

U. S. DEPARTMENT OF COMMERCE  
HARRY L. HOPKINS, Secretary  
COAST AND GEODETIC SURVEY  
LEO OTIS COLBERT, Director

Special Publication No. 216

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275  
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no.216  
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# THE UNITED STATES COAST AND GEODETIC SURVEY

Its Work in Surveying and Charting the Waters  
of the United States and Possessions  
Geodetic Control Surveys, and  
Other Activities

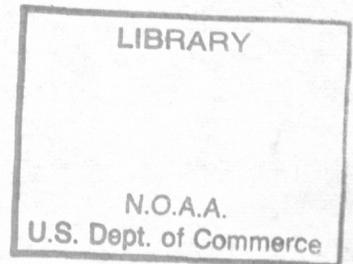
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THE UNITED STATES DEPARTMENT OF COMMERCE  
August 1938 Edition



U. S. COAST & GEODETIC SURVEY  
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JAN 25 1939

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UNITED STATES  
GOVERNMENT PRINTING OFFICE  
WASHINGTON : 1938

# National Oceanic and Atmospheric Administration

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12200 Kiln Court

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January 1, 2006

## COAST AND GEODETIC SURVEY

LEO OTIS COLBERT, *Director*

Every motorist who travels for any distance finds it convenient to use road maps and other data, that he may choose suitable routes, distances between overnight stops, accommodations en route, and available short cuts. The mariner, particularly in unfamiliar waters, finds charts and supplemental nautical publications more than convenient—they are indispensable. Approaching land, following sailing routes along a coast, or entering harbors, the navigator, unlike the motorist, cannot see the road ahead nor the underwater dangers to be avoided; in storm, fog, or darkness, there are no opportunities to ask the way. Unseen forces of the tide and ocean currents are acting continually to change the depth of the water under the keel of his ship, and to deflect him from his course.

The mariner is dependent in a large measure on adequate navigational information, not alone for the expeditious passage of his ship but for the safety of the lives and property under his charge. Striking evidence of this need is seen in the advantages, including decreases in shipwrecks and lower insurance rates, which invariably follow the completion of comprehensive coastal surveys and the publication of the resulting data.

Every maritime nation realizes the great practical value of a detailed knowledge of the nature and configuration of its coasts, the varying water depths, character of sea bottom, locations of reefs, shoals, and other dangers, the rise and fall of the tides, the directions and strength of currents, and the nature and amount of magnetic variation. All of these data, secured primarily for charts and related nautical publications, are becoming increasingly valuable because of their many collateral uses and their availability to everyone, as shown later in this section.

### HISTORY OF BUREAU GROWTH

The Federal agency which carries on this work for the waters under the jurisdiction of the United States is the U. S. Coast and Geodetic Survey. Organized in 1807, during the administration of President Thomas Jefferson, as the "United States Coast Survey," this service began operations in 1816, and except for the periods 1818–1832 and 1834–1836 has carried on its functions without interruption.

This service may be likened to any large self-contained manufacturing organization, with a central office of administration in Washington, D. C. (and an office in Manila covering the Philippines), supervising the operations of various charting activities on land and sea and utilizing the results, together with cer-

tain data from other sources, as basic materials for the preparation, printing, and distribution of the finished work.

The Atlantic coast from Maine to Georgia constituted the entire seaboard to be charted in the early days. With the addition of Florida, Texas, the Louisiana Purchase, the discovery of gold in California, the purchase of Alaska, and the addition of Puerto Rico, the Canal Zone, Guam, the Hawaiian and Philippine Islands, and the Virgin Islands of the United States, the demands upon the Bureau have grown with our national progress. Our seaboard now has a shoreline about 103,000 miles in length—more than four times the distance around the world.

From these coasts, surveys of water areas must be carried out to the edge of the continental shelf, in some places more than 100 miles from land, for the configuration of the ocean floor is now as much an aid to the navigator equipped with modern depth-registering devices as are the outstanding landmarks he sees on approaching land. Furthermore, there are extensive sections along this vast seaboard which are subject to constant changes, from both natural causes and the works of man. Resurveys of such areas at suitable intervals are necessary to maintain the accuracy of our charts, and they constitute a never-ending task.

