TECHNICAL SERVICES
COAST AND GEODETIC SURVEY

Rear Admiral
Robert F. A. Studds
Director

U. S. Department of Commerce
Charles Sawyer, Secretary

TECHNICAL SERVICES

of the

U.S. COAST AND GEODETIC SURVEY

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U.S. DEPARTMENT OF COMMERCE
Charles Sawyer, Secretary

COAST AND GEODETIC SURVEY
Robert F. A. Studds, Director

July 1951

For sale by Coast and Geodetic Survey Price 75 cents

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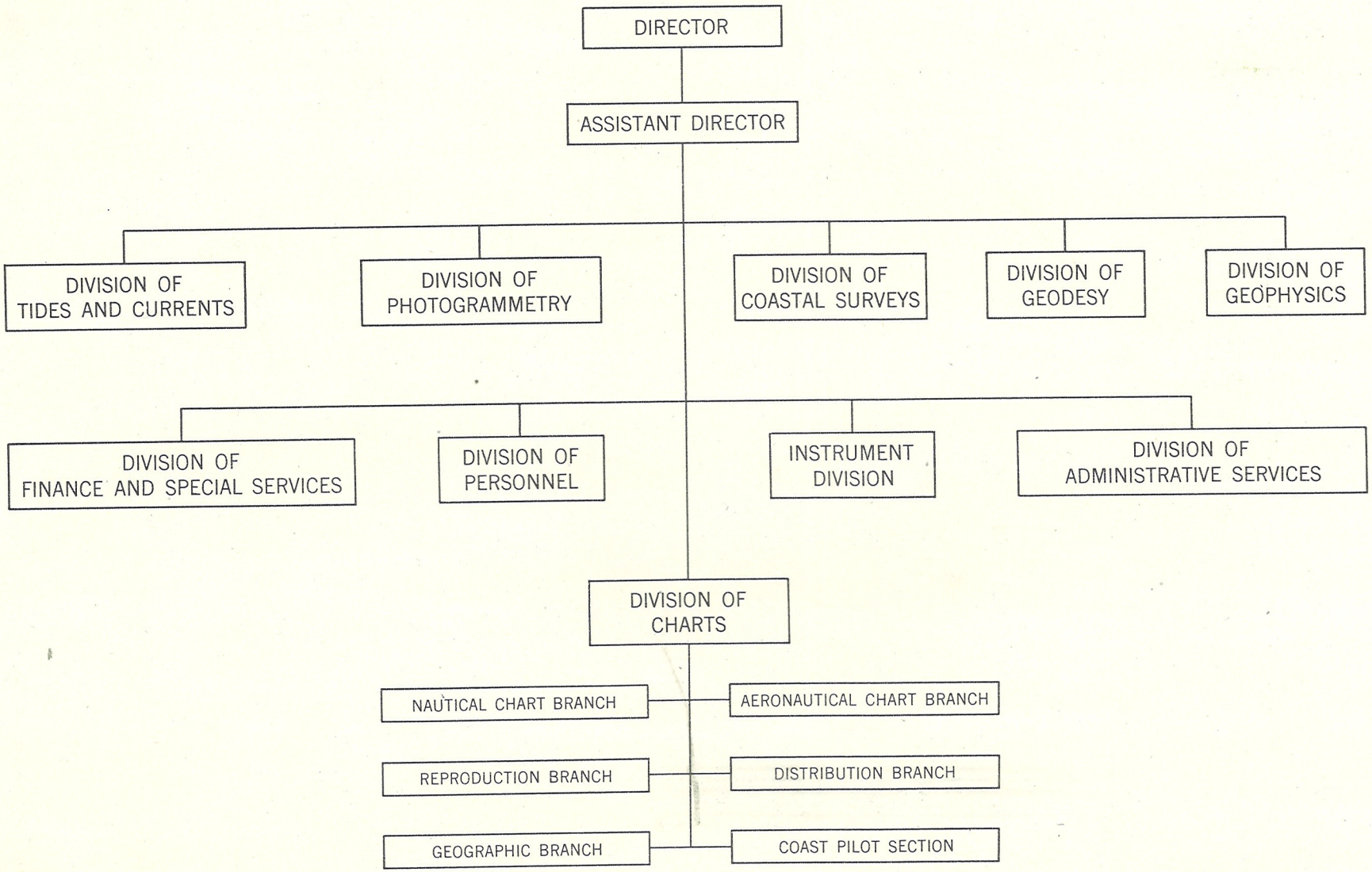
U. S. COAST AND GEODETIC SURVEY



