soundings will come in play. Whenever it is decided to change, the interval angles should be taken, so that the interval may be uniform between each two determined positions. If running by time on a range, note the time in its proper column and place opposite to it the number of the position in its symbol. The recorder, watching his clock, should give the word "sound" in time to let the leadsman get his cast just as

the interval is up. The boat or vessel should be kept at a uniform speed, not too fast to allow the leadsman to get good up and down casts.

Angles for position.

47. Angles for position should be observed often enough to insure the line's preserving its direction, and also whenever any marked change of depth occurs. The officers and coxswain should watch for ranges about to come on, and an angle should generally be taken with each range. When a change of course occurs for any reason, the position should be determined, the end of a line should be fixed and described as in the case of the beginning.

48. There is room for the exercise of considerable judgment in selecting objects to observe upon. Some positions of the objects with reference to the observer giving very favorable, some very unfavorable, angles, and others, all shades between. The case commonly called a "revolver" is that where the observer and the three objects observed upon are in the circumference of the same circle, or pretty nearly in it; the position will then plot in any part of the circumference. *A good general rule to follow is to have the middle object nearer to the observer than either of the outer ones.* The most favorable position is where the observer is within a triangle whose vertices are occupied by the three signals.

Points to be carefully noted.

49. Reference has already been made to the necessity of recording the state and direction of wind, current, and sea. In noting these, great care should be taken to mark the time of passing from sheltered to exposed positions, and the reverse, or from a current to an eddy or into still water and *vice versa.* Note the crossing of tide-rips, and give their trend. Squalls and lulls should be noted if the speed, steering, or drifting of the vessel or boat is at all affected by either. The positions of whirlpools should be carefully noted.

50. When there is any reason to suppose that the shore-line has changed since it was last surveyed, careful angles should be taken at various points, and the intermediate line sketched in.

51. If, as occasionally happens, the hydrography precedes the topography the shore-line, should be put in as above, but should be plotted on the sheet in pencil.

Fixing the position of the vessel by angles from on shore.

52. When employing the method referred to in paragraph 32a, i.e., that of fixing from time to time the position of a sounding vessel or boat by angles taken simultaneously from two established points on shore, the records of angles will be kept in the angle-books already referred to, while the soundings will be noted as usual in a sounding-book; three note-books will thus be required for the complete record.

53. The instruments generally employed in this method are the *hydrographic theodolites* issued from the Coast Survey Office, though sextants may be used if necessary.

54. It is preferable, though not absolutely necessary, that the stations of the two observers be intervisible. Each will take the angle between the station of the other and the vessel or boat. If using a sextant, this angle may become too great, when any other fixed object may be used. When a sextant is used the name of the *right hand or reflected* object will always be named first in noting the "objects observed." The theodolites are graduated from left to right, from 0° to 360°, consequently, if using a theodolite to measure the angle between two points, the *left-hand* object must be first named. This illustrates the necessity for mentioning the instrument used at the beginning of the record of each set of observations.

55. The hydrographic theodolites, not being *repeaters,* cannot be set conveniently with their zeros upon any required point. It will be most convenient, therefore, for each observer to set his zero to the left of his left-hand object, the one who sees the vessel to the left of the fixed point to which his angles are to be referred setting his zero to the left of any position the vessel can take during the day. Each will then turn his telescope upon his fixed object and record the reading of his instrument, and will cut upon the vessel in the same way for each required position. What he actually records will thus be in each case the angular distance of the fixed point or of the vessel from the zero. The angle between the point and the vessel at any position will obviously be obtained by a simple subtraction. It will be easier in practice, however, for the draughtsman to lay down lightly with pencil upon his sheet the zero-line, or, what amounts to the same thing, a point of that line, and to protract his angles from that zero.

56. It will not be necessary to record the cut upon the fixed

object oftener than, say, at the head of each page, but the observer should frequently turn his telescope upon it to make sure that his zero has not moved.

57. A *time-ball* on flag will be shown from the vessel each time that a position is required, and the angles will be observed *at the moment when it is dropped.* Each observer and the recorder on board the vessel will carefully note the *time* as well as the *number* of the position. It is desirable to observe on board the vessel or boat the angle between the two fixed stations at each position.

58. *If observing by time only* arrangements should be made for dropping, as often as the vessel comes near enough, a *time-ball* for comparison of clocks or watches.

Special note.

59. On the books being brought together at the end of each day's work, carefully note on every page of each the numbers of the pages of the other two on which simultaneous work is recorded. As, for example, say on a given page of Angle-book No. 1, note——

"Angle-book No. 2, p. 13.
Sounding-book No. 6, pp. 18, 19, 20, and 21."

III.—TIDES.

Terms used.

60. The word *tide* should be used exclusively for the vertical movement of the sea; and when the horizontal motion is referred to in the field-book, it should be called the *tidal current.* The words *rise* and *fall* should be used in referring to the tide, and the words *flood* and *ebb* in referring to the tidal current. The word *stand* should be used specifically for the period of time, at high or low water, when no vertical change can be detected; and the word *slack* for the period of time when no horizontal motion can be detected. *Set* and *drift* are terms applicable only to the tidal current, the first for *direction* and the second for *velocity*. The *range* of the tide is the height from low water to high water. This term is usually applied to the average height; but upon the Coast-Survey chart the expression *mean rise and fall* replaces it.

Plane of reference.

61. The *plane of reference* is the datum plane to which the soundings upon a chart are reduced, and this datum plane for Coast Survey charts has been fixed at *mean low water*.

62. The immediate object of observing tides in connection with a hydrographic survey is to determine this *plane of reference*, and furnish the means for reducing the soundings to this plane. The tides, however, are observed also for the purpose of supplying the data necessary to construct a tide-table for the chart. Continuous observations of tides are necessary while the soundings are being made, and in order that the plane of reference may be determined closely and the elements of a tolerable tide table procured, the observations of consecutive high and low waters should be carried through an entire lunar month; or, if it be impracticable to observe tides at night, the day-tides of two lunar months may be substituted.

63. The tides are subject to so many variations dependent upon the movements of the sun and moon, and to so many irregularities due to the action of winds and river-outflows, that a very long series of observations would be necessary to fix any natural plane. In consideration of this—and keeping in view the possibilities of repetitions of the surveys or subsequent discoveries within the field of work—it is necessary to ascertain the position of the plane of reference which a short series has given by leveling up from the tide-gauge to a permanent *bench*, precisely as if the adopted plane were arbitrary.

Bench mark.