The remarkable growth of our country has been accompanied by a corresponding development in its commerce and navigation. Vessels plying our waters have changed from a few leisurely moving sailing ships, of some 15 feet in draft, to large and speedy liners and freighters with drafts up to 40 feet. This development has necessitated on several occasions complete changes in the type of charts required for navigation.

The added responsibilities of this Bureau, caused by the growth of our country and the constantly increasing requirements of navigation, have been met to some extent by moderate increases from time to time in its personnel and facilities and to a much larger degree by internal improvement through the consistent development of new methods and equipment, some revolutionary in character, enabling the Bureau with an attendant accuracy of results to increase greatly the possible output from a rather fixed appropriation.

### GEODETIC SURVEYS

A consideration of the several major functions of the Bureau discloses the relationship which links these duties into a composite whole. One of the first requirements in the survey of any region is the establishment of geodetic control which is absolutely essential to the satisfactory execution of all extensive charting and mapping projects.

Geodetic operations, which take into account the curvature of the earth, include the determination of geographic positions (latitudes and longitudes) by triangulation or traverse, and the measurement of elevations by leveling. They also involve astronomical observations, the measurement of base lines, and the determinations of gravity, to the extent necessary to provide essential data for the prosecution of field work and the office interpretation of results.

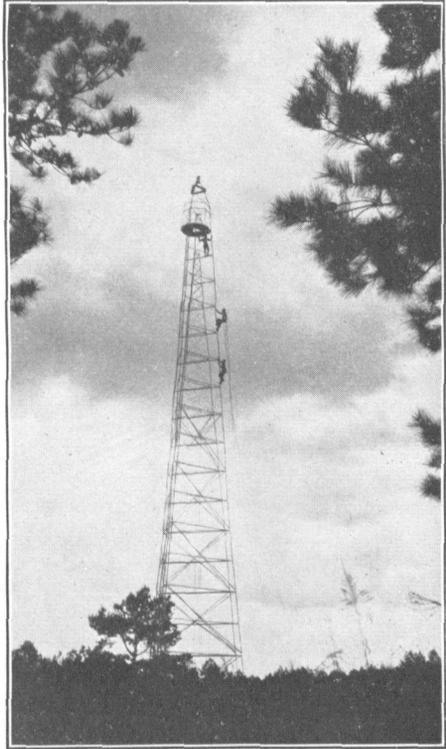
Having always carried on coastal control surveys, the Bureau in 1878 was assigned the continuation of such surveys into the interior, and its name was changed at that time to the "United States Coast and Geodetic Survey." It is because of this very practical control-survey job that a series of charts and maps covering the United States in its entirety may be put together like the many pieces of a picture puzzle.

As evidence of this work, there are today thousands of triangulation stations and bench marks distributed over the United States in accordance with the specific requirements at the time the work was executed. Any of these marks which may be disturbed can be accurately relocated in their original positions, merely by tying in with undisturbed stations in other areas.

While the job is far from complete, much work has already been accomplished, with control surveys carried out to some extent in every State. Our own Federal system has been extended by the Canadian and Mexican Governments, so that the whole American continent now has a uniform basis of control, known as the North American Datum.