GENERAL STATEMENT

This publication describes the technical services of the Coast and Geodetic Survey--a highly technical Bureau directly aiding the United States Department of Commerce in carrying out the mandate of Congress to promote, foster, and develop the industry and commerce of the country.

The "Survey of the Coast" was organized on 1807, during the administration of President Thomas Jefferson, but did not begin operations until 1816. Since then, it has functioned without interruption, except for the periods 1818-32 and 1834-36. Through the years the Bureau has been given the added responsibilities of the extension of geodetic control surveys into the interior of the country and the compilation and publication of certain aeronautical charts.

Those engaged in travel, commerce, business,and engineering are provided an easy method of making full use of the data collected by the Bureau for its charting and mapping activities. These engineering and scientific data, gathered through field operations, are used essentially for water and air navigation, mapping the country, developing natural resources, and serving national defense. This information is becoming increasingly valuable because of its collateral uses--engineering, industrial, and scientific--and its availability to everyone.

The production of nautical and aeronautical charts is a major function of the Survey. Sailing directions, tide tables, current tables, and tidal current charts are published as supplements to the nautical charts. Included in these activities are the compilation and printing of aeronautical charts to cover the United States, its Territories, and possessions as required for civil aviation, and for military use where requirements are parallel; and aeronautical charts to cover international airways as required primarily by United States civil aviation.

A basic responsibility of the Survey is the execution of geodetic control surveys to provide control for maps; charts, intermediate and local surveys; and various engineering projects, both public and private. Large-scale topographic and planimetric maps of areas along the coasts of the country are produced as by-products of the compilation of nautical charts. Aerial photographs insure an adequate amount of reliable topographic detail on these charts. Tidal surveys are conducted to reduce to a common level or datum plane the soundings taken at different stages of the tide during hydrographic surveys. Also essential in the preparation of nautical and aeronautical charts are the magnetic surveys. Seismological studies and

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investigations, through the use of seismographs and the earthquake data which have been systematically collected, aid in mapping earthquake areas and evaluating earthquake risks.

The data collected from other activities of the Bureau are compiled and published in books and pamphlets, in addition to maps and charts. The Bureau likewise issues numerous annual and special publications on the results of its operations and researches in triangulation, leveling, geomagnetism, seismology, tidal phenomena, special tide and current studies of particular harbors and rivers, and manuals covering its various fields of work.

The products of the Survey 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 as long as the waters flow, earthquakes occur, and changes are made by man and nature. These 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.

Further information concerning the work of the Bureau may be obtained upon request to the Director, U.S. Coast and Geodetic Survey, Washington 25, D. C.

