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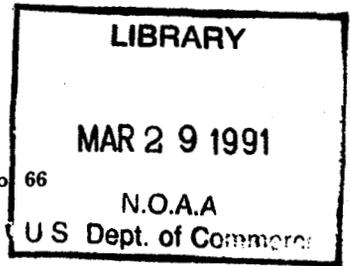
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RULES AND PRACTICE

RELATING TO

CONSTRUCTION OF NAUTICAL CHARTS

Special Publication No. 66



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The contents of this manual supersede all previous instructions, rules, and circulars upon the subjects treated and are to be followed by the cartographers of the drafting section in constructing and correcting the charts issued by the U. S. Coast and Geodetic Survey.

R. L. FARIS,
Acting Director.

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RULES AND PRACTICE RELATING TO CONSTRUCTION OF NAUTICAL CHARTS.

By GEO. L. FLOWER, *Chief of Drafting Section.*

INTRODUCTION.

Although this publication is intended primarily as a guide for the cartographers of the U. S. Coast and Geodetic Survey, it should be useful to others who are interested in the preparation of nautical charts. For example, the commissioned officers of the Survey, who by their labors in the field produce the material from which the charts of the Bureau are constructed, should be informed of the rules and practice governing the use made of their surveys by the cartographers in the office.

It is desirable that, so far as possible, all of the charts in a series should be uniform in treatment and appearance, but this is a more difficult problem than one not thoroughly familiar with the subject may imagine it to be.

The personal equation enters to a very considerable degree into the construction of nautical charts, and there is a limit beyond which no general rules for guidance can be formulated. New and unforeseen problems present themselves in the preparation of nearly every chart, the solution of which must be left to the initiative, technical knowledge, and skill of the cartographer.

There are, however, certain rules and practice which may be formulated to govern, to a large degree, the construction of all charts. Such rules and practice must necessarily be formulated to meet the conditions and restrictions under which a chart-producing organization is functioning, and modified from time to time to meet changing conditions. For example, with the necessity of a certain production by an inadequate number of cartographers, much of the less important topographic details and other features, although desirable, must be simplified or omitted.

The rules and practice set forth in this publication are those which meet the present conditions and requirements of the U. S. Coast and Geodetic Survey.

PROGRAM OF CHART PRODUCTION.

The Coast and Geodetic Survey's program of chart production, at present partially completed, and which is being carried out as rapidly as possible, is as follows:

Atlantic and Gulf coasts.—(a) One chart, scale 1:1,200,000 in latitude 40°, and another, scale 1:2,000,000 in latitude 25°, both on the Mercator projection, to replace charts Nos. 1001, 1002, and 1007.

(b) A series of 12 charts, scale 1:400,000 on the Mercator projection, to replace the series on the polyconic projection.

(c) A series of 86 charts, scale 1:80,000 on the Mercator projection and oriented with the meridian to replace the series of charts, same scale polyconic projection, and mostly diagonal orientation, the new series to have the soundings expressed in feet instead of fathoms and feet of the old series, with the topography much simplified.

(d) All charts on a larger scale than 1:80,000 whose meridians are not parallel with the side neat line to be so oriented, and all such charts whose soundings were given in fathoms and feet to be changed to feet.

(e) A series of charts of the shores of Long Island Sound, eight on the north shore to replace the 1:10,000 scale charts, and one on the south shore to replace three small harbor charts.

(f) A series of charts on an adequate scale to cover the inland waterways along the coast.

(g) Two or more harbor charts to meet changing conditions, or an insistent demand, are usually in the course of preparation.

West Indies.—CHARTS OF THE VIRGIN ISLANDS.—Until the surveys are completed and the requirements known, the number of charts and their scales can not be determined.

Pacific coast.—(a) A series of 11 charts, scale 1:200,000 on the Mercator projection and oriented with the meridian, with soundings in one unit (fathoms) to cover the entire coast and replace the diagonal, double-unit, polyconic series of charts of the same scale.

(b) The changing of the soundings on 55 additional charts where they are given in a double unit to a single unit, the unit to be determined as each chart is taken in hand for the change.

(c) The changing of the plane of reference on Puget Sound charts from "2 feet below mean lower low water" to "mean lower low water."

Alaska.—(a) A series of 5 Mercator charts, scale 1:1,200,000 in latitude 49°, extending from the Straits of Juan de Fuca to Attu Island, to replace the old series of charts on the polyconic projection.

(b) A series of 18 charts, scale 1:200,000, and 4 charts, scale 1:300,000, all on the Mercator projection extending from Dixon Entrance to Attu Island. Excepting the series mentioned in (a), this is the first scheme of charts to cover this extent of coast. It will eventually replace the five 1:200,000 scale polyconic projection charts of southeastern Alaska and the 1:200,000 polyconic projection chart of Prince William Sound.

(c) A series of 6 charts, scale 1:80,000, for Prince William Sound.

(d) HARBOR CHARTS.—In Alaska from two to eight harbor plans are usually grouped on one chart. These are usually conceived only after surveys are made and as the development of the territory necessitates, and for these reasons no comprehensive scheme of large-scale Alaska charts has yet been adopted.

Hawaiian Islands.—(a) A chart on Mercator projection, scale 1:80,000, of the island of Oahu and surrounding waters.

(b) In addition to the charts already published, such additional harbor charts as may be necessary to meet the demand.

Philippine Islands.—The charts of the Philippine Islands are prepared under the supervision of the Director of Coast Surveys at the Manila office. Charts have been published as rapidly as the surveys have progressed, but the approval of a final comprehensive program of charts for the islands has been postponed pending the further completion of such surveys.

I. INFORMATION AND DRAWING.

1. **Specifications.**—Chart specifications, approved by the Director, are prepared for each new chart. They give the chart number, price, scale, area to be covered, approximate dimensions between neat lines, the sounding unit, plane of reference, and other details requiring special mention. They are to be carefully read before starting work on the drawing and kept constantly in mind during the progress of the work. When they differ from any of the rules or instructions which follow, they are to be regarded as approved amendments thereto.

2. **Charting material.**—All charting material used in the compilation of charts must be critically examined, whether originating within or without the Survey. Note the actual date of survey, projection datum, depth unit, plane of reference, purpose and character of the survey, and whether original or compiled. Revise the depth curves where they are inaccurate or inadequate for the purpose of the chart and so that they include within their limits all soundings of the same depth as the curve after mentally reducing them for charting in accordance with article 12.