64. The plinth of a light-house, the water-table of a substantial building, the base of a monument, and the like, are proper benches; and where, these are not within reach, a mark in a rock, not likely to be moved or started by the frost, may be made , or, if no rock naturally exists in the neighborhood, a block of stone buried below the reach of frost and plowshare should be the resort. In all cases, the bench must be sketched and carefully described in the field-book, and its location marked on the hydrographic sheet with a statement of the position of the *plane of reference* (mean low water) relative to it. The note upon the hydrographic sheet, directly under the tide-table, should be in something like the following form: "The bench (see location) is the outer edge of the water-table, about two

feet above the ground, on the west side of the custom-house; and the plane of reference (mean low water) is sixteen and eight-tenths (16.8) feet below it."

By the term *mean low water,* upon the Atlantic and Gulf' coasts, is to be understood the mean of all the low waters observed; but, upon the Pacific coast, where there is a great difference between the heights of the two low waters of each day, the plane of reference *is the mean of all the lower low waters.*

65. The leveling from the bench-mark to the tide-gauge may be done, when a leveling-instrument is not available, by measuring the difference of height of a number of intermediate points by means of a long straight-edged board, held horizontal by the aid of a good carpenter's spirit-level, or even a plummet-square; taking care to repeat each step with the level inverted end for end. A line of sight to the sea-horizon, when it can be seen from the bench across the tide-staff, will afford a level line of very sufficient accuracy, especially when observed with the spy-glass. It will often be convenient to combine the two latter methods.

Kind of gauge.

66. In perfectly sheltered localities, the simplest and best gauge is a staff graduated upward in feet and tenths, and so placed that its zero shall lie below the lowest tides. The same gauge may also be used where there is considerable chopple, if a glass tube with float inside is secured alongside of the staff, care being taken to partially close the lower end of the tube so as to exclude undulations. The empty bulb of the thermometer, with a portion of the stem to give it more weight, makes a good float, and in lieu of this a little colored oil has been successfully used to give definition to the water-line within the tube.

67. Where there is considerable swell, and where, from the situation of the gauge, or the great range of the tide (making it inconvenient for the observer to see the figures from different positions), the staff gauge can not be used, recourse must be had to the box-gauge. This gauge consists of a vertical box closed at the bottom, with a sufficient number of 1/8 inch gimlet-holes on each side from the bottom up to a height of a foot, to allow free access of water, but to prevent the admission of any outer undulations. If the waves cause too great oscillation with these holes, they can be covered by a thickness of coarse blanket or sponge tacked over them. Within the box is a copper float,

with graduated rod, moved up and down with the tide. The observer notes in this case the figures of the rod as they pass a certain point (the top of the box or an opening in the side of it), which is technically called the *reading-point.* The staff of a box-gauge is graduated downward, and the box must extend some distance below the lowest tide in order that the float may never touch bottom. One of the objections to the use of the box-gauge has arisen from the carelessness of hydrographers in properly referring its zero-reading to the bench. To make this reference properly, a line of levels must be run from the bench to the reading-point, and then the distance measured from the zero (or some other stated division of the staff) to the water-line of the float, so that the elevation of the bench above the surface of the sea for any reading of the gauge can be calculated. The water-line is well marked upon the copper float after the gauge has been in operation a few days. As this float-line is apt to rise upon the float, as the rod is made heavier by dampness, another determination of its position relative to the zero of the staff should be made at the close of the season and recorded.

Situation of the gauge relative to the field of work.

68. As the tidal observations are to be used to correct the soundings, care must be taken to make sure that the gauge is placed in a situation visited by the same form of tide as that which occurs at the place where soundings are to be made. It will not answer, for instance, to correct the soundings upon an inlet-bar by tidal observations made within the lagoon with which this inlet communicates, because the range of the tide within the lagoon is less than upon the outside coast. A partial obstruction, like a bridge, or a natural contraction of the channel-section, while it may not reduce the total range of the tide or materially affect the time of high or low tides, will alter the relative heights above and below at intermediate stages, so that the hydrographer must be careful to see that no such obstruction intervenes between his field of work and the gauge.

Where there are no such changes as those we have named above, the same gauge may be used for correcting the soundings over many miles where there is good depth of water. The limit of distance at which a gauge may be placed so as to require no correction of the observations for difference of time of

tide may be ascertained by the hydrographer by the following general rule:

Airy's rule.

69. *The rate at which the tide travels is equal to the velocity acquired by a body falling through space front a height equal to half the depth of water.*

This rule may be used in correcting the tides of a distant station, so as to use them for correction of soundings; but it is usually safer to put up another tide-gauge when the work has advanced so far that the simultaneous readings at the first gauge can no longer be used.

Connection of gauges so as to reduce the observations to the same zero and bench.

70. Wherever in the course of a survey it becomes necessary to make new tidal stations from point to point, the different gauges and their benches should be referred to each other, if it is deemed necessary to reduce all the soundings to the same plane—as it would be if they are all to appear upon the game published chart of a harbor or bay not of the lagoon form.

71. As running lines by leveling-instrument round the borders of harbors and bays is usually laborious, and sometimes impracticable, because of intervening streams, the following simpler and really safer methods for connecting tidal stations are to be preferred :

Coast Survey rules for water-levels.

72. Where there is no considerable river-outflow, make observations upon the two gauges to be referred, every fifteen minutes from one low water to the second following (for the same tides); the average in each case will be *mean level*, and *the difference between the readings of mean level on the two gauges is the difference in the elevation of their zeros.*

The above rule will not apply where there is considerable river-outflow; but the following rule holds good wherever the outflow of river-water does not wholly reverse the flood-current.

Set up graduated staves at such distances apart that the slacks of the tidal currents shall extend from one to another. By simultaneous observations ascertain the difference in the readings of these gauges at the stack between ebb and flood

currents, and again the difference at the slack between flood and ebb; *the difference in the elevations of the zeros of the gauges is equal to one-half the sum of the differences of their readings at the two slack waters.* (Appendix No. 11 of the Annual Report of the Coast Survey for 1870.)

It will be seen that this latter rule includes all the cases of the former likely to occur in any single season's work; and since its application involves less time and labor, it may properly be used, whether there is any river-slope to be eliminated or not. This same rule will be found applicable to the case where gauges inside and outside of inlets are to be connected, and where those above and those below obstructions are to be referred to each other.