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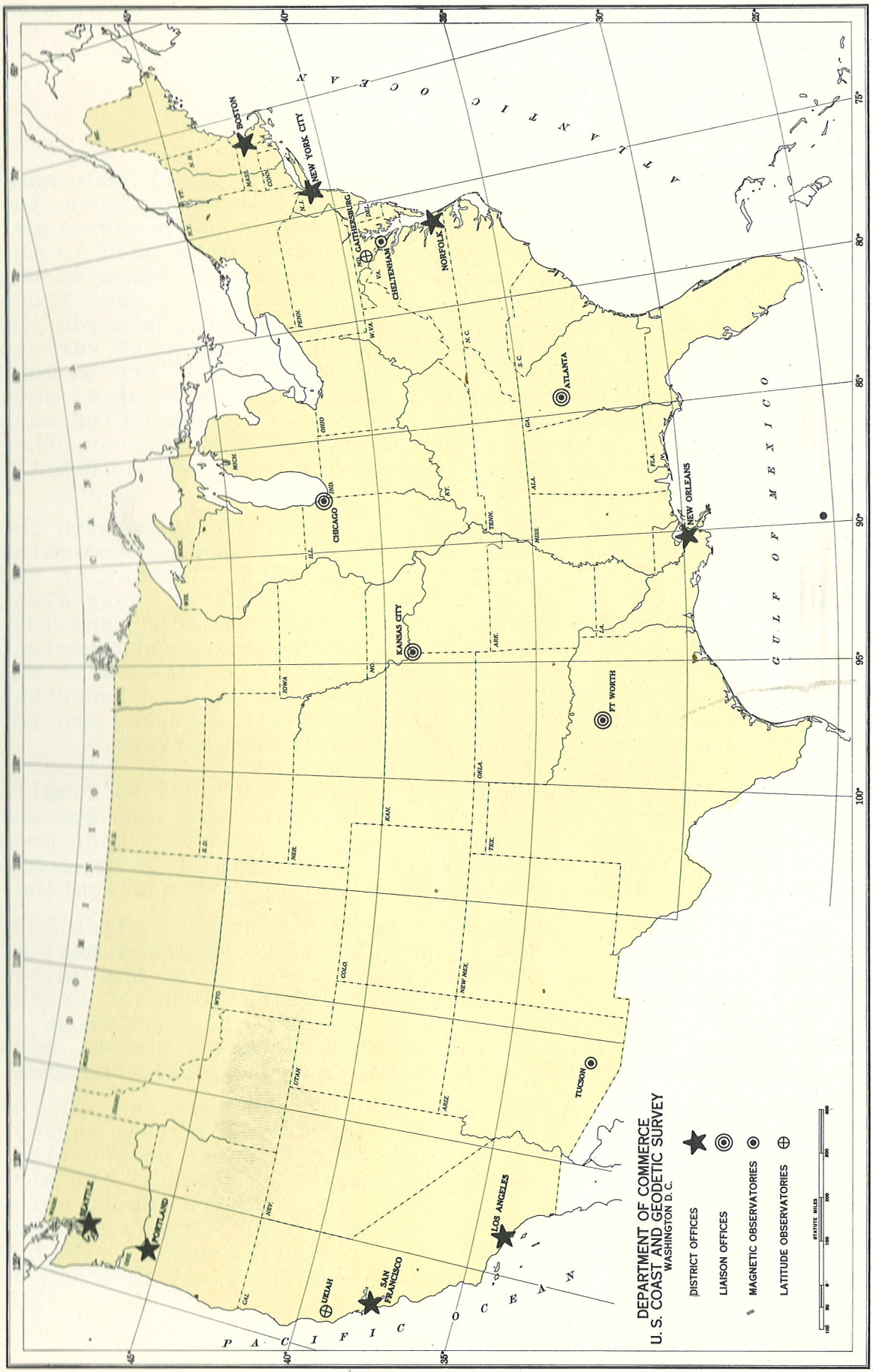

PLATE I

COASTAL SURVEYS AND CHARTS

ORIGINAL SURVEYS

The Coast and Geodetic Survey since 1835 has made many thousands of topographic and hydrographic surveys along the coasts of the United States, Alaska, and other possessions. These surveys are the principal source of data used in the construction and revision of nautical charts published by the Bureau. They provide a comprehensive record of conditions existing at the specific time a survey was made, whereas the chart is generally a compilation of data secured at various times. The topographic and hydrographic surveys are on much larger scales than the nautical charts and, of course, show considerably greater detail. They are independent of each other: topographic surveys do not include soundings or other hydrographic data; hydrographic surveys do not include details of adjacent land areas.

Detailed topographic surveys used in conjunction with the hydrographic surveys of the Bureau in the production and maintenance of nautical charts have been made for most of the coastline of the United States and for extensive areas along the coast of Alaska. Surveys between the years 1835 and 1935 were made by planetable methods. The recorded data include detailed information on terrain characteristics adjacent to and including the shoreline at the high-water line. Important landmarks and mountain peaks which are visible at sea are the only inland features usually included in the surveys.