In the case of conflicting information proper weight must be given according to the facts. The latest information does not necessarily supersede all earlier. In unchangeable areas all well-controlled hydrographic surveys should be combined, while in localities under constant and radical change the latest information only should be used, except that the shoal soundings over rocks or rocky ledges in such areas on any of the surveys must not be rejected without convincing proof of their inaccuracy. In regions where some areas are undergoing change, while other areas remain unchanged, partial rejection of the different surveys may be necessary. The proper acceptance and rejection of the available information and its coordination constitute the supreme test of the skill of the cartographer.

The results of this critical examination should be noted on the face of the respective file copies of surveys made by other organizations and, together with those relating to our own surveys, entered on the record form of the chart.

Descriptive reports of the survey sheets, Coast Pilots, decisions by the United States Geographic Board, and reports of the Chief of Engineers, U. S. Army, should be consulted, and triangulation records and computations, especially in such regions as Alaska, should be examined for information which may not be included in the geographic positions or shown on the topographic sheets (such as positions or elevations of hills or mountains, tangents to rocks, islands, or points beyond the limits of the sheet, etc.).

3. Size of charts.—The standard maximum size of charts should be about 30 by 40 inches, within neat lines, and this should be exceeded for only exceptional reasons. When practicable, the charts should be made smaller than 30 by 40 inches, remembering that many mariners are not provided with facilities for the care and use of very large charts.

The limits mentioned in the specifications should generally be considered as approximate only. On charts with subdivided border scales each neat line should be at one of the subdivisions, preferably one marking a whole minute.

4. Drawings.—There are two classes of drawings—one class known as compilations and the other as smooth drawings. A compilation of a limited portion of a published chart from new material is known as a "correction," and a smooth drawing of a "correction" is called an "insert." Both compilations and smooth drawings are to be made on the scale on which they are to be published.

The overlapping portions of charts of the same scale should be identical so far as practicable.

That accuracy and clearness are the chief requisites of a chart should always be kept in mind. It is a common fault to attempt to show on a chart all the information that is given or could be shown on a chart of much larger scale, with the result that the details are so crowded and minute as to be illegible.

Compilations are either sent to the engraving section to be engraved or are used to trace the smooth drawings from. They should be kept reasonably clean and the lines, figures, and letters made sufficiently bold so as to be readily seen through tracing vellum. No time should be taken to produce an artistic effect or to do fine lettering. The curves of equal depth should be drawn in colored ink, using yellow for low water, 4 and 10 fathoms; green for 1, 6, and 100 fathoms; red for 2, 5, and 50 fathoms; and blue for 3 and 20 fathoms.

All drawings must be verified. As no two cartographers will produce identical results from the same material, the verification of a compilation does not mean a new compilation. The verifier should see that the latest information was used, that no mistakes were made, that all dangers and shoals are shown, and that the lines of maximum depths over bars and in channels are shown by the soundings.

In tracing smooth drawings or inserts lay out the work so that the north and south direction shall run with the length of the roll of vellum, so as to obtain uniform expansion or distortion on different pieces so far as possible. The projection lines on inserts should coincide with those on the chart tracing and a perfect junction made with the old work. When drawings for a chart are made on more than one piece of paper or vellum, it must be clearly indicated how they are to be combined.

The ink for smooth drawings must be intensely black for all work; shading effect to be accomplished by spacing and thinning the lines and not the ink.

5. Record.—A concise record of each drawing shall be kept on appropriate forms, giving a list of all material consulted; if used, the extent to which it was used and the area affected; if rejected, the reason for rejecting. This record must be signed by the compiler and the verifier of the compilation, also by the maker and verifier of the smooth drawing.

The area covered by all charting material and all changes in the aids to navigation must be indicated on the charts affected in the standard file, together with the authority or file number of such material, the date of the drawing, and the date when it is applied to the chart.

II. PROJECTIONS, SCALES, AND BORDERS.

6. **Projections.**—The Mercator projection must be used for all charts. The authorized datum for all charts of the coasts of the United States and Alaska is the North American datum. The projections for all new charts must be based on this datum if the positions are available. If the positions are not computed on the North American datum, then the best datum available should be used.

If possible, projections should be placed on all charts and plans, even if only an approximate datum is available.

Each projection for a chart drawing must be verified and must be signed by each of the persons making it and verifying it.

In the construction of Mercator projections use Table XIII in *Traite D'Hydrographie* by Germain.

7. **Changing projections.**—When the positions are available for changing to the North American datum charts which are not now on that datum, the projection lines will be changed when a new drawing of such a chart is made, when a new basso is made, or when such a chart is engraved, except that for the 1:80,000 scale charts remaining unchanged the change will be made by correcting the projection figures in the border to agree with the North American datum to the nearest whole second.

In Alaska the changing of a projection is a subject for special consideration.

8. **Projection lines.**—Projection lines are to be full lines extending from neat line to neat line, broken for soundings, lettering, and other features that would be obscured by drawing the lines through them. They are to be at wide intervals at the multiples of 1, 2, 5, 10 minutes, or degrees, etc., so as to keep the chart area clear, but not too wide for convenient span with dividers. (See article 12.) Such smaller quadrangles as convenient should, however, be used for the working projections on compilations.

The drawing of full lines on those charts where intersections only are now shown is in each case a subject for special consideration. If not changed from intersections to full lines, the intersecting lines must be made at least 5 millimeters long at the most opportune time.

9. Scales.—Numerical and graphic scales should be placed on all charts whose mean scale is 1:80,000 or larger. The graphic scales will consist of a scale of nautical miles, followed by a scale of yards, and for Philippine Islands charts a scale of kilometers will be added in the order nautical miles, kilometers, and yards.

A complete marginal scale (of the arrangement used on chart No. 1209) should be placed on charts of scale 1:50,000 and smaller, subdivided as indicated in article 12.

10. Borders and projection numbers.—The border of a chart consists of either a neat line or a border scale defining the limits of the area charted and a fine and heavy line drawn close together and separated from the neat line or border scale by a space in which the projection numbers are placed.

The border lines of a chart should form rectangles, with the side lines parallel with the middle meridian.

For charts of scale larger than 1:50,000 every minute of latitude and longitude should be shown at the border either by the projection lines or by lines 3 millimeters long inside the neat lines.

The projection lines are to be numbered as indicated in article 12. The numbers should be placed in the space between the neat line or the border scale and the outer border lines and centered on the projection lines or subdivisions to which they refer.