73. When practicable, in selecting a tidal station, reference should be had to the facility for obtaining a competent observer for moderate wages. A petty-officer or seaman may sometimes be used as an observer; his extra expenses being paid out of the Coast Survey appropriation. In general, it is desirable at a permanent station, where there is no self-registering gauge, that observations be made hourly. In this case, two observers should be provided for the station.

74. The *reductions of* the *soundings,* required for the height of tide, will be entered in the sounding-books. Two persons should compute them independently, or the chief may revise the work of the assistant.

75. As a general rule, applicable not only to these but to all computations, unless the results are computed independently by two persons, and agree, they ought not to be taken as having sufficient evidence for their final use. Not less than one lunar month's observations of the tide should be used in obtaining the plane of reference of a chart. For a reconnaissance, a few days' observations will suffice, noting the time of the moon at which they were made.

76. There are frequently *remarkable facts* in reference to the tides known to persons navigating the waters in the vicinity of the work. These should be examined, and, if the alleged facts are important, with proportionate care. The highest or lowest tide ever known in the vicinity, its date and circumstances, should be obtained.

77. The *original record* of the *tides* should, as with all such records, be preserved, even though it may be necessary to have

a fair copy made, and a duplicate. The tables of reduction will be referred to under the head of office-work.

78. Observations of the direction and force of the *wind,* of the *barometer, thermometer,* and *weather* generally, will be made in connection with the permanent tide-stations, and entered in their appropriate columns in the register. The thermometer attached to the barometer, and a thermometer giving the temperature of the air, will both be registered. The latter should be placed, if possible, on the north side of some permanent structure, and be screened from direct and reflected light and beat. The instrument should be observed before or after taking the observations of high and low water.

79. Requisitions for these and other instruments required by the instructions will be made by the chiefs of the parties in the form elsewhere prescribed.

Instructions for hydrographic parties observing tides on the Atlantic and Pacific coasts.

80. The object in general is to obtain the best tidal data for use in reducing soundings.

If there is only time for continuing the observations in a place a single day, have them kept up long enough to embrace two high waters and two low waters, or for a lunar or tidal day, which will be nearly twenty-five solar hours. Where it can be conveniently done, it is desirable to have them continued for half a lunar month, a lunar month, or a number of such months.

It is very important to keep up the observations night and day; but it will sometimes be sufficient to observe only the high and low waters night and day.

Continuous observations are, however, much better. It must not be supposed that the night-tides can be safely omitted, unless the plane of reference for the work has been previously determined from other tidal observations.

Instructions for hydrographic parties observing tides on the coast of the Gulf of Mexico.

81. As the tides here for the most part rise and fall only once in a lunar day, it will be necessary to have them observed night and day, in order to get the best results for use in reducing soundings.

A correct plane of reference cannot be computed from day observations only, as any one will find by plotting such a series. The rise and fall being generally small, it will be sufficient if the tides are observed every hour or half-hour, especially if the observations are plotted and the tidal data for reducing soundings be taken from the plotted curve.

Day observations suffice only in cases where the proper plane of reference has been determined by previous tidal observations.

It is desirable to have the observations kept up for at least half a lunar month, and if there is time a full lunar month, or a number of such months, as the tides here go through most of their short-period phases of change in a lunar month or a little more.

82. The tide-observer will compare his watch or clock frequently with that on board the vessel and will carefully note the time at each reading of the tide-staff. He will also be careful to fill the columns for wind and weather.

83. The name of the tide-observer will be inserted in the tide-book each day, and whenever he is relieved the fact and name of the relief will be entered opposite the last observation taken by the observer going off duty.

84. The officer in charge will be especially careful to have filled in all the information required in the opening pages of the tide-books, *i.e.*, the descriptions of tide-gauge, locality, bench-mark, &c., the sketch showing locality of bench-mark. Should the same book be used at more than one tide-gauge, fill in the same data on the two pages next preceding the first record at each new gauge, and make a note at the bottom of pages 1 and 2, giving the number of the pages where such information is to be found.

85. When the observations referred to in paragraph 72 are being taken, a note should be made in the column of remarks, in each tide-book to call attention to the fact. It would be well to use one book, for recording the comparisons of all gauges with the standard. The watches or clocks of the two observers should be compared, so that if it is found that there is considerable difference between the times of high and low waters at the two gauges a curve may be drawn for the reductions of soundings at intermediate points.

Tide-table.

86. A sample of tide-table is given below, and requires but a few words to explain the manner of its construction.

TIDES.

The plane of reference to which the soundings are given is mean low water.. Sandy Hook.

Corrected establishment, or
Average time of high water after moon's meridian passage.. VII ^{h} XXXI.^{m}

Mean rise and fall of tides, or

Rise of mean high water above the plane of reference.....	4.7 ft.
Rise of high water, spring-tides, above the plane of reference..... average..	5.1
Fall of low water, spring-tides, below the plane of reference..... average..	0.4
Rise of high water, neap-tides, above the plane of reference..... average..	4.3
Height of low water, neap-tides, above the plane of reference..... average..	0.4
Mean duration of rise.....	6^{h} 08^{m}
Mean duration of fall	6 17

The time of high water observed is the middle time of the stand, and this is referred to the next preceding transit, whether it be *superior* (southing) or *inferior* (northing). The two springs of a lunar mouth are of unequal range, and therefore the mean of two, four, six, or more *even numbers* of observations are averaged.

The duration of rise or fall is counted from the middle time. of one stand to the middle time of the next.

There should be added to this table the highest and lowest tides known to have occurred, provided these can be determined so as to be referred to the plane of reference and bench. Wherever such data have been obtained and recorded, they have proved of the highest value in connection with marine constructions, drainage, &c.

IV.—TIDAL CURRENTS.

Use of terms.

87. Under the head of Tides, the distinctive terms to be used in the field-notes when reference is made to the tidal current have been pointed out and defined as far as seems necessary.

Relations of tides and tidal currents.

88. Although the tide and the tidal current are associated phenomena—indeed, are but different phases or manifestations.

of one and the same phenomenon—it has nevertheless been found impracticable to compute the elements of one from the other.

Local character of tidal currents.

89. Tides of nearly the same establishment and range are usually found in different parts of the same port or in adjacent ports; but the tidal current is in many respects *strictly local*, being affected in much greater degree by the configuration of the bottom, form of section, &c., than the tide. Current observations must, therefore, be made wherever, by reason of dangers or difficulties, the navigator may find it essential or advantageous to know the set and drift; and this may be at many different points in the same port and its approaches.

Currents of different stations do not vary with tides; those repeated at same station vary with range of tide—Reduction to mean.