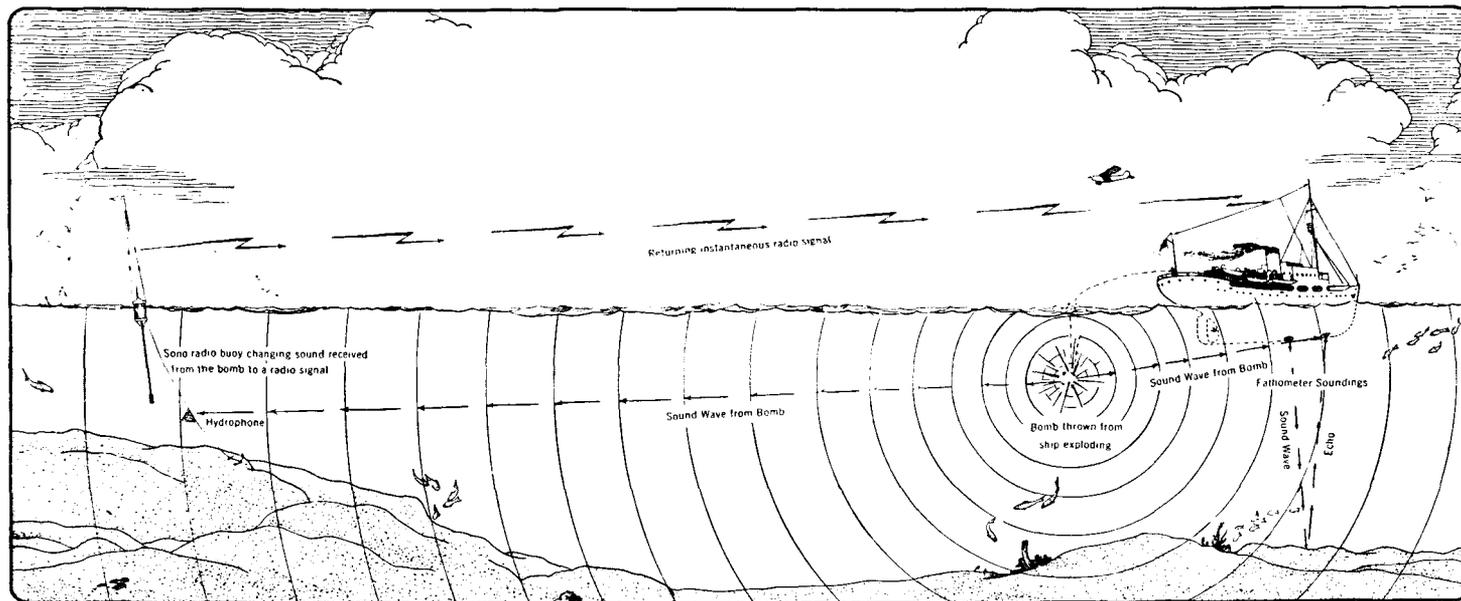
### HYDROGRAPHIC AND TOPOGRAPHIC SURVEYS

With control points available in the area under survey, the work of gathering the information required for charting purposes can be begun. A detailed topographic survey of the area adjacent to the coast line is made for use on the nautical chart but farther inland only important landmarks and mountain peaks visible at sea are included, since nautical charts are published primarily for navigational use. Topographic surveys by plane table, the method in use for many years, have recently been supplemented to a considerable degree by the use of air photographs, particularly in the lowlands near the coast. These air photographs are now being taken by a 9-lens air camera, designed by the Bureau, which can photograph, for survey purposes, over 130 square miles in a single exposure.



*Bilby Tower Used in Survey Work.*

Preparing to dismantle a 116-foot steel portable triangulation tower for transportation by truck to the next station. Many of these towers, designed by a member of the U. S. Coast and Geodetic Survey, are in constant use by field parties engaged in geodetic control surveys, as they overcome interference in vision due to the curvature of the earth, forest growth, etc. The inner tripod structure supports the theodolite used in measuring the angles of triangulation. The outer tripod, independent of the other so as not to disturb the instrument, is for the observer and recorder, or lightkeeper.



### Fathometer Soundings and Radio Acoustic Ranging.

Showing two of the scientific methods employed by the Coast and Geodetic Survey of the Department of Commerce to insure on nautical charts (1) correct water depths and (2) the precise positions of such depths, many of which are given for water areas far out of sight of land. Depths are determined with a fathometer, which measures the time required for a sound to travel to the sea bottom and return to the ship as an echo. They are made at the rate of 4 or more per second, while the survey ship proceeds back and forth over the area at her regular speed. The positions of these depths are fixed by radio acoustic ranging, from previously determined positions, of two or more sono radio buoys (of which one is shown). The time elapsed between the sound from the bomb as received on the survey vessel, and the radio signals from the sono radio buoys, is measured from a chronograph tape on the surveying ship to one one-hundredth of a second. Knowing the velocity of sound in water, the distance between the survey ship and each of the sono radio buoys, can be calculated accurately.

The surveys made from air photographs are published in the form of large scale planimetric maps. There are 650 of these available for various sections of the coast and the number is constantly increasing as new maps are published.

The nautical chart might be described as a topographic map of an area which has been flooded to the elevation of the contour represented by the shore line. Information concerning the water area of the chart is obtained by hydrographic surveys, which include the measurement of depths, the determination of the geographical positions of such depths, and the location of shoals, wrecks, aids to navigation, and similar features.