On charts where only degrees are numbered, the numbers for the multiples of 10 degrees are to be 3 millimeters high and the others 2.5 millimeters high. On charts where degrees and minutes are numbered, the numbers for minutes are to be 2 millimeters high, those for degrees used with minutes 2.5 millimeters high, and for whole degrees 3 millimeters high and the 00 minute omitted.

11. Border dimensions.—When the sum of the length and breadth of the chart does not exceed 40 inches, the heavy outside line will be 1 millimeter wide. When the sum of the length and breadth of the chart is greater than 40 inches, but does not exceed 55 inches, the heavy line will be 1.2 millimeters wide, and when the sum of the length and breadth of a chart is greater than 55 inches the heavy line will be 1.5 millimeters wide.

The space between the heavy and light lines of the border will be the same width as the heavy lines.

The space between the light line of the border and the neat line or the outer line of the border scale will be 7.5 millimeters wide.

Lines of the border scales will be 1.5 millimeters apart.

12. Schedule of projection intervals, border subdivisions, and projection numbers.—

Scale.	Projection-line intervals.	Border subdivisions.	Projection numbers.
		<i>Border scale.</i>	
1 : 3,000,000	5 degrees	5 minutes	Each degree.
1 : 1,000,000	2 degrees	1 minute	Each degree.
1 : 1,200,000	2 degrees	1 minute	Each degree.
1 : 600,000	1 degree	1 minute	Each 20 minutes.
1 : 400,000	30 minutes	1/2 minute	Each 10 minutes.
1 : 200,000	20 minutes	1/2 minute	Each 10 minutes.
1 : 100,000	10 minutes	1/10 minute	Each 5 minutes.
1 : 80,000	10 minutes	1/10 minute	Each 5 minutes.
1 : 60,000	5 minutes	1/10 minute	Each 5 minutes.
1 : 50,000	5 minutes	1/10 minute	Each 5 minutes.
		<i>No border scale.</i>	
1 : 40,000	5 minutes	1 minute	Each 5 minutes.
1 : 30,000	2 minutes	1 minute	Each 2 minutes.
1 : 20,000	2 minutes	1 minute	Each 1 minute.
1 : 15,000 and larger	1 minute	1 minute	Each 1 minute.

III. LETTERING AND NUMERALS.

13. Heights and gauges.—The heights of letters and numerals are defined by the numbers stamped on letter gauges. Letter gauges have either two prongs or three prongs. The number stamped on the gauge is the distance, in tenths of millimeters between the two prongs of a two-prong gauge, or between the middle prong and the more distant prong of a three-prong gauge.

Lettering to consist of capitals and lower-case letters will be called for as l. c. with the gauge number, which will be the height of the lower case "a."

Lettering to consist of capitals only will be called for as caps. with the gauge number, which will be the height of all the capital letters when the Roman alphabet is used and the height of all the capital letters except the initial letters when block letters are used for place names; the heights of the initial letters being one-sixth greater than the gauge of the others in the latter case.

In the same manner the heights of numerals will be called for by gauge numbers.

14. **Lettering.**—So far as practicable, names belonging to the land should be placed on the land area and names belonging to the water should be placed on the water area. If possible, they should be lettered wholly on either a shaded or an unshaded surface.

The chart number and price and the subtitle and chart number should be inked on the smooth drawing in the position, gauge, and style as on chart No. 1266.

The minimum height of letters should be 10 gauges.

For names of railroads initials only should be used. The initials should be those of the corporate name of the system rather than those of a particular branch of a system.

Notes other than the standard notes are to be lettered in 12-gauge l. c. slanting block letters.

The letters of a name should not be so far separated as to be difficult to read. The eye should see the name at a glance without the necessity of following the letters one by one. Legibility is more important than the extension of a name to cover the entire area of the feature named. If the feature is of considerable extent, as a river, the name may be lettered in more than one place.

In general, names not parallel with the bottom of the chart should be lettered on a curve so as to be read from the direction of the bottom of the chart, except that, when the axis of a channel is practically a straight line, the name should, if possible, be lettered on a line parallel with the axis and the name of a range should be parallel with the range line. Sharp curves and reverse curves should be avoided.

All lettering relating to land features or fixed objects above high water in the water area should be in upright letters, except that when the abbreviation Bn at a beacon symbol is placed on the water area the lettering should be slanting block. The most important place names should be in upright roman caps. The less important place names and the descriptive names of objects of importance to navigation whose positions are accurately determined should be in upright block caps. All other land objects named, such as "Customhouse,"

Soll Chain
 "City Hall," "Village," etc., are to be lettered in l. c. upright block, with upright block caps., for the initial letters.

The characteristics of lighthouses, lighted beacons, and post lights should be in upright block letters and numerals, using caps. and l. c. letters, as given in the standard notes.

Descriptive words or clauses relating to land features, such as "high hill," "sand dunes," "heavily wooded," "swampy," etc., should be in upright block, all l. c. letters.

All lettering relating to water areas, underwater features, floating objects (such as light vessels and buoys), and the abbreviation Bn at day beacon symbols when it is placed in the water area should be in slanting letters. The names of the most important water areas should be in slanting roman cap. letters and less important names should be in l. c. slanting roman letters, the gauge increasing with the importance of the name. In case of l. c. roman, where the letters C, G, and S occur as initial letters, these letters should terminate with a ball instead of a spur. Names of buoys and light vessels when shown should be in slanting block caps., and the characteristics of light vessels, buoys, and the bottom should be lettered in slanting block letters, using caps. or l. c., as given in the standard notes.

Descriptive words or clauses, referring to water or underwater features, such as "tide rips," "breakers," "shoal reported," "dangerous area," etc., should be lettered in slanting block, all l. c. letters.

Legends and numerals in or along dredged channels, such as "24 feet June 30, 1919," should be in slanting block, all cap. letters.

No periods should be used in water areas, as they may be taken for rocks.

The placing of names in water areas so as to obstruct channels should be avoided; for instance, do not place a name along the line of deepest water nor across a channel, if it can be otherwise arranged.

Names of water areas which can not be placed inside the limits of such areas without detracting from the clearness should, when possible, be placed outside, where the work is more open, in a position to clearly indicate the area named. If this is impossible, then the name may be lettered on land, which, although objectionable, is better than detracting from the clearness of the work.