90. While, as has been stated, the currents of *different* stations compared with each other do not indicate any dependency upon the tide that can be generalized, observations, repeated at the *same* station from day to day, show usually that *the velocities vary nearly in the ratio of the rise and fall of the tides;* so that the observations covering a single flood or a single ebb can be corrected so as to represent the mean drift by a coefficient derived from comparing the rise or fall (simultaneously observed) with the average rise or fall from a long series. Tidal observations, then, must continue while the currents are being measured, so that the velocities ultimately given for all the stations shall be those corresponding to the same average tide.

Location of current stations.—Specific provision for certain stations.

91. The hydrographer must be guided by his own judgment or the advice of pilots in deciding upon the proper locations of current-stations, with the following provision: that *in the channel-ways over outer bars, and at the entrances to all inlets, bays, or harbors,* the currents must be observed. The navigator not only desires to know the set and drift in the vicinity of dangers, but also about what time he may expect a favoring or adverse current on entering or leaving port.

Slack-water tables impracticable.

92. It would be highly desirable to construct a table showing the times when the ebb and flood would commence, but this has been found impracticable, because these times are very irregular.

Irregularities of tidal currents.

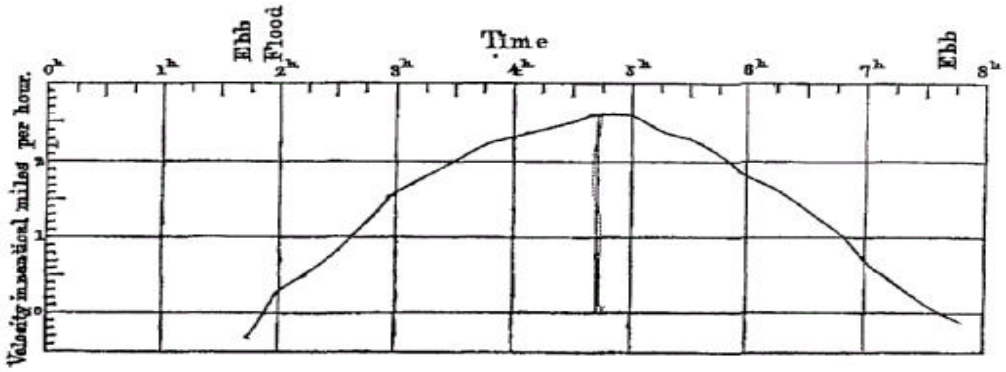
93. The times of slack water, are of course, subject to all the *inequalities* which appear in the times of high and low tides, and they are also affected by winds and river outflows to a much greater degree than the tides, so that they by no means recur at the same interval after the tide from day to day.

Stability of time of maximum velocity.

94. Theoretically, the least variable element of time in the tidal current is that of maximum velocity, which, at most of our ports, is free from the *diurnal inequality*, and but little affected by steady winds and river-outflows. To obtain this element from a short series of observations, the following method of procedure is necessary:

Method of computing the time of maximum velocity.

95. Let the velocity of the ebb or flood current be observed every fifteen or twenty minutes from one slack water to the next; plot these observations upon profile-paper, and draw a line from the apex of the curve so as to bisect all the chords and the base of the figure. The average time to which this axial line corresponds is the middle time of the current, and is found in long series, to represent the time of maximum velocity. The middle time from a short series is corrected, so as to represent the mean by a comparison with the times of the tide. The whole process is illustrated by the following example and diagram :



Observations.			Observations.			Observations.		
Time.	Velocity, in nautical miles, per hour.		Time.	Velocity, in nautical miles, per hour.		Time.	Velocity, in nautical miles, per hour.	
h. m.		Ebb.	*h. m.*			*h. m.*		
1 45	—0.30	Ebb.	4 00	2.30	Flood.	6 15	1.60	Flood.
2 00	.30	Flood.	4 15	2.40	Do.	6 30	1.40	Do.
2 15	.50	Do.	4 30	2.55	Do.	6 45	1.10	Do.
2 30	.80	Do.	4 45	2.60	Do.	7 00	.70	Do.
2 45	1.15	Do.	5 00	2.60	Do.	7 15	.40	Do.
3 00	1.55	Do.	5 15	2.40	Do.	7 30	.10	Do.
3 15	1.80	Do.	5 30	2.30	Do.	7 45	—0.05	Ebb.
3 30	2.00	Do.	5 45	2.10	Do.			
3 45	2.20	Do.	6 00	1.80	Do.			

		h. m.
Middle time, given by diagram		4 42
Lunar interval		6 30
	h. m.	
Middle time of the rise of tide (simultaneously observed)	4 07	
Lunar interval	5 55	
Lunar interval of middle time of tide from long series	5 42	
Correction		—0 13
Which, subtracted from the middle time of current (observed), give (Mean interval of maximum flood-current.)		6 17

Middle time of tides.

96. The above example assumes that at least a lunation of observations of the rise and fall of the tide has been made, which affords the means of correction. The *interval of middle time* from such a series is simply half the sum of the mean intervals of high and low tides.

Most favorable times for making current observations.

97. In selecting dates for making current-observations, those days should be preferred on which the tides have about their average rise and fall, or midway between spring and neap tides, because the times of slack water—and consequently, but in less degree, the times of maximum velocity, as we compute them—are subject to variations dependent upon the range of the tide. For instance, the filling and draining of distant interior basins or marshes by a tide of unusual range may cause the flood and ebb to run later than usual in the main artery of the port.

Marking station on the hydrographic sheet, &c.

98. Upon the hydrographic sheet, the current-station should be plotted as a small circle, from which two arrows should be extended, indicating, respectively, the directions of ebb and flood at the time of maximum; and at the end of each arrow this maximum velocity should be stated in knots or nautical miles per hour, thus:

Establishment.

99. The establishment of the current should be given in a table upon the same hydrographic sheet, thus:

Station.	Locality.	Maximum velocity after moon's meridian passage	
		Flood.	Ebb.
		h. m.	*h. m.*
1	Entrance	6 17	0 35
2	Main channel	6 27	0 39

Geographical range of current-table.

100. As a general rule, it will be found that where there are no intervening contractions of the channels or widely-expanding basins, the current-intervals undergo but slight variations from point to point along the central pathway; so that, wherever, by reason of the meandering course of a channel, it becomes necessary to make many current-stations, in order to represent the directions of the drifts, the time-results can usually be combined and stated generally as those of the entire channel. For instance, in the Hudson River the lunar interval of maximum current does not vary two minutes to the mile above the Tappan Sea; and the above form of current-table holds from day to day about as well as the tide-table, although the river-outflows change the slack-waters many hours.