Various classes of vessels are utilized in this work, ranging from sea-going survey ships, in the offshore areas, to small launches or pulling boats for the work close to shore. A variety of methods for measuring depths and determining the position of the survey vessel are available for use, depending on the depth of water and the distance of the work from shore. In some regions where there are submerged dangers of small extent, such as pinnacle rocks and boulders, it is necessary to use a special apparatus called the "wire-drag," to make sure that all such features have been discovered by the survey. Hydrographic work is controlled with respect to location by the geodetic surveys in the vicinity and is closely related to the latter as well as to adjoining topographic surveys.

The diagram, page 12, graphically portrays two of the scientific methods employed today for hydrographic surveying. These and other developments have enabled the Bureau during recent years to reduce the cost of its work and extend the offshore limits of accurate surveys.

## TIDE AND CURRENT SURVEYS

The tidal work of the Survey serves a number of important purposes. For maritime commerce and for many lines of engineering work, the need for a knowledge of the rise and fall of the tides and of the flow of the currents is obvious. The establishment of datum planes for surveying, especially the determination of mean sea level at various points along the coast to serve as a basic datum for a level net extended over the whole country, is a prime necessity. A knowledge of tides and currents is also a basic requirement to scientists engaged in certain lines of research such as a study of marine life, phenomena associated with storms and earthquakes, and crustal movements of the earth as related to sea-level changes. As an essential element in the production of charts for the use of navigators, tides must be observed in connection with hydrographic surveys in order to reduce all soundings to a common datum. In addition to basic purposes outlined above, the tidal records also provide data serving many individual needs, as evidenced by frequent requests for special information pertaining to the tides in a particular locality.

Primary tide stations where tide observations are carried on continuously over a period of years have been established at a number of points along the coasts of the United States and Alaska. These are equipped with automatic gages which trace graphic records showing the rise and fall of the tide and operate

day and night with only occasional attention from an observer. Secondary tide stations where observations are carried on for relatively short periods of time are established at numerous places in connection with hydrographic surveys. Results obtained from such short-period observations are reduced to mean values through comparison with simultaneous observations at one of the primary stations.

Observations of tidal currents are usually attended with much more difficulty than are observations of the tide. Special current surveys in which a number of vessels are employed and which involve considerable expense are undertaken from time to time in some of the principal waterways of the country. Current observations are also frequently obtained in important passages by vessels engaged in a general hydrographic survey of the area.