Handwritten examples of slanting letters:
 II n n n

15. Numerals.—Sounding figures and the elevations of hills, mountains, and other objects on land should be in upright block numerals, on lines parallel with the bottom border of the chart. Elevations (except those at lighthouses and lighted beacons) which for any reason have to be placed in the water area, should be in slanting block numerals, inclosed in parantheses.

The numbers at buoys and at day beacons, when placed in the water area, should be in slanting block numerals.

The projection figures should be in upright roman numerals.

Fractions should be one-third higher over all than the gauge of the whole numbers, and, when used with whole numbers, the dividing line should be omitted. When a fraction is used by itself, the dividing line should be shown or it will look like two whole numbers.

IV. TOPOGRAPHY.

16. Shore-line and conventional signs.—The conventional signs used on the land areas of chart drawings should be those heretofore adopted by the U. S. Geographic Board, or that may hereafter be adopted by the Board on Surveys and Maps.

The shore line (high-water line) being the dividing line between land and water, should be a firm, solid line, the most prominent line on the chart inside the neat line. (See chart No. 1209.)

Unnecessarily minute detail, such as was shown on the old charts of the 1:80,000 and 1:400,000 series, should be avoided; but, on the other hand, all topographic features should not, in general, be omitted from any chart. (See charts Nos. 221 and 1213 as samples of the amount of detail to show at this time. With a larger personnel more detail than shown on those charts may be authorized.)

Fence lines, property lines, and boundary lines between political subdivisions should not be shown unless specifically called for.

All vegetation symbols will generally be omitted from charts of scales smaller than 1:100,000, and grass symbols from all charts.

When vegetation symbols are shown, they should be drawn with fine lines and widely spaced; this applies particularly to marsh ruling. They should be entirely subordinated to all other features and kept quite clear of the lettering, numbers, and other lines. They should

never be so drawn as to make them prominent nor so placed as to detract from the clearness.

House and building symbols should, in general, be omitted except along the water front and except in the case of some prominent buildings, such as customhouses, city halls, maritime exchanges, etc., the charting of which will be desirable information for a mariner. Such individual buildings, back from the water front, should always be named on harbor charts.

17. Prominent objects.—Prominent objects which can be seen and identified from the water, such as the summits of hills or mountains, lighthouses, towers, tanks, stacks, spires, etc., are of special importance to mariners. Their positions, if determined by the triangulation, should be carefully plotted by their geographic coordinates, or, if located by cuts on the topographic sheets or by sextant angles on the hydrographic sheets, their positions should be carefully transferred from those sheets to the drawing.

Lighthouses are represented by their own distinctive symbol and should not be accompanied by the word "light." On charts of scale of 1:200,000, or smaller, mountain or hill summits are represented by a dot surrounded by hachures, and on large-scale charts, if a triangulation point, they are represented by a dot inclosed in a small triangle. Other such objects are represented by a dot to define the position, inclosed in a small circle, together with a short descriptive name such as "Tank," "Tower," "Ch. sp.," "Tallest chy.," etc.

18. Cities and roads.—Only through, connecting, public highways and roads leading from such highways and terminating at the shore should be shown. They are all to be represented by two fine parallel lines. The distance between the lines should never be less than four-tenths of a millimeter on charts of scale 1:80,000, or smaller, or the space will fill up in the process of reproduction. On the larger-scale charts the distance between the lines should be increased.

In general, highways should not be shown on charts of smaller scale than 1:250,000.

Cities and towns will be represented as stated below.

On charts of scale 1:60,000 and larger show the lines (double lines), in their correct position, of such streets only as are actually constructed and in use, or as much thereof as is directed by the chief of section. The street intersection should be left clear, and the lines should all be of equal strength.

Show buildings along the water front on harbor charts and only such individual buildings back from the water front as are of special prominence.

Street lines should be broken for the city names and other lettering, and in general the blocks should not be shaded.

On coast charts, scale 1:80,000, and on general charts of the coast, scale 1:200,000 to 1:400,000, represent cities as follows:

Show such streets only as are actually constructed and in use by single lines. If the lines are crowded, omit alternate streets or as many as are necessary to prevent crowding. The street lines should not be less than 1 millimeter apart.

On sailing charts, scale 1:600,000 and smaller, represent cities by the conventional symbol of crossed or intersecting lines, shaping the symbol for large cities to approximate their extent and shape.

City streets should be named only on the largest-scale harbor charts when the street lines are far enough apart to admit of clear lettering.

In general, city electric railways should not be shown nor suburban electric railway lines within the city limits.

In railway yards, represent only enough of the tracks to indicate that the area of the yard is covered with tracks or show the limiting tracks and add an appropriate legend. An extensive system of side-tracks should be similarly treated.

19. Elevations.—Elevations of distinctive hills, all mountain summits, important islets, and prominent cliffs are to be charted whenever the information is available. They should always be placed close to the point referred to in such manner that there may be no uncertainty as to the identity of the object.

Elevations of points on side slopes should be omitted.

Only when necessary to a proper understanding of the topography, elevations may be placed in the contour lines at suitable intervals,

either in breaks in the lines or at their ends and parallel with the direction of the lines. The positions for such elevation figures should be selected so as to be read from the direction of the bottom of the chart.

20. Contours and hachures.—In general, on charts of scale 1:200,000 and larger the land forms should be represented by contour lines. The contour interval is a subject for special determination for each chart and will be indicated in the specifications.

The contour interval on any one chart should be uniform; but where important to bring out a summit or other feature, an intermediate contour in a dotted line may be shown.

If accurately determined contour lines and form lines appear on the same chart, the form lines should be shown by broken lines; otherwise both should be shown by full lines. An appropriate note should be added to the chart when form lines are charted.

Every fourth or fifth (in elevation) contour line or form line should be accentuated, but these accentuated lines should not be as heavy as the shore line.

Depressions are best shown by adding the elevation of the lowest contour line in the depression.

For charts of scale smaller than 1:200,000 contours should not be used, but the hills should be hachured (at least at the summit), and, if shaded, the light is to be considered as a northwest light.

21. Military features.—No name or symbol will in future be used in any chart compilation which relates to any occupied fortification, and no lettering which indicates the position of forts, batteries, barracks, or other military structures. At and near actual batteries nothing should be shown except the natural features of the ground and such lighthouses, beacons, and other structures as have been erected as aids to navigation.

In rare instances, where an object of present military importance may also be considered to be an essential navigational feature, it is to be brought to the attention of the chief of section, and may be charted only after the Chief of Engineers, U. S. Army, consents thereto.