Current-table not affected in value by river-floods.

101. Even when the flood-current is annihilated by the river-discharge, the table is equally valuable as indicating maximum and minimum periods of the outflow.

Instruments used in current-observations.

102. Observations of currents may be made with the ordinary log-chip and line, or the chip may be replaced by a weighted pole. The advantage in using the weighted pole lies in the greater hold it has upon the water in proportion to its exposure to winds, surface-ripples, &c. In ports where many vessels lie at anchor, the surface-currents are cut up into bands of unequal motion, and these sources of error in the observations with the chip are in a great measure eliminated in using the pole. It is, however, not advisable to use poles of greater draught than that of ordinary vessels visiting the port, because the information to be obtained is for the use of these vessels, and the currents below are not always in correspondence with those in which the vessels move.

Method of dividing the log-line.

103. The log-line should be so divided that, running off from the reel during a period of thirty seconds, they should measure the drift in nautical miles and tenths per hour. The larger divisions, miles, should be marked by leather strips, in which holes are perforated to represent the number, thus: For one mile, one hole; for two miles, two holes, &c. These strips should be placed 50.72 feet apart when the line is thoroughly wet, making no allowance for leeway or drag, as has been the custom in marking log-lines for determining the sailing-rates of ships. Between each pair of leather strips nine knotted cords should be placed at intervals of 5.07 feet, to mark tenths of a mile; the number of knots on each cord indicating the number of tenths.

Stray-line.

104. Between the log-chip, or pole, and the initial division or zero, there should be, at least, 60 feet of stray line, in order that the float may pass beyond the eddies of the vessel before the count begins.

Direction of flow.

105. The set or direction should be determined by measuring the angle subtended between the float at its most distant point and some known object on shore, or by compass if no shore-signals are in sight.

Position and angle of direction.

106. The position of the boat, if determinable by angles or shore-signals, should be recorded at the strength of the flood, and again at the strength of the ebb.

Rule.

107. The following rule, relative to the choice of signals, where they are numerous, (equally well-defined making equally well-conditioned triangles, &c.,) should be used: *For position, prefer near signals; for direction of current, the most distant.*

Night-observations.

108. Special floats for determining directions of currents at night have been devised, and will be furnished upon application to the Office.

Soundings.

109. Soundings should be made at the current-station, and recorded at each slack-water, together with comments upon the kind of bottom, whether good holding-ground, &c.

110. Blank forms for current-observations will be furnished upon application to the Office, and the necessary stop-watches; the latter should be compared with the chronometer before used, and the error of the second-hand recorded on the forms, so that the observer may make the proper allowance, and make no subsequent correction of recorded velocities necessary.

111. At current-stations, sufficiently important for a full series or observations to be made at them, the first set should be made after and during an interval of calm or light airs, to give the *normal condition* of the current. The plotting of the results of this series will show, by the accordance of the separate curves, or their discordance, that the observations have been accurate, or the reverse, sufficiently numerous or insufficient to show the phenomena. Having obtained several series which give a satisfactory result, the *effect of winds* is next to be studied, by observing after and during the prevalence of a strong wind in a particular direction. The same tests will be applied to these results as to the former, and on a separate sheet of diagram a comparison will be made of the mean results by drawing the two broken lines for velocity, and the two for direction, on the

same page. The effect of the prevailing winds only, or those which chiefly affect the currents, need be studied.

112. From the mean results taken from the final abstract No. 2, referring to the currents in their normal state, the direction and the velocity at 0, ¼, ½, ¾, and one of the interval of flood and ebb, will be deduced and formed into a table, as on the map of New York Bay and Harbor. The direction and velocity for ¼, ½, and ¾ of the interval of ebb or flood will be shown on the chart by means of arrows and dots, as in the diagram.* Full arrows show direction of flood; half arrows that of ebb; the dots indicate by their order the direction in which the current turns, and the velocity is written at the head of the arrow. Notes will serve to indicate the differences during the prevalence of particular winds, or similar tables may be prepared for such cases when the phenomena are complex.

113. In particular cases, as for example at Hell's Gate and Wood's Hole, it is desirable to trace the motion of the water through the passage, to connect it with the rise and fall of tides, and with the area of the passage and character of the bottom.

114. The results should be represented on a sketch, showing the tide and current stations, the direction and rate of the current, and following the stream at flood and ebb from its entrance to its exit through the different passages or water-ways.

V.—CURRENTS.

115. The observations of permanent currents, such as that of the Gulf Stream, will be the subject of special instructions. No opportunity should be lost to obtain a correct knowledge of them by comparing the position of the vessel by dead-reckoning and by astronomical observations. The anchoring of boats by the water-anchor should be tried when practicable. Every hydrographic vessel should be provided with Massey's log for registering their motion through the water, and with instruments of the best quality for determining the latitude and longitude.

VI.—MISCELLANEOUS OBSERVATIONS.

116. Descriptions of the *light-houses* should be given as a part of the hydrographic notes, stating the general character of

*See Appendix No. 49 of the Coast-Survey Report for 1854.

the site and structure; the height of the lantern above the water; the kind of light, whether fixed or revolving (if the latter, the time of showing and of eclipse), showing steadily or with a flash; periods of flash if used; the color of light; the optical apparatus, whether mirrors or lenses; the number of burners; positions of the lights; distance to which, in ordinary states of refraction and in clear weather, the light may be seen. To these, any other particulars should be added which would enable the navigator to recognize the light-house by day or the light by night.

117. The table from which the distances of visibility of lights are computed, supposing the eye to be fifteen feet above the surface of the sea, is given in the United States Light-House List. Any great variations of observations from that rate should be noted.

118. It will be interesting, too, to have noted the distance to which fog-bells, fog-whistles, cannon, or other fog-signals can be heard in different cases, as to direction and velocity of the wind.

119. Similar descriptions should be given of *light-vessels*, with the addition of the determination of the position at different times and under different circumstances.

120. Suggestions in regard to the positions of light-houses, light-vessels, or buoys, for the use of the Light-House Board, will at all times be acceptable; and any aid in regard to placing light-vessels or buoys, which may be desired by collectors or officers of the Light-House Board, and which will not interfere with the regular progress of the work, should be given. The Treasury Department has always shown a willingness in return to lend such aid, through the collectors of customs, by the use of rooms and store-houses, boats, and even an occasional use of a cutter, as may not interfere with the regular duties in regard to customs.