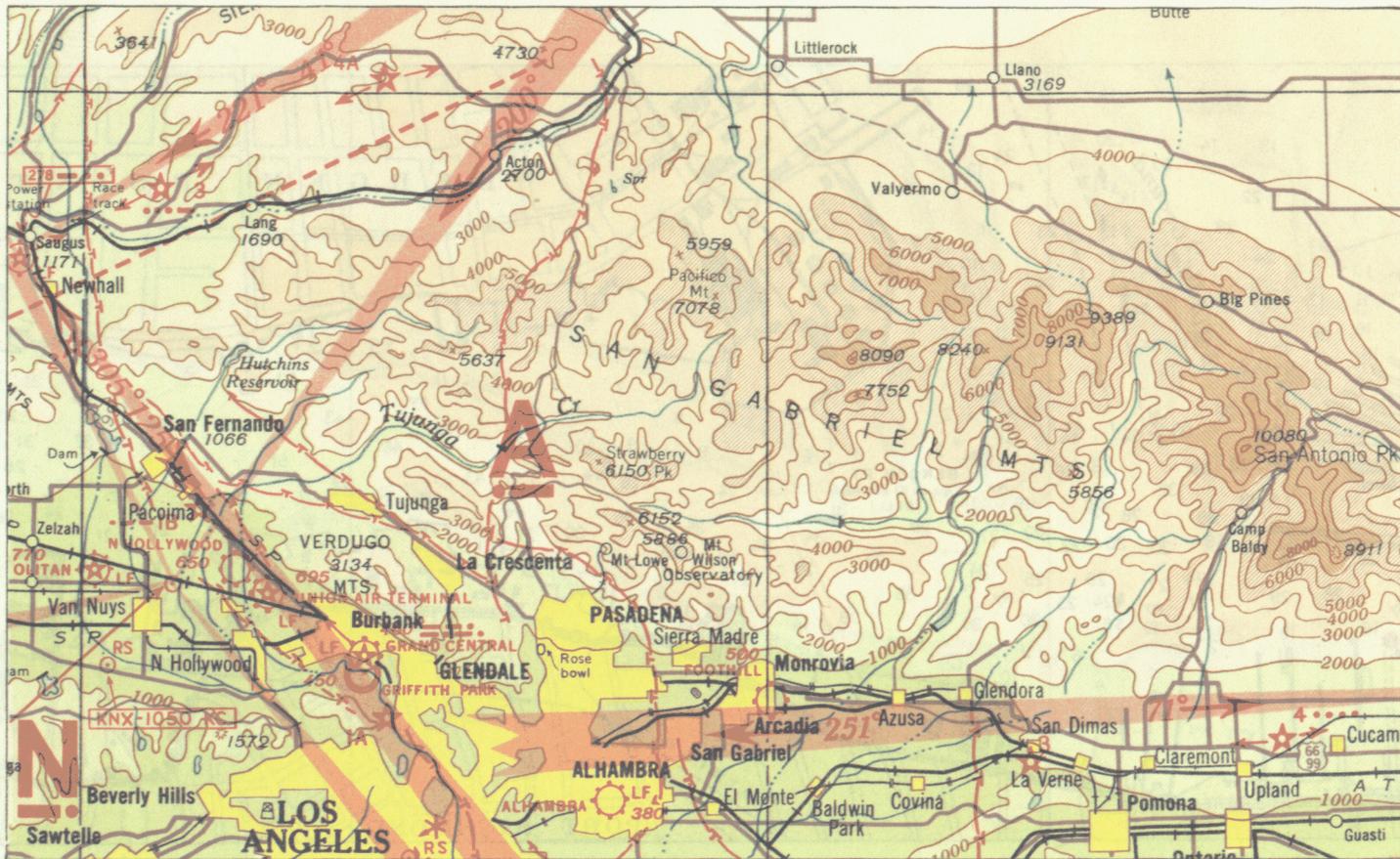
Tide and current tables giving predicted times and heights of the tide and times and velocities of the current are published annually in advance. These tables constitute the source of tidal predictions given in newspapers and almanacs throughout the country. The predictions are based upon observational data previously obtained for the various localities, and, with the exception of certain predictions for foreign ports secured through an exchange agreement, are made by means of a machine that has been especially designed to make the necessary calculations mechanically. Tidal current charts showing the velocity and direction of the current at different hours of the tide have also been published for several waterways. Other publications issued in connection with the tidal work of this Bureau include descriptions and elevations of tidal bench marks, discussion of results obtained from special current surveys, and various manuals for carrying on the work.

### MAGNETIC SURVEYS

When Columbus discovered that his compass did not continue to point to the north as he crossed the Atlantic Ocean, consternation reigned amongst his crew. Today navigators of the sea and air are furnished with the variation of the compass for all places on the earth, each country contributing its share of observations to complete the picture. To secure this information the Survey has made observations at over 6,000 places throughout the United States and its Territories and its vessels have made observations in the adjacent water areas, though the Survey does not possess a much needed small nonmagnetic ship. The change in the earth's magnetism from year to year is determined by continuous observations at five magnetic observatories, supplemented by short-period "repeat" observations at secondary stations in all States of the Union, and at suitable intervals along the coast and adjacent waters.