Such names and features now on the charts should be retained until their removal is directed.

V. HYDROGRAPHY.

22. Conventional signs.—The conventional signs used should be those heretofore adopted by the U. S. Geographic Board, or that may hereafter be adopted by the Board on Surveys and Maps. Reef symbols should be used only when the area covered is sufficiently large so that the symbol may be distinctly drawn. When the area is of small extent, the symbol reproduces as an exposed rock or islet. For such areas use one or more sunken rock or rock-awash symbols or both, according to the conditions. A sufficient number of the symbols should be used to cover the area without crowding.

In drawing the rock-awash symbol one of the lines should be parallel with the bottom neat line, then crossed with an oblique line; the third line should then be drawn as two dashes not quite touching the other lines, so that the center will not fill up when reproduced. This symbol should never be less than a full millimeter across.

All rock symbols and rocks above high water should be surrounded with a dotted curve when they are not on a sanded surface; this is to make them more prominent and prevent their being taken for dirt spots.

The symbols for sunken rocks and rocks awash may be used in a conventional way in localities that are generally foul, where it is impracticable to get the actual depths.

The sunken-rock symbol should not be used when the depth on the rock is known, except on small-scale charts, when there is no room for the depth figure.

23. Size of sounding figures.—When making corrections to charts, the size of the soundings should correspond with those on the chart.

On compilations and smooth drawings of new charts or of new drawings of published charts use 18 gauge for soundings in open water and throughout the entire area of large-scale charts where the detail permits. When necessary, use 15 gauge for soundings inshore or in complicated areas. In exceptional cases soundings of 12 gauge may be used, but none smaller than 12 gauge.

When soundings of different gauges are used on one chart, they should be used systematically and soundings of one size not intermingled indiscriminately with those of another size.

In compiling, the tendency is to draw small sounding figures, especially in complicated areas, as it is simpler to use many soundings than to show the conditions with a fewer number. This results in crowded conditions and lack of clearness on the smooth drawings when the standard gauges are used. It is better practice on the compilations to use figures larger than the standard rather than smaller.

The least depths on shoals are important and the figures should never be made smaller in size than the deeper surrounding soundings nor obscured by placing deeper soundings close to them.

It must be kept in mind that small figures and symbols are illegible in the uncertain light that navigators very often have to work with, and that it is the duty of the compiler never to make the sounding figures smaller than the gauges mentioned above except on corrections where the soundings already charted are smaller.

24. Unit for soundings.—On any one chart all the soundings must be expressed in the same unit, either in feet or in fathoms. This includes larger-scale plans on a chart and applies also to all of a group of plans forming a chart.

Existing charts on which the soundings are expressed in two units are to be changed only when a change to one unit is called for.

25. Plane of reference.—The plane of reference for soundings will be stated in the chart specifications. In general, the plane of reference on the Atlantic and Gulf coast is mean low water and in other regions it is mean lower low water. There are exceptions, and for this reason, in correcting charts, the plane of reference should be noted and the correction made to correspond.

The plane of reference of the soundings on all charting material must be satisfactorily established before using and the soundings reduced, if necessary, to the plane of the chart.

26. Use of fractions.—The following rules must be followed in charting soundings from all data used:

SOUNDINGS CHARTED IN FEET—General rule.—No fractions should be charted. To convert to integers, drop all fractions less than 0.8 and for every fraction amounting to 0.8 or more take the next higher integer. For the minimum depth on an outlying shoal or danger,

when such depth is less than 40 feet, drop the fraction of the minimum depth.

Exceptions.—On bars, ranges, or in channels the fraction one-fourth, one-half, or three-fourths should be used where its use will keep a depth curve open to more clearly define the channel.

In converting tenths to quarters use the following:

0.1 equals 0	0.6 equals $\frac{1}{2}$
0.2 equals $\frac{1}{4}$	0.7 equals $\frac{3}{4}$
0.3 equals $\frac{1}{4}$	0.8 equals $\frac{3}{4}$
0.4 equals $\frac{1}{2}$	0.9 equals 1
0.5 equals $\frac{1}{2}$	

SOUNDINGS CHARTERED IN FATHOMS.—*General rule.*—For depths less than 7 fathoms, soundings should be charted in fathoms and quarter fathoms (one-half being charted for two-fourths), and for depths of 7 fathoms and greater, but less than 8 fathoms, the soundings should be charted in fathoms and half fathoms. For depths greater than 8 fathoms no fractions should be used.

Exceptions:

First. For the minimum depth on a shoal, reef, or rock, surrounded by generally deeper water, and for the controlling depth on a bar or range or in a channel where the depth is less than 40 feet, and when the use of a fraction will keep a curve open to more clearly define a channel, the soundings, if in feet and fractions, should first be converted into integers according to the general rule under "Soundings charted in feet" and then charted in fathoms and sixth of fathoms, using one-half for the fraction three-sixths.

Second. Fractions should usually be omitted near the edge of reefs and on abrupt slopes where they have little significance.

In converting feet to quarter fathoms use the following:

0.0 to 0.9 or 0	to $\frac{3}{4}$ feet equals 0 fathom.
1.0 to 2.4 or 1	to $2\frac{1}{4}$ feet equals $\frac{1}{4}$ fathom.
2.5 to 3.9 or $2\frac{1}{2}$	to $3\frac{3}{4}$ feet equals $\frac{1}{2}$ fathom.
4.0 to 5.4 or 4	to $5\frac{1}{4}$ feet equals $\frac{3}{4}$ fathom.
5.5 to 6.0 or $5\frac{1}{2}$	to 6 feet equals 1 fathom.

In converting feet to half fathoms use the following:

0.0 to 1.9 or 0	to $1\frac{3}{4}$ feet equals 0 fathom.
2.0 to 4.9 or 2	to $4\frac{3}{4}$ feet equals $\frac{1}{2}$ fathom.
5.0 to 6.0	feet equals 1 fathom.

In converting feet to fathoms use the following:

0.0 to 4.9 or 0 to $4\frac{3}{4}$ feet equals 0 fathom.

5.0 to 6.0 feet equals 1 fathom.

27. Dredged areas.—In general, the limits of dredged channels and other improved areas should be shown by broken lines and a legend added either within the improved area or channel or just outside the channel lines, giving the controlling depth and date; for instance, such a legend as "24 feet June, 1920." This is sometimes modified or changed by direction of the chief of section.