Since 1927 aerial photographs have been used to compile topographic surveys, and, in many cases, have been supplemented by planetable surveys of the shoreline. The surveys made from aerial photographs are published in the form of large-scale planimetric maps described elsewhere in this publication.

Detailed hydrographic surveys have been made since 1835 for the entire coastline of the United States and most of Alaska, as well as other insular possessions of the United States. These surveys include the measurement of depths (soundings); the determination of geographical positions of such depths; and the location of shoals, banks, wrecks, aids or obstructions to navigation, and other hydrographic features.

Some of these surveys are accomplished by means of the wire drag. The wire drag is a method of hydrographic surveying which makes possible the discovery of small obstructions such as pinnacle rocks, boulders, ledges, et cetera. The wire drag consists of a wire maintained at any desired depth which is towed through the water by two launches. Lengths of drags vary from 1,000 feet or less used in channel areas to 15,000 feet in open-water areas, which is about the limit that can be handled with two towing launches.

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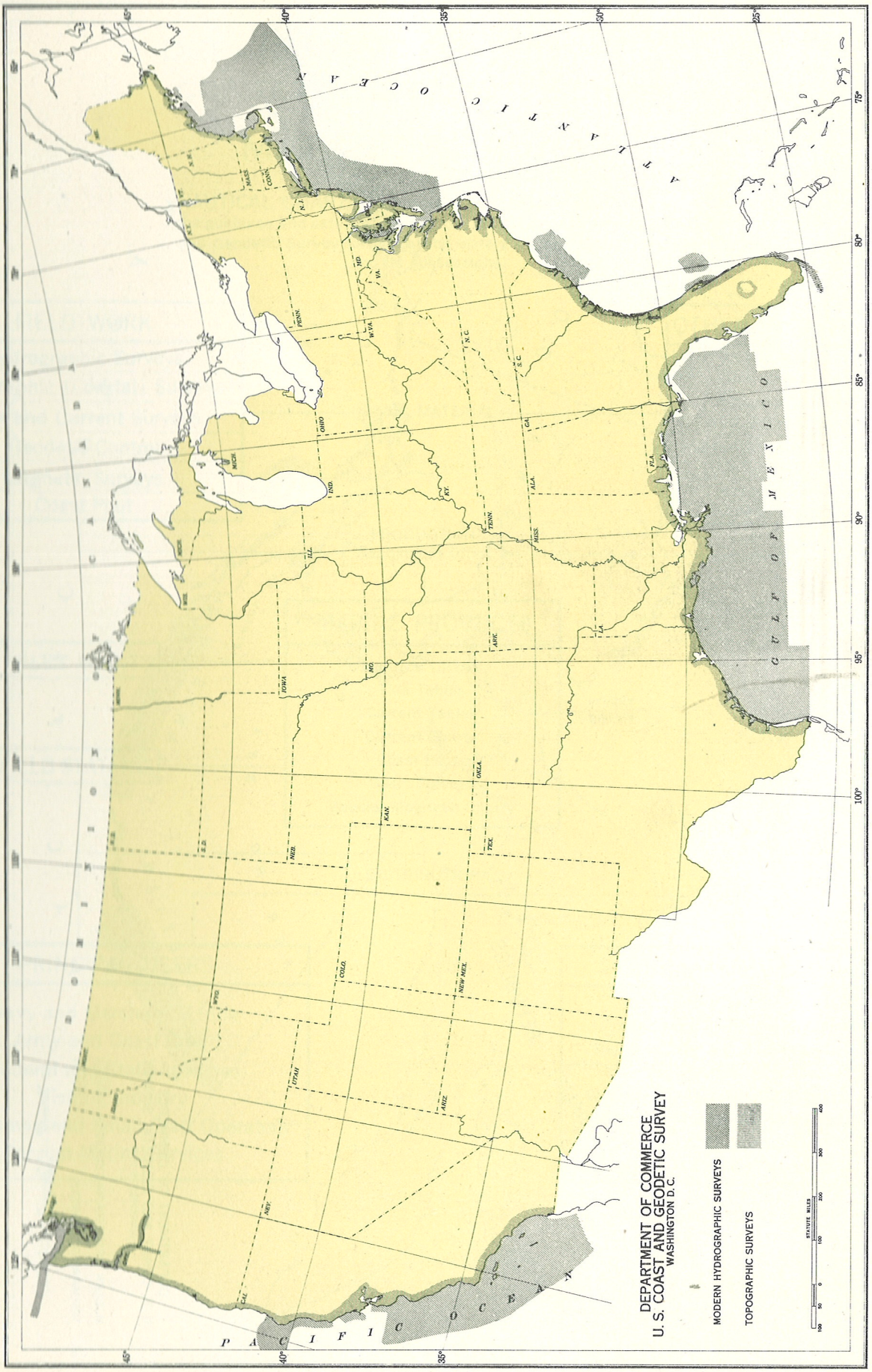