### OFFICE COMPILATION

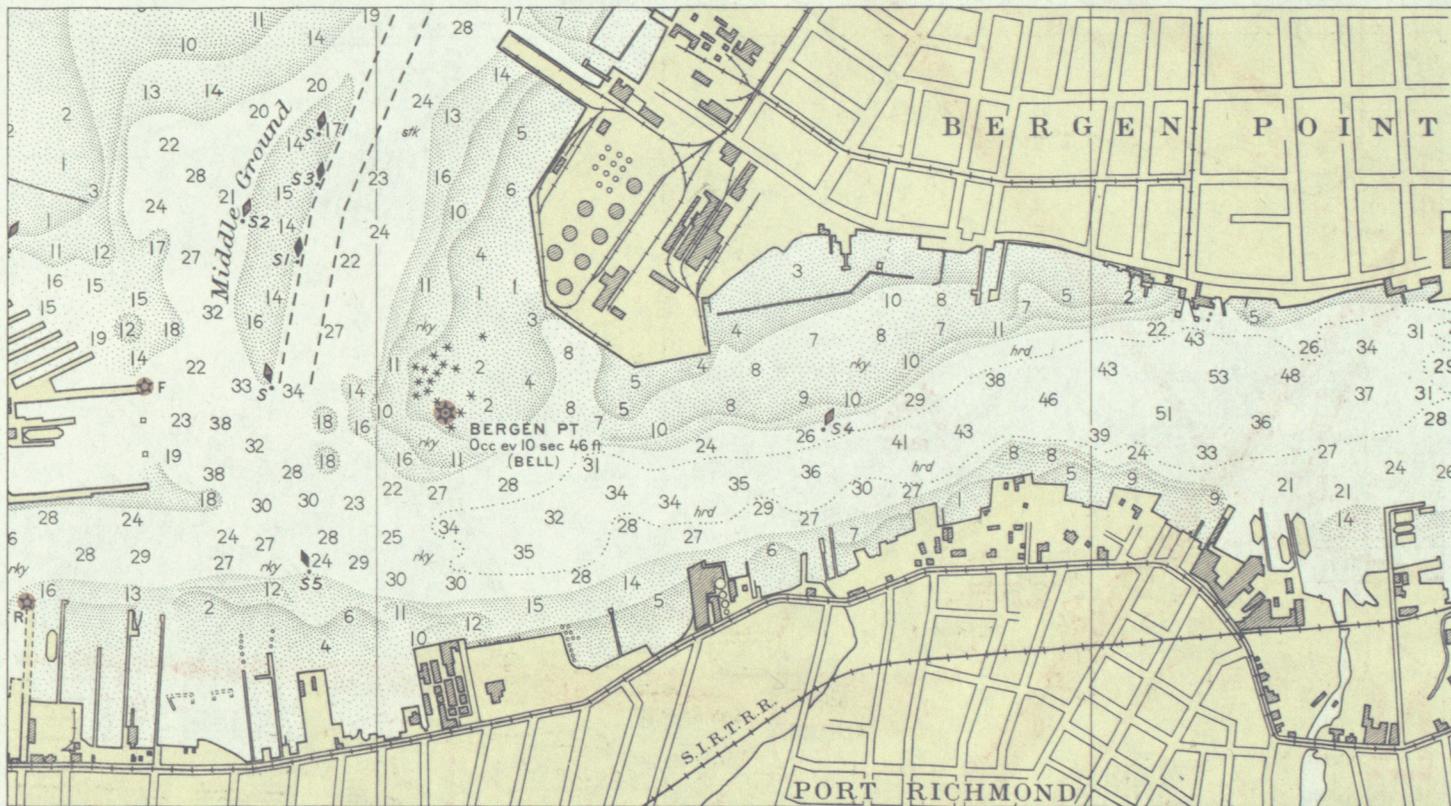
After the completion of the varied field surveys, a considerable amount of office work remains to be done. The geodetic control surveys must be computed, adjusted, and tabulated. The hydrographic and topographic surveys



PART OF LOS ANGELES AERONAUTICAL CHART

C. & G. S. Print A-693

The Los Angeles Sectional Aeronautical Chart is one of a series of 87 similar charts which cover the entire United States. They are prepared and printed by the U. S. Coast and Geodetic Survey of the Department of Commerce for use in air navigation and show necessary aeronautical information in addition to the best available topography of the area. The scale of this series is approximately 8 miles to the inch and adjacent charts in any direction may be joined together. The charts are frequently revised and new editions issued.



C & G. S. Print A-693

PART OF NAUTICAL CHART No. 285 - KILL VAN KULL, N.Y. AND N.J.

Nautical charts of the coasts of the United States and possessions are prepared and printed by the U. S. Coast and Geodetic Survey and are based on field surveys made by that Bureau. Chart No. 285, scale 1:15,000, is one of approximately 800 nautical charts for use by mariners and others interested in the navigable waters of our coasts. Charts are frequently revised and new editions issued and are corrected by hand for vital information to date of issue.

must be checked carefully and given a thorough review during which they are compared with previous surveys in the same area. The results of the tide and current surveys must be checked and tabulated and the datum planes computed. Observations obtained in magnetic surveys are compared with previous observations in order to predict the magnetic variation for the nautical charts.

### NAUTICAL CHARTS

The results of all of the above are used in the construction and revision of the some 800 nautical charts published by the Survey. These nautical charts cover the coastal waters of continental United States, Alaska, Philippine Islands, Hawaiian Islands, and other United States possessions.