On charts of scale smaller than 1:100,000 the limiting lines are sometimes shown without the legend when the area is covered by charts of a larger scale.

28. Wire-drag surveys.—The soundings on shoals or rocks discovered with the drag should be the first to be charted in compiling a new chart or a new drawing of a published chart.

In applying the soundings of drag sheets to published charts, examine all advance information received from the chiefs of wire-drag parties, to the end that the same sounding will not be charted twice. (The advance positions of shoal soundings are often taken from boat sheets and charted by bearings and distances and may differ in position from the position on the finished drag sheet. The final reduced depths may also differ from those furnished in advance.)

After charting the soundings the area covered by the drag should be examined for soundings of less depth than the effective depth of the drag. This applies to finished compilations, as well as the published charts, and a wire-drag sheet may not be considered as applied to either until this is done. The source of all such soundings should be ascertained, if possible. If such a sounding comes from a miscellaneous report, remove the sounding; if from a survey sheet, bring it to the attention of the chief of section that it may be referred to the section of field records. The chief of section will then direct how such soundings should be treated, and the facts in the case should be entered on the record form of the chart.

29. Selection of soundings.—It must be kept in mind that no feature of the chart is of more importance than the selection of soundings

so as to properly and clearly represent the hydrographic features. As the survey sheets are generally of much larger scale than the chart and contain as many of the soundings taken as can be plotted thereon, it is obvious that only a percentage of the soundings can be shown on the chart. Moreover, it is objectionable to crowd the chart with unnecessary soundings, which detracts from its clearness and shows only a lack of skill on the part of the cartographer.

As stated in article 28, the soundings on wire-drag sheets come first; then should follow the soundings that will bring out clearly all shoals by their least depth and the channels by the practicable channel depths. This must be done before spacing the surrounding soundings. Subject to the foregoing, the soundings over areas completely developed should be shown fairly uniformly and without crowding.

The details of the survey sheets should be generalized so as to show the predominating characteristics only.

Before selecting the soundings study the charting material thoroughly until you are sure of the control, the plane of reference, the unit of soundings, the dates of the surveys, and the general characteristics of the area covered. Until this is done an intelligent selection is impossible.

In selecting channel soundings first draw a line through the soundings of maximum depth running with the channel and select soundings along this line. If there are channel ranges, a line of soundings on the range should be selected. After this is done, in order to fill in with other soundings, draw in a curve on the survey sheets of a depth approximately the controlling or minimum depth on the maximum-depth line. This curve will define the navigational limits for a vessel whose draft approximates the controlling channel depth and will aid in filling in soundings within those limits. In general, the soundings will be more closely spaced in such areas than elsewhere, and it follows that any unnecessary sounding is more objectionable than it would be in other areas.

After the shoals are shown and the channels developed, the selection for the rest of the chart depends on the physical characteristics of the bottom, so no hard and fast rules can be stated. If the slopes

are gentle, it is simply a matter of as uniform a spacing as the surveys will permit.

If the bottom is undulating, consisting of a series of ridges and hollows, as on the New Jersey coast, a uniform selection, using the soundings of least depth will result in an erroneous representation. In such a case some of the deeper soundings should be shown, even if it necessitates a somewhat closer selection. If the bottom is rocky and broken, a uniformly spaced selection is impossible. The minimum depths must be shown and then filled in with the deeper soundings between them, care being taken not to place a deep sounding so close to a danger as to tend to obscure it.

Soundings of the same depth as a curve and placed close to or on the curve are of doubtful value.

When the scale of the chart is so small that channel depths can not be clearly shown with standard-gauge soundings, the soundings should be omitted, and the smaller the scale the more should the details be generalized.

Do not make an office survey. If a recent survey shows greatly changed conditions where it joins an older survey, do not force a junction, but leave a blank space beyond the limits of the more recent survey.

30. Shoals and dangers.—Shoal spots must be clearly shown and nothing permitted to obscure the soundings.

Exaggerate the size of surrounding curves on the compilation so that they will not touch the sounding figures, and, if it is a curve that is usually sanded, draw it sufficiently distant from the sounding to permit of several rows of sand dots outside the sounding figure. This must be done on the compilation and not left to the engraver or draftsman making the smooth drawing. Sand dots must not be placed within the numerals nor nearer to the body of any numeral or letter than the average space between dots. When the curves around shoals join, they should be generalized into one shoal. In interpreting the above, however, care must be taken not to close or seriously lessen the width of practically navigable channels.

A shoal sounding on an isolated rock should have the abbreviation Rk placed near it.

Soundings should be omitted within the space covered by groups of rocks or coral heads through which there is no well-defined channel.

Islets and rocks awash must never be confused by placing soundings close to them; the symbols, as they represent the greater dangers, are of much more importance than adjacent soundings.

When of sufficient importance and the information is available, the height of rocks which are covered at high water may be indicated as follows: "bares 7 ft." or "7 ft. above L W."

Isolated shoal soundings, not definitely located by survey should be accompanied by the abbreviations PD or ED, as indicated by the information.

31. Depth curves.—Depth curves or sanded spots other than low-water sand should never be used in the place of a sounding to designate a shoal. The depth curves that will most generally be shown on charts are the 0 or low water, the 1, 2, 3, 5, and 10 fathom curves. Other curves that are shown on some charts are the 4, 4½, 6, 20, 30, 50, 100, and 1,000 fathom curves.

The symbols heretofore adopted by the U. S. Geographic Board, or those that may hereafter be adopted by the Board on Surveys and Maps, should be followed, except when the area inclosed is sanded, in which case the outer edge of the sand or dotted surface represents the curve.

Depth curves are used to supplement the soundings in bringing out hydrographic features and to emphasize shoals and dangers. They are not intended to be accurate contour lines, and more liberty may be taken with them. It is absolutely necessary in good charting work to exaggerate, at times, the area inclosed by a curve and to generalize freely.

Unimportant detail in depth curves should be avoided; unnatural convolutions, due, perhaps, to slight inaccuracies in the survey, and small and narrow indentations of no navigational importance should be smoothed out; spots or lumps, separated by deeper water, should be included in a single curve when the intervening spaces have only slightly greater depth or have no navigational importance and can not be shown properly on the scale of the chart. Curves should

never touch or run through sounding figures and should be enlarged for shoals, as stated in article 30.

Depth curves should include all soundings of the depth represented after the soundings have been reduced for charting; for instance, a sounding of 30.7 feet on the survey sheet would be outside the 30-foot curve on that sheet. Reduced for charting, it becomes 30 feet and should be included in the curve.