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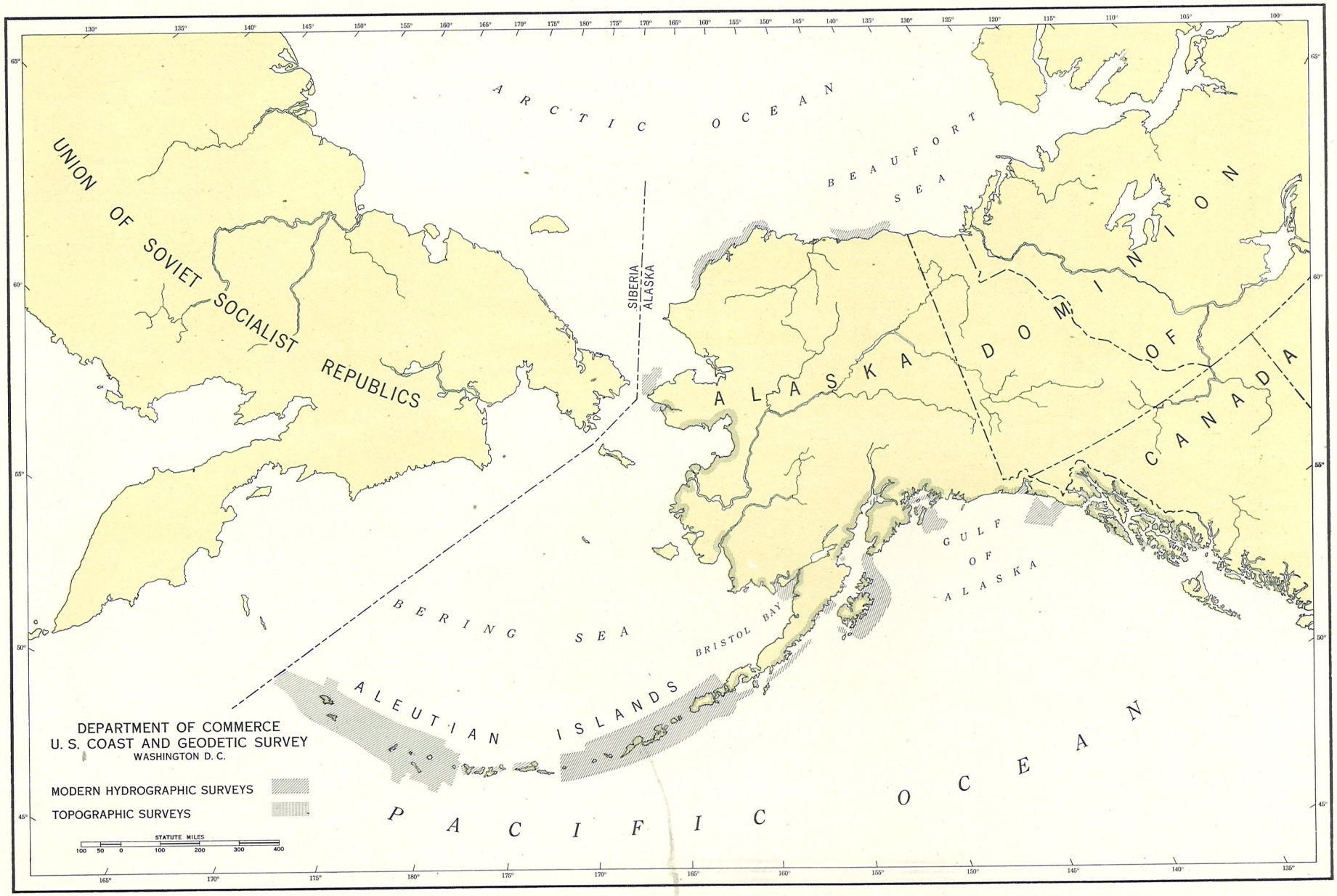
ARCTIC OCEAN
BEAUFORT SEA
UNION OF SOVIET SOCIALIST REPUBLICS
SIBERIA
ALASKA
DOMINION OF CANADA
ALASKA
GULF OF ALASKA
BERING SEA
BRISTOL BAY
ALEUTIAN ISLANDS
PACIFIC OCEAN
DEPARTMENT OF COMMERCE
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MODERN HYDROGRAPHIC SURVEYS
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STATUTE MILES
100 50 0 100 200 300 400