121. The positions of *buoys* should be accurately determined under different circumstances of tide and wind, and, when practicable, from one season to another. Note should be taken of their form, material, color, their names, from the locality or other circumstances, and their object. Suggestions as to how the existing buoys fulfill the objects for which they are laid down, and, if such are necessary, in regard to places for new buoys, should be made.

Views.

122. Careful note should be taken of the appearance of the land, and report should be made of the *views* desirable for illustrating sailing-directions, for entering or leaving harbors, or sailing along the coast in the tracks generally followed, in the channels of navigation between important places. In general, views will be made by an assistant detailed for the purpose, and who will accompany the hydrographic party at some convenient opportunity.

When the draughtsman or other officer of the party is competent to take these views, they should be sketched, as convenience serves, during the hydrographic operations.

Sailing directions.

123. Special notes will be made of all remarkable *objects on the shore,* which may be useful to the navigator by serving as landmarks, of peculiar range-marks, which actually are or may be employed by pilots. Suggestions should be made where it is desirable to erect artificial marks. Information of landmarks removed by design or accident should be communicated.

124. When the execution of work assigned in a particular region or harbor has made the chief of a party familiar with its navigation, and enabled him to arrange the facts which he may have collected from observation or the information of others, he should draw up *sailing-directions* for entering and leaving the harbor, for avoiding the dangers of the coast, and for sailing in different tracks used by vessels navigating the water. These sailing-directions should be completely tried under different circumstances, and examined, when plotted on the reduced sheets, by reference to the data of currents, variations, &c., obtained from the work itself. At suitable intervals along the line to be sailed over, soundings should be taken, recorded, and compared with the results of the general survey. These intervals will be regulated by the depth of water, the rapidity of its change, the ease or difficulty of entrance, and other circumstances, of which the chief of the party will judge. The bearings should be magnetic, and the miles nautical miles. The changes required by the change of variation of the compass can be easily supplied when necessary.

The chief of the party should enter in a table the depths which may be of special interest on shoals, in harbors, rivers,

&c., on the ground of his work, or over which he may have passed, so frequently examining the special points as to make him sure of his facts.

125. General facts, which may be of interest to navigation should be carefully verified and noted. Memoranda of the character and amount of navigation, its facilities or dangers, the record of property destroyed, the peculiar sources of danger, when properly authenticated, will always be acceptable. The history or tradition of remarkable disasters may frequently prove of interest.

126. The limits of *tide-rips and breakers*, the effects of change of winds and tides upon them, the general facts relating to them, the causes of their peculiarities, if ascertained, should be noted.

Names of localities.

127. Pains should be taken to obtain correctly the *names*, and, as far as practicable, the *orthography* of the *names*, of points, headlands, and all collections of water not inland, shoals, reefs, and the like. A memorandum should be made of the authority, when there is doubt in regard to a name, or its spelling, and of the weight attributable to the authority; and where many names are obtained from the same person, book, or chart, reference should be made to this effect.

This subject requires more attention than is usually given to it, since fishermen and pilots may use names corrupted from originals which it is desirable to restore. This is true especially of aboriginal names along our coast. The information of some great local authority should be sought in such matters, to be communicated in the form of a report on the names of localities.

128. Charts made or compiled by former authorities should be consulted, and comparisons instituted with the new work. All *changes* of either water or land thus observed, or resting upon competent authority, should be reported with the facts and authority. The names of new channels, shoals, and reefs will be given by the Superintendent, according to a plan approved by the Secretary of the Treasury, in which the unity of the work is maintained, while the claims of the chief of a hydrographic party, executing the work where the discovery is made, are duly recognized. Single rocks, newly discovered, will be named by the chiefs of parties.

The errors of the compass.

129. Special attention must be paid to the various sources of error in the use of the compass; the observer should assure himself that the needle or card is properly balanced and traverses freely, and that the lubber-line is correctly placed.

The standard compass should be so placed as to be least exposed to the disturbing action of the ship's iron, and should therefore be elevated above deck as much as practicable. The steering-compass must be made to depend entirely on the indications of the standard or azimuth compass. Mechanical correction of the standard compass is not, in general, recommended, owing to its want of permanency, by the gradual loss of magnetism in the correcting-bars, and to changes in the induced magnetism, due to considerable changes in the geographical position of the ship; besides, mechanical correction does not relieve us from the necessity of occasionally testing its efficiency.

130. The errors of the standard compass should in all cases be ascertained by direct observation before leaving port, and repeated from time to time, and whenever any considerable change has taken place in the distribution of iron in the ship.

131. In order to ascertain the deviations of the compass on a different course, the ship must be swung and the bearings of a distant object taken, with the ship's head in at least the eight principal compass points. The method of reciprocal bearings may equally well be applied. The observations may be laid down to form a Napier diagram as the readiest means of passing from the disturbed to the correct magnetic course, and *vice versa*. It is better, however, to tabulate the results in a table arranged for 32 courses, with the addition of the corresponding bearings of the steering-compass. The "heeling-error" may sufficiently be tested when the ship is heading north and south.

132. At sea, the deviation of the compass may, at any time, be tested by astronomical bearings, the regular variation for the ship's place being taken from a chart. All observations for deviations of the compass must be fully recorded, and turned in with the season's work.

133. Detailed instructions respecting the practical operation of testing the compasses, or for the computation of their deviation, are fully given in "The Magnetism of Ships and Deviations of the Compass," published by the Navy Department, 1867.

The variation of the compass and magnetic declination.

134. The variation of the direction of the magnetic needle from the true north is best ascertained on shore in a locality free from local attraction. When the observations are made on board, the local deflection due to the effect of the ship's iron must be accurately allowed for. The latitude, approximate longitude, and local time (or sun's altitude) being known, the variation is readily found from bearings of the sun when near the horizon, taken with an azimuth-compass.

135. Accurate determinations of the magnetic declination, however, require the use of a portable declinometer, for which fall instructions will be found in Coast-Survey Report of 1872, Appendix No. 14. Observations of this class are generally made by shore-parties, and are not required of hydrographic parties except by special directions.

136. These miscellaneous observations (VI) will be inserted in a book, to be kept for the purpose, under the different heads of light-houses, light-vessels, buoys, &c. The volume will be furnished with an index referring to the subjects.

137. Hydrographic signs, intended to produce uniformity in representing the same objects, will be furnished from the office.

VII.—PLOTTING OF WORK DURING THE SURVEYING SEASON.