When depth curves run together, as they will on abrupt slopes, retain the curve of least depth, and omit the others between the points where the curves meet.

An isolated sounding of less than 18 feet should be surrounded by one sand curve only, together with the next charted curve of greater depth than 18 feet, if the surrounding depths are greater than that curve.

Depth curves around depressions within the limits of a curve are of little value and should be omitted except those that aid in indicating the line of a navigable channel. It is, however, good practice to chart the deeper soundings within the limits of curves to indicate the physical characteristics of the bottom.

When a curve is closed off at the head of a bay or in a river, it is usually desirable to omit this curve farther up.

When the survey does not develop the curve, either omit it or show broken portions only. Do not attempt to develop the curve in the office.

The depth curves should be so drawn as to show a distinct, continuous line, avoiding spaces too great between the dots and dashes and avoiding open spaces at abrupt turns in the line.

32. Sanding.—Sanding is the name applied to the shading of an area by means of dots. The dots should be round in shape to look well.

The areas included by the low water, 1, 2, and 3 fathom curves are usually accentuated by sanding, heavier at the curves and so drawn as to give the appearance of a rounded edge and so as not to form distinct lines of dots back of the first line on the curve. When the areas are extensive, the sanding should extend back only a short distance, the shading becoming lighter and lighter until it

blends into the unshaded area in such a manner that the eye will see no distinct limit between the shaded and unshaded portions.

There should be no great distinction in the shade of these curves. Very light sanding for the 3-fathom curve is not sufficient for this important curve, while too heavy sanding for the low water and 1-fathom curves diminish the distinction between land and water.

The low-water curve is always sanded, while the 1, 2, and 3 fathom curves may sometimes be shown by their symbols, as directed.

(See also article 30 for sanding around letters and numerals.)

33. Bottom characteristics.—Information as to the character and material of the bottom is of great help to the navigator, and should be charted when known. The abbreviations of the words used to describe this material, when charted, are known as "bottoms."

The abbreviations heretofore adopted by the U. S. Geographic Board or those that may hereafter be adopted by the Board on Surveys and Maps, should be used, omitting the periods.

In harbors and inland waters the chief value of the bottoms is to indicate good, bad, or indifferent holding grounds for anchors, and should be limited to single words, such as "M.," "S.," "rky.," "stk.," "sft.," "hrd.," etc.

Offshore bottoms are of value as an addition to the soundings in aiding the navigator to locate his position. They should be more descriptive than the bottoms for inland waters, but should not be too long and complex. They should be placed at useful intervals and not crowded, a distinct "bottom" within an area of a different "bottom" is of special value. They should be placed in line with the sounding, but a little below and to the right, if practicable.

34. Anchorages and forbidden anchorages.—Anchorages and forbidden anchorages, when charted, should be shown by lettering an appropriate legend within the limits which should be indicated by lines of short dashes (two dashes joining at the angles), except that on the special anchorage chart, No. 541, the limiting lines are to remain full lines, as shown thereon.

35. Dumping grounds, cables, and pipe lines.—Dumping grounds, when charted, should be shown by lettering the legend, dumping ground (see article 14) within the limits, which should be shown

by lines of short dashes; two of the dashes should join at the angles. Except for the legend the area within the limiting lines should be left clear.

Unless specially directed, cables and pipe lines should not be shown.

36. Sailing lines and bearings.—Sailing lines are charted in only special cases when directed by the chief of section.

Bearings or azimuths of sailing lines and ranges, when given on charts, should be expressed as from seaward and in degrees using the graduation 0° to 360° from true north. The word "True" should be lettered after the bearing in block caps, and both the numerals and letters should be slanting and on a line parallel with the line to which they refer.

VI. AIDS TO NAVIGATION.

37. Conventional signs.—The objects usually referred to as aids to navigation or "aids" include lighthouses, post lights, lighted beacons, range lights, day beacons, spindles, fog-signal stations, light-ships, and buoys of all kinds. They should be represented by the conventional signs heretofore adopted by the U. S. Geographic Board, or those that may hereafter be adopted by the Board on Surveys and Maps.

On charts of such small scale that they can not be used in the navigation of inland waters (waters inside the general coast line) all the aids to navigation, except those of sufficient prominence to be used as landmarks, should be omitted from the inland waters.

Lighthouses are shown by a six-pointed star, and post lights, range lights, and lighted beacons by a five-pointed star, on all charts of scale 1:400,000 and larger, and all lights are to be represented by a round dot on charts of smaller scale than 1:400,000; all symbols centered on the plotted position when determined by triangulation or by the surveys.

The six-pointed star should measure about 3 millimeters over all, except that on the small-scale charts, when the lights are colored they should measure about $2\frac{1}{2}$ millimeters. The five-pointed stars should measure about 2 millimeters and the round-dot symbols a scant millimeter over all.

The ray lines (limits of sectors) should be represented on the smooth drawings by straight lines of dots, with a suitable legend such as "red sector," "light obscured," etc., lettered between the ray lines on an arc of a circle.

No distinction is made in representing the different kinds of day beacons. They are all shown by the filled-in triangle accompanied by the abbreviation Bn. The base of the symbol should be parallel with the bottom neat line of the chart.

Buoy symbols should not be made so small that they can not be seen at a glance. Wherever there is room, the ordinary buoy symbols should measure about 4 millimeters from the dot to the top of the symbol, and so far as practicable, should be uniform in size on any one chart or in any distinct area of a chart. The dot marks the position of the buoy.

The symbol for a spindle should always be accompanied by the word "Spindle."

The position of a mooring buoy is indicated by the small circle at the base of the symbol.

The position of a lightship with one mast is indicated by the dot at the top of the mast on the symbol, and the position of a lightship with two masts is indicated by a point midway between the dots at the top of the two masts on the symbol.

38. Applied to drawings.—The positions of all lighthouses, post lights, range lights, and beacons, when determined by the triangulation, are to be plotted by their geographic coordinates, or, if determined otherwise and shown on the survey sheets, they are to be carefully transferred to the compilation. Extreme care should be taken, however, by examining the records, that no change in position has occurred since the date of the triangulation or survey. Such determined aids should be inked in at once on the compilation.

All other aids should be transferred from the survey sheets when shown thereon, but left in pencil on the compilation.

Buoy symbols and the lettering at the aids should be so placed, if possible, as to leave the channel clear.