PLATE III

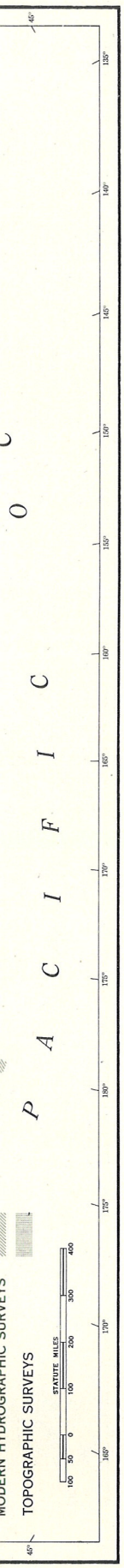

PLATE III

DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
MARINE SERVICE

NAUTICAL CHARTS and related publications, essential for the guidance and safety of navigation, are produced by the Coast and Geodetic Survey for all coastal waters of the United States and its possessions.

FIELD WORK
- Hydrographic Surveys
- Topographic (Coastal) Surveys
- Tide and Current Surveys
- Geodetic Control
- Magnetic Surveys
- Coast Pilot

BASIC MATERIAL

OTHER INFORMATION
- Aids to Navigation (U.S. Coast Guard)
- Channel Surveys (U.S. Army Engineers)
- Interior Topographic Surveys (U.S. Geological Survey)
- Local Information (Bureau Field Stations)

PRODUCTION
[Washington Office]

MARINE PRODUCTS
- Nautical Charts
- Tide Tables
- Current Tables
- Current Charts
- Coast Pilots
- Basic Surveys
- Special Magnetic Charts

SALES AGENTS

FIELD STATIONS

DISTRIBUTION

PRINCIPAL USERS
- Navy and Merchant Marine
- Army and Coast Guard
- Federal and State Agencies
- Fishing Industry
- Yachtsmen and Small Craft Operators
- Foreign Marine Services

COLLATERAL USES
- Construction of Port Facilities
- Dredging and Harbor Developments
- Beach Erosion and Sanitation Studies
- Fishing Bank Locations
- Waterfront Property Litigation Evidence
- Submarine Geological Investigations
- Oil Explorations
- Submarine Cable and Pipeline Planning

PLATE IV

NAUTICAL CHARTS

One of the principal products of the Coast and Geodetic Survey is the nautical chart, on which is shown all available information necessary for safe marine navigation. The data included are of two kinds: vertical data described by the depth and elevation figures and horizontal data locating the features by latitude and longitude. In general, the data shown on these charts are as follows: soundings; depth or fathom curves; shoals; reefs; underwater dangers to navigation; artificial aids to navigation; topographic and cultural features; and shore installations, et cetera, adjacent to the shore which are of aid to the mariner. These charts are lithographed in color. Seldom are more than five colors used.