138. There being a sufficient number of officers attached to hydrographic parties, no difficulty should be had in keeping the "finished" hydrographic sheet nearly up to the progress of the soundings.

139. During the days when no soundings can be made, the officers who have no deck-duty must perform office-duties. These duties must begin at 9 a.m. and close at 3 p.m., the usual office-hours of the government. The angles or positions should be protracted upon the working-sheet the same day in which they are taken or determined, to show the actual positions of the lines. These angles or positions can be transferred to the "finished" sheet by tracing-paper or otherwise, and the soundings plotted during the progress of the work.

140. The work on this "finished" hydrographic sheet requires no draughtsman. It requires but accuracy and capability of writing and making plain figures in the ordinary style of writing; nothing more whatever is wanted. As each position is plotted on the sheet, a point should be pricked through to show

its exact location. The point should be inclosed in a very small circle (say of the size of a lower-case o of *small pica* type), and made with a light hand. The number of each position should be put down at its side, and the *letter* of the day's work at least at the beginning and end of each line, and at any point where there is a change of course. The letter generally is put down for each station, but it is not so important for the intermediate ones; *the number, however, must in no case be omitted.* A station will often fall at the point of crossing of two lines, and without the number it would generally be impossible to tell to which it belonged. In making the small circles, use red ink for the vessel's work; and for that of each boat the color of its letter. (See paragraph 44.) The letters and soundings should be plotted in pencil. Sheets have occasionally been received from the field, which have had to be rejected, because the circles and letters were so large and heavy that they occupied space needed for plotting the soundings.

Reduction for tide.

141. In every case the tidal observations connected with soundings should be at once reduced, and the corrections obtained entered in the sounding-books.

142. It is essential that the chief of a party determine a sufficient number of points from the observed angles to keep the run of the work of soundings, so as to direct the lines to the greatest advantage; also that he put down a sufficient number of characteristic soundings to ascertain if he can trace the curves. This is not labor lost; for the points determined and soundings set down will enable him to check the work of his draughtsmen or officers.

143. Copies should also be made of the note-books; this work not being allowed to accumulate through the season. The rule in regard to double computations, or a computation and revisions, should be observed; and the copies should be compared with the originals. By keeping regular office-hours, which duty is enjoined upon the chief of every hydrographic party, all duplicates of the original notes and records can generally be made and compared while the work is progressing. It gratifies a proper pride, and fixes responsibility, to have the names of those executing the work—the officer in charge of the vessel or boat; those taking respectively the right-hand and

left-hand angles, the theodolite angles from the shore, the recorder, the computer, the copyist, the helmsman, the leadsman—entered in connection with it.

When the hydrography precedes the topography.

144. The shore-line should be obtained from the Office, or from the topographical party acting in the vicinity, and entered upon the sounding-sheets. In some cases, the shore-parties furnish tracings; in others, lend their maps to be copied.

145. In special cases, when the hydrography must be made before the shore line can be furnished, the signals may be set up and employed, arrangements being made for the determination of their positions by a triangulation or by a topographical party. When none such is at hand, as sometimes happens in reconnaissance, the approximate positions of the signals should be determined by the hydrographic party, and the shore-line be sketched in, noting the fact. The most important shore-stations should in this case be carefully marked, that they may be determined by the triangulation subsequently, and the hydrographic work be replotted. In connection with this, a set of projection-tables should be in the possession of each chief of a party, who should see that his draughtsman understands their uses.

Projections and plotting.

146. The projections for the sounding-sheets should be made under the direction of the chief of the party, when not furnished from the Office; the working scale of 1:10000 is usually preferred where the lengths of lines permit its use. The off-shore work may be protracted on a scale of 1:20000 or 1:40000. Special surveys are often required on a scale of 1:5000.

147. The most convenient mode of plotting the three-point problem, where a three-arm protractor cannot advantageously be used, is by laying off the angles on transparent paper, drawing the lines from a point suitably chosen upon the sheet, and moving the transparent paper over the drawing-sheet until the lines pass through the three points between which the angles have been observed. Each party will be provided, however, with a three-arm protractor.

In laying down the soundings, the geometrical problem for dividing a line into equal parts (either of parallel lines to be laid diagonally or the fan-shaped scale, both drawn on tracing-paper) is very useful.

148. The curves for observations of the currents should be plotted for the same reason as the rough soundings, that the chief of the party may know whether the results are satisfactory and sufficiently numerous.

Rejected work.

149. Whenever a chief of party finds it necessary to reject any portion of the work of his party, if it be but a single sounding he *should make a note in the column of remarks, giving in full his reasons for rejecting it*, and if any subsequent special examination has been made which has justified his rejection he should call attention to it in the same note, thus: "See note, Sounding-book, No.—, p. —."

VIII.—SPECIAL OBSERVATIONS.

150. Special observations of temperature are required in the Gulf Stream, and have been made the subject of detailed instructions. A similar course will be pursued in regard to other observations of the same class; the present instructions, being confined to such as are more generally required of the hydrographic parties.

IX.—OFFICE WORK.

151. One of the most important duties in the office is the *reduction of the hydrographic charts* to the publication-scale. The soundings being numerous, and executed in lines, such a selection is to be made as will represent the bottom correctly, carefully giving least and greatest depths, without crowding, and present as equal a distribution of the soundings as practicable.

152. The *specimens of the bottom* will be placed in ¼ ounce vials, with wide mouths, and marked upon the cork with a reference to the position of the sounding, by date, number, line, and depth; or in offshore sounding, by date, number, and latitude and longitude. The form of label will be furnished from the office.

153. *Hydrographic notes* for the charts should be prepared and carefully reviewed by the chief of the party before reporting them. The character and color of the curves of equal depth should be distinctly explained in the notes on the original sheet, and if sailing directions are deemed unnecessary the

fact should be so stated on the chart. With the notes, the data for the conclusions will be reported to the Superintendent.

Report of office-work.

154. *A general report* of the *office-work* done should be made to the Superintendent before recommencing active operations, stating the nature of the work executed, its extent generally, and the fact of its completion; and the work should be presented for his inspection, and for such examination as he may direct, from time to time, as any part of it may be completed.

155. The records of all observations, and the results obtained from them, should be so complete that they may be used by any one acquainted with the subjects of them, without necessity for reference to the chief of the party personally under whose immediate direction they have been procured.

156. The notes upon the working-charts and upon the reductions should give the history of the work, showing the time when executed, and by whom, and the surveying-vessel employed.