The minimum depths on shoals, rock symbols, and islets should never be erased or obliterated in placing buoy symbols. If neces-

sary, the symbols should be placed out of position sufficiently to clear such features.

After the compilation is finished it should be submitted to the cartographer in charge of aid corrections for examination, and to furnish the other aids to be charted, together with the lettering at all the aids. These should then be inked on the compilation and the work revised, if necessary, where erasures are made for the symbols and lettering.

The above procedure is for all compilations, whether for new charts, new drawings of published charts, or corrections.

The aids to navigation are not to be inked on the smooth drawing until the rest of it is finished and not until the aids are again revised.

39. Erased from charts.—It frequently happens that a spindle, beacon, light, or other aid is built over an islet or rock or in the position of a minimum sounding on a shoal. Extreme care should be taken, therefore, whenever such an aid is erased from a chart, to restore the space occupied to its condition before the aid was charted.

VII. MISCELLANEOUS.

40. Coast Guard stations and radio-compass stations.—Coast Guard stations should be shown by the conventional sign, together with the number of the station, such as C.G. No. 12, except that, when some feature of the station is a prominent object and determined, a small circle with center dot should be used with a descriptive legend, such as "Cup. C.G. No. 14."

Radio-compass stations should be shown by a small circle with center dot and the capital block letters "R. C."

41. Names.—For geographic names the decisions of the U. S. Geographic Board will govern. For names not covered by such decisions those already charted or published may be used, preference being given to those previously published on the charts of this Bureau. Names on the survey sheets may be used if it is stated in the descriptive reports that they are local names, but new names suggested by any officer of the survey may not be charted until a favorable decision is made by the U. S. Geographic Board.

While it is desirable that places should be correctly named and the names correctly spelled, that is not a feature of first importance on a chart. It is a feature, however, on which an amount of time out of all proportion to its value may be spent, and this must be avoided. When there is a question as to a choice of names, refer the matter to the chief of section.

On compilations of new charts or new drawings of published charts omit the possessive form of geographic names; but this is not a matter of sufficient importance to warrant the expenditure of time in correcting such names on the published charts.

Generally, excepting geographic names and the names of railroads, no personal or corporate names should be charted, and the only name of the personnel of the Survey to appear on the chart is that of the Director in the publication note.

In the use of the terms "shoal," "bank," and "reef" the following distinctions should be made, but only in case of new objects not previously shown or where the usage has not been fixed: "Shoal" should be applied only to knolls of small extent and also to larger areas on which there is a depth of 6 fathoms or less surrounded by deeper water; "Bank" should be applied to areas of some extent on which there is more than 6 fathoms surrounded by deeper water; and "Reef" is always of rock or coral formation of some extent and should not be used where the minimum depth is more than 6 fathoms at low water.

42. Immediate corrections.—All changes in the aids to navigation and all dangers to navigation, such as rocks, shoals, wrecks, etc., reported or developed by the surveys must immediately be indicated on the charts affected, by the cartographer in charge of such work, to be applied by hand to the existing supply of charts.

43. Corrections to Charts.—Drawings for corrections to published charts should differ from those for new charts and new drawings of published charts in that they should follow the style of the chart corrected.

As some of our charts are still published with the double-sounding unit (feet and fathoms), this fact should be specially noted when correcting such charts. Also the datum on which the projection of the chart is based should be carefully noted before proceeding with

the correction. Consult the file of "Chart Datum" rather than relying on the correction shown to the projection figures of the chart, which are correct only to the nearest second.

It should also be kept in mind in correcting the charts of Porto Rico and neighboring islands that the elevations on most of those charts are expressed in meters.

When a chart is taken in hand for correction, the correction should be applied to all the charts affected in the order of their scales, making the drawing for the largest-scale chart first.

44. Title and notes.—The title, and standard notes should not be lettered nor drawn on the chart drawings unless so directed. The title and notes should be "set up" on cards in the order and position in which they are to appear on the chart. One card is to contain the title, numerical scale, and sounding note, in the order named, and needs no reduction. Another card will contain the notes, and a reduction to two-thirds of the size should be indicated thereon.

The position of the title and notes should be indicated on the smooth drawing in blue ink.

The publication note, seal, and correction note need not be "set up" nor lettered, but their positions should be indicated.

45. Compass roses.—The positions of the compass roses should be indicated on smooth drawings in blue ink, together with the variation and annual change. Compass roses should be located so as to be convenient to the most important navigational areas and at such intervals that any part of the water area is within the reach of a parallel ruler. So far as practicable they should be placed in areas clear of soundings or having few soundings, or on the land clear of topographic features. In no case should a compass rose be so placed as to obscure a danger.

In general, compass roses are to be corrected on charts when new bassos are made of copper plates, or when a new aluminum plate is made of a chart published by photolithography, or when the accumulated change in variation amounts to 1 degree, or whenever the year for which the variation is stated dates back more than 10 years.

46. Chart references.—References to large-scale charts, when directed, will be placed on charts in light italic l. c. block and in

parentheses, thus: (chart 369). They are to be engraved on the plates of charts printed directly from copper and printed in red ink on those charts printed from aluminum plates. They should never be placed on the smooth drawings. The reference should be placed in a convenient location contiguous to the area included or to the name of the feature covered by the larger-scale chart.

47. **Projections on copper.**—When a new chart is to be engraved on copper or the projection changed on a new basso, the projection should be constructed on the copper plate by a cartographer.

The interval of the projection lines should be that given in article 12, unless otherwise directed. The neat lines should also be traced on the plate and must be as correctly located as the projection lines, due allowance being made for the shrinkage or expansion of the drawing, so that they may be used by the engraver in laying down his work. As the drawing changes in dimensions under different atmospheric conditions and at different rates with and across the grain of the paper, while the copper plate remains practically true to scale, the photographic matrices made of the drawing to transfer the work to the copper plate will not exactly fit the corresponding lines on the copper. However, they can be made to fit in one direction, leaving the adjustment to be made in one direction only. The cartographer should determine the direction such necessary adjustment would least affect the accuracy of the chart and indicate on the drawing the direction in which the matrices should be made to exactly fit. Then in the other direction lines should be drawn on both the drawing and the copper, dividing the projection intervals into a sufficient number of equal spaces, or bands, to secure a practically correct junction of the work when laid down on the copper in bands of the same width as the subdivisions.

All lines should be traced lightly on the copper with a slightly dulled point, so as not to cut them so deeply that they may not be readily burnished out.