Nautical charts are produced primarily for the use of the mariner, but they also serve the public interest in many other ways as they are the most accurate source of detailed information for the offshore areas and the coastal areas immediately adjacent to the shore.

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 changes, such as dredging and harbor improvements, and changes in the aids to navigation. Upon receipt of this type of information, new editions or new prints of the charts are prepared and published. Old editions are canceled by new editions and should not be used. In addition to these new editions and new prints, the charts are kept current by hand corrections for critical changes reported to date of issue.

Nautical charts vary in scale from 1:2,500 (Harbor Charts) to 1:5,000,000 (Sailing Charts). These charts are of the following classifications:

Sailing Charts. -- Scales 1:600,000 and smaller. These charts are intended primarily for use in fixing the mariner's position as he approaches the coast from the open sea, or for sailing between distant coastwise ports. The shoreline and topography are generalized and only offshore soundings, principal lights, outer buoys, and landmarks visible at a considerable distance are shown.

General Charts. -- Scale 1:100,000 to 1:600,000. These charts are designed for offshore coastwise navigation outside outlying banks and shoals.

Coast Charts. -- Scale 1:50,000 to 1:100,000. These charts are designed for inshore coastwise navigation, for entering bays

and harbors of considerable width, and for navigating large inland waterways.

Harbor Charts. -- Scales larger than 1:50,000. These charts are planned for harbors, anchorage areas, and the smaller waterways.

Intracoastal Waterway (Inside route) Charts. -- Scale of 1:40,000. This is a special series of charts embracing the inside route in New Jersey; the route from Norfolk, Va., to Key West, Fla., on the Atlantic coast; and from Key West, Fla., to the Mexican boundary on the Gulf coast. These charts are designed for harbors, anchorage areas, and the smaller waterways.

PUBLICATIONS OF GENERAL INTEREST

CATALOG OF NAUTICAL CHARTS AND RELATED PUBLICATIONS.

(U.S. Coast and Geodetic Survey) Serial 665. October 1949. 49 p. Indexes for all nautical charts. (May be obtained only from the Coast and Geodetic Survey, its field offices, or its sales agents.)

Other publications of a more general nature are listed in "Related Nautical Publications" Section.

RELATED NAUTICAL PUBLICATIONS

COAST PILOTS

The Coast Pilots published by the Coast and Geodetic Survey are primarily for navigational use; their purpose is to furnish that information required by the navigator which cannot be shown conveniently on nautical charts. Each Coast Pilot covers a selected section of the coast and contains detailed data relative to the coastline and harbors; port information; sailing directions for coasting and entering harbors; and general information as to weather conditions, radio service, et cetera. New editions are published about every 7 years. Supplements, containing changes and new information, are published annually and distributed free. The Coast Pilots are listed as follows:

Atlantic Coast:

Section A, St. Croix River to Cape Cod, 1950
Section B, Cape Cod to Sandy Hook, 1950
Section C, Sandy Hook to Cape Henry, including Delaware and Chesapeake Bays, 1947
Section D, Cape Henry to Key West, 1948

Gulf Coast:

Key West to the Rio Grande, 1949

West Indies:

Puerto Rico and Virgin Islands, 1949

Pacific Coast:

California, Oregon and Washington, 1942
(1951 edition in press).

Alaska:

Part I. -Dixon Entrance to Yakutat Bay, 1943
Part II. -Yakutat Bay to Arctic Ocean, 1947

Hawaiian Islands, 1950

DISTANCE TABLES

Tables of distances, in pamphlet form, have been compiled for the purpose of giving in condensed and convenient form, the distances between ports of the United States and its outlying Territories. Distances are given between some 10,000 ports along the shortest route marked by aids to navigation. Also included is a time table for various distances at different speeds.