The hydrographic and topographic surveys made by the Bureau are the basic data used in the construction of nautical charts. These surveys are supplemented by data from other organizations, especially data relative to dredged channels by the U. S. Engineers Corps and data relative to aids to navigation from the Bureau of Lighthouses. All of the above data are combined in one drawing of the proposed chart on a suitable scale, which after being carefully verified is reproduced by the most modern process of photolithography in the reproduction plant of the Coast and Geodetic Survey.

Nautical charts are issued on various scales most appropriate for the use which is to be made of them. Charts on large scales are available for harbors and inland waterways; sailing and general charts of the coasts on small scales for offshore navigation; intermediate scales for coastwise navigation. Special charts are available for special purposes, such as those of the Intracoastal Waterways and of Georges Bank.

All nautical charts must be revised constantly in order to keep pace with the never ending natural changes along our coasts and the many man-made cultural changes, such as dredging and harbor improvements. In addition to frequent new editions and new prints the charts are corrected by hand for all changes in aids to navigation and dangers to mariners reported up to the date of issue. (See illustration facing this page.)

Charts are issued only by the Survey and its accredited agents and in the interests of safety of the mariner every effort is made to prevent the issuing of charts which have been declared obsolete by the Bureau.

### MISCELLANEOUS PUBLICATIONS

The results of other activities of the Survey are compiled and published in books and pamphlets. In addition to the Tide Tables and Current Tables which have been mentioned, these include the various United States Coast Pilots published for the mariner. Each of these latter volumes covers a particular area and contains detailed descriptive information of such a nature that it cannot be shown conveniently in graphic form on the nautical chart. This includes descriptions of headlands and landfalls, port regulations and facilities, sailing directions for coasting and entering ports and general information as to weather conditions, currents, radio service, etc.

The weekly Notice to Mariners is issued jointly with the Bureau of Lighthouses to keep mariners advised of changes which have been made in aids to navigation and new dangers which are reported in order that they may keep their charts and Coast Pilots corrected up to date. Safety at sea is the first requisite in these publications as well as in the nautical chart and every possible safeguard is utilized in order to insure the accuracy and completeness of the information.

The Survey likewise issues numerous annual and special publications on the results of its operations and researches, in triangulation, leveling, tide datums, terrestrial magnetism, seismology, special tide and current studies of particular harbors and rivers, and manuals covering its various fields of work.

### AERONAUTICAL CHARTS

Aeronautical charts are prepared and printed by the Survey. They are one of the essential aids to air navigation, and are compiled from the basic survey data of the Bureau supplemented by the best topographic data from other sources. Superimposed on this is shown the special information needed for air navigation. These charts are designed to be read easily by the pilot in a rapidly moving airplane; they show altitudes, towns and cities, railroads, highways, streams, and other features usually found on topographic maps, supplemented by the airports, lights, radio ranges, radio beacons, and obstructions. They also show compass roses and lines of equal magnetic variation. Revisions of these charts are frequently necessary in order that the information shown on them is correct and up to date; new editions are issued when these revisions are made.

These charts are issued in several different types and scales. The basic series is composed of 87 sections of one projection which can be joined together in any direction. If placed altogether they would form a composite map of the United States. These sectional charts are on a scale of approximately 8 miles to the inch and each covers an area of  $2^{\circ}$  of latitude and  $6^{\circ}$  of longitude. (See illustration facing p. 14.)

A second series is being issued on a scale of approximately 16 miles to the inch. These are for fast long distance flights and each includes about six times the area of one of the sectional charts. Still a third series is being prepared on a scale of approximately 32 miles to the inch. The entire country will be included on 6 of these latter which are especially adapted for radio-navigation.

### EARTHQUAKE SAFEGUARDS

When the Federal Government began to take an active interest in the economic and social aspects of the earthquake problem, the function of carrying out the program was vested in the Coast and Geodetic Survey, since seismographs already were in operation at its magnetic observatories. The subject is becoming of rapidly increasing importance with the growing density of population and volume of investment in structures exposed to possible damage.

The work carried on by the Survey serves as a nucleus for cooperating with and coordinating the local efforts of various public and private organizations also engaged in such studies. In no way competing, the Survey conducts investigations in areas not covered by them. While earthquakes cannot be prevented, there are many ways in which, because of our increasing knowledge gained from analyses of the comprehensive records obtained from instruments installed in regions subject to shocks, precautions may be taken to prevent their maximum detrimental effects. Results already obtained have been used in designing many different types of structures, especially those connected with very large projects financed in whole or part from Federal funds.