157. Every original hydrographic sheet when turned into the Office must contain—

a. Projection in black ink, with the latitudes and longitudes on each end of each parallel and meridian where they have been determined; and when not, the fact must be stated in a note.

b. Triangulation, plane-table, and such other points as may have been determined or established by the hydrographic party, must be given, each with its distinctive sign. (See paragraph 2.)

c. The shore-line must be drawn on the sheet in a continuous black line if it has been surveyed by a topographical party; if sketched in by the hydrographic party, it is to be indicated by a broken line.

d. The lines of soundings, with the angles marked to distinguish them from the soundings; lettered in reference to the day of the month, and numbered in reference to the day; the figures of soundings to be in pencil, as also those of the angles and references (the circles inclosing station-points alone to be in colors—see paragraph 140). Fine drawing is not necessary upon these sheets; nothing more is needed than simple, neat, and legible writing; accuracy and legibility only are necessary. The object of turning the sheet into the office in the "rough,"

as it were, is that errors discovered during the verification of the work in the office can be easily corrected, and the inking completed in the office.

e. Curves must be drawn to show 6,12, and 18 feet water. Where the position of any of these depths comes between two numbers, one greater and one less, however small may be the fractional differences, the curve is to be drawn through this position. Where, as in a rapid slope, there may be no soundings of these absolute depths, the positions of the curves must be estimated between the depths next greater and less. Where the slope is very small, the same depth is frequently carried some distance, and in such cases the curve must be drawn through the *outer* sounding, having all the depths of that curve *within,* and none but greater depths *outside,* however small may be the fraction of difference.

Too much care cannot be given to these curves. They must be drawn in continuous lines; the 6-foot curves in *green,* the 12-foot curves in *red,* and the 18-foot curves in *blue.*

f. Rocks, reefs, coral and shell banks, sunken or awash, must be marked with the proper signs; if awash at half-tide or high water, the fact must be stated.

g. The character of the bottom must be carefully inserted often enough to leave no doubt, and particularly at the limits of change, where the character on each side of such must be given. Too little attention has been paid to this, especially in the hydrography of *bars.* A mere notice of *hard* or *soft* bottom is not sufficient.

h. The positions of all buoys, light-vessels, &c., must be given with their proper signs, and a note must state the condition of tide (half-flood), and state the weather, and when the position was determined, with the length of moorings of the light-vessel. The positions of all these must be ascertained at half-flood.

i. The heights above the plane of reference of shoals, bare at low water, must be given. (See paragraph 26.)

j. The limits of grass, kelp, &c., mast be given. If the bottom is grassy, it is to be so written. Kelp must be marked with its proper sign.

k. The names of all islands, points, rocks, reefs, shoals, banks, channels, creeks, &c., must be given on the sheet. This is very important, and the greatest care must be taken to obtain these names accurately. (See paragraph 127.)

l. All ranges, bearings for dangers, &c., sailing-lines on

courses or ranges, should be given and drawn as follows: The *range* in black lines, broken with long dashes and a dot between them; the bearings in black lines, broken with long dashes; and the *sailing-lines* in black lines, broken with short dashes, with the positions of the objects for ranges and bearings determined, marked, and named, and the names of the objects and the purpose of the range or bearing written along its line.

m. Current-stations must be plotted in position.

n. The title of each hydrographic sheet must be as follows:

United States Coast Survey.

Carlile P. Patterson, Superintendent.

Frenchman Bay,

Maine.

Begun ——— —,1874.
Ended ——— —,1874.

Horace Anderson, assistant.

Scale, $\frac{1}{10000}$

Here insert list of observers, recorders, leadsmen, and tide-observers, with the rank or rate of each.

o. There must be a table of reference, showing: 1. Date of soundings. 2. Letter of reference to date. 3. Number of the sounding-book. 4. Number of soundings taken in the day. 5. Number of miles of soundings run in the day. 6. Number of angles taken in the day. 7. Name of vessel or boat. 8. Name of officer who did the work. Thus:

Date.	Letter.	Number of–				Name of vessel.	Surveyed by–
		Sounding-book.	Soundings.	Angles.	Miles.		
Total on sheets							

Enter at the foot of the table the number of days worked, and the number of soundings angles, and miles run in the sounding. When more than one boat or vessel works on the same day on the same ground, the letters and number of the angles should be of different colors.

p. A note must be given showing within what limits the soundings are expressed in feet and fathoms; giving also the plate of reference, the depth at the curves, and how expressed in reference to the colors.

q. A tide-table of the temporary tidal stations used for reducing the soundings on the sheet, giving the names of the localities, and at each the following particulars:

(1.) Mean low water (plane of reference
(2.) Lowest tide observed.
(3.) Highest tide observed.
(4.) Mean rise and fall.
(5.) Name of observer.

} Giving for these the readings on the staff.

r. Give also on the sheet the magnetic variation at the date of work, with one or more compasses drawn to half-points.

s. The scale of the sheet must be given under the title, and scales drawn to statute and nautical miles, with subdivisions to each of eighths of a mile.

t. The sheet must be signed by the chief of the party and by the draughtsman.

u. The sheet will be verified in the Office, and signed by the draughtsman making the verification. It will be finally indorsed by the Hydrographic Inspector.

158. The following general notes and forms should be bad from the office, and if not supplied, the chief of a party should apply for them to the Superintendent:

1. Laws and regulations of the Coast Survey.
2. General rules for the parties of the Coast Survey.
3. General instructions in relation to the hydrography.
4. Hydrographic signs.
5. Forms for observation of tides (1), and for their reduction (Nos. 1 and 2).
6. Forms of observations of currents (1), and their reduction (2), with ruled paper for diagrams (Nos. 1 and 2).

7. Forms for requisitions for instruments (1), and for station. ery (2).

8. Forms for monthly reports of work.

9. Forms for daily journal.

10. General rules in regard to classification of expenses.

11. Form of inventories.

12. Log-books.

13. Steam Logs (for steamers).

159. The Hydrographic inspector will furnish the forms for quarterly returns to the Bureau of Equipment, &c., Navy Department, on requisition by the chief of party.

160. The chiefs of parties will find it conducive to exactness in the execution of these instructions to prepare an abstract, which they may refer to from time to time, and to bear in mind, and cause their assistants to bear in mind also, that only such work is accepted at this office as can be plotted from the data furnished by the party and without the aid of a member thereof. The necessity, therefore, is apparent of making complete notes with the day's work, and recording everything that would aid a stranger in thoroughly comprehending the subject.

Carlile P. Patterson,

Superintendent of the United States Coast Survey.

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