### INFORMATION VALUABLE FOR OTHER PURPOSES

The facts gathered by the Coast and Geodetic Survey in connection with its charting and mapping activities have many collateral uses. To carry on harbor or waterfront improvements without authentic, comprehensive information about water depths and changes in tides and current would be as wasteful as haphazardly constructing a massive building without the benefit of previously prepared plans. It would be just as wasteful to carry out any engineering project covering an extensive area, or to locate boundary lines of countries, States, and municipalities, without utilizing geodetic control data; or to construct buildings in earthquake areas without making use of available studies in seismology.

Geodetic data are therefore available as vital cost-reducing factors in engineering and industrial operations such as water-power development, drainage and irrigation projects, flood control, highway location, boundary lines, and the like.

Terrestrial magnetism is one of the most important yet elusive forces of Nature. Investigators in our great scientific institutions and the research departments of our great corporations, are constantly pressing forward in their efforts to utilize this force for the benefit of mankind. For the data which constitute the foundation for such research work in the United States, these scientists look to the Coast and Geodetic Survey. Magnetic methods, based on past and present surveys, continue to be utilized in studying geological structure, especially with reference to the search for oil and minerals. Surveyors engaged in the retracing of land boundaries determined by compass many years ago depend largely upon the observations of this Bureau for information regarding the change in the direction of the compass needles with lapse of time. A comparatively recent discovery is that the quiet or disturbed condition of the earth's magnetism has a definite relation to radio transmission.

Hydrographic and topographic surveys are usually made on larger scales and show more details than the finished chart. Successive resurveys of changeable areas also furnish a record of changes of great value in planning waterfront development and protection and in settling litigation concerning such properties. Copies of original sheets, furnished at a nominal cost, are in considerable demand.

Its field operations being somewhat out of the ordinary as to character and accuracy, the Survey has had occasion to design and develop many of its own

instruments. The varied nature of this work has led to the collection of a considerable fund of scientific information regarding materials and methods of instrument construction, which is available to the public upon inquiry.

Thus the varied products of the Coast and Geodetic Survey constantly grow in importance with the increasing needs of our people and the spreading knowledge of the many purposes for which they can be used to advantage. Its labors must continue with unabated vigilance so long as the waters flow, earthquakes occur, and changes are made by man and Nature. Such very necessary services do not show themselves directly by dollars-and-cents returns, but they reveal their value in the untold wealth of added security to life and property on land and sea.

To make immediately available to interested persons the results of its various activities, the Coast and Geodetic Survey maintains a mailing list of persons and firms desiring to receive notice of the issuance of charts and of its many other publications. Those desiring this information, should write to the Director, U. S. Coast and Geodetic Survey, Department of Commerce, Washington, D. C., for the mailing-list circular.



## PUBLICATION NOTICES

To make immediately available the results of its various activities to those interested, the Coast and Geodetic Survey maintains mailing lists of persons and firms desiring to receive notice of the issuance of charts, Coast Pilots, maps, and other publications.

Should you desire to receive such notices, you may use the form given below, checking the lists covering the subjects in which you are interested.

(Date)-----

DIRECTOR, U. S. COAST AND GEODETIC SURVEY,  
*Washington, D. C.*

DEAR SIR: I desire that my name be placed on the mailing lists indicated by check below, to receive notification of the issuance of publications referring to the subjects indicated:

- 109. Astronomic work
- 109-A. Base lines
- 109-B. Coast Pilots
- 109-C. Currents
- 109-D. Geodesy
- 109-E. Gravity
- 109-F. Hydrography
- 109-G. Leveling
- 109-H. Nautical charts
- 109-I. Oceanography
- 109-J. Traverse
- 109-K. Seismology
- 109-L. Terrestrial magnetism
- 109-M. Tides
- 109-N. Topography
- 109-O. Triangulation
- 109-P. Cartography
- 109-R. Aeronautical charts

(Name)-----

(Address)-----

A catalog of the publications issued by all bureaus of the Department of Commerce may be had upon application to the Chief, Division of Publications, Department of Commerce, Washington, D. C. It also contains a list of libraries located in various cities throughout the United States, designated by Congress as public depositories, where all publications printed by the Government for public distribution may be consulted.