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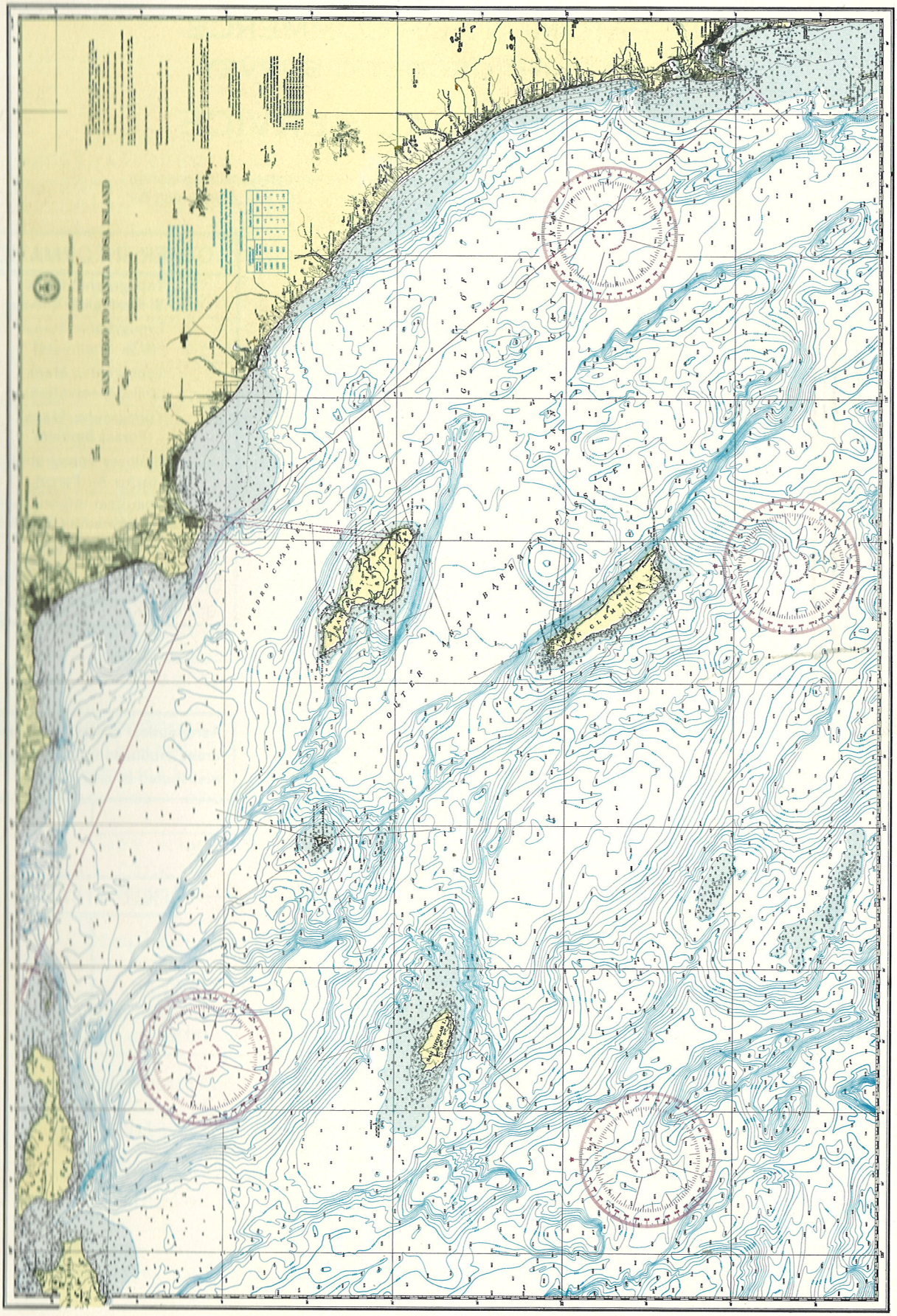


PLATE V - CHART 5101A
(Approximately one-fifth actual scale)

DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
AERONAUTICAL SERVICE

AERONAUTICAL CHARTS essential for the guidance and safety of air navigation are produced by the Coast and Geodetic Survey for the U.S. and Alaska and for special routes outside of the country.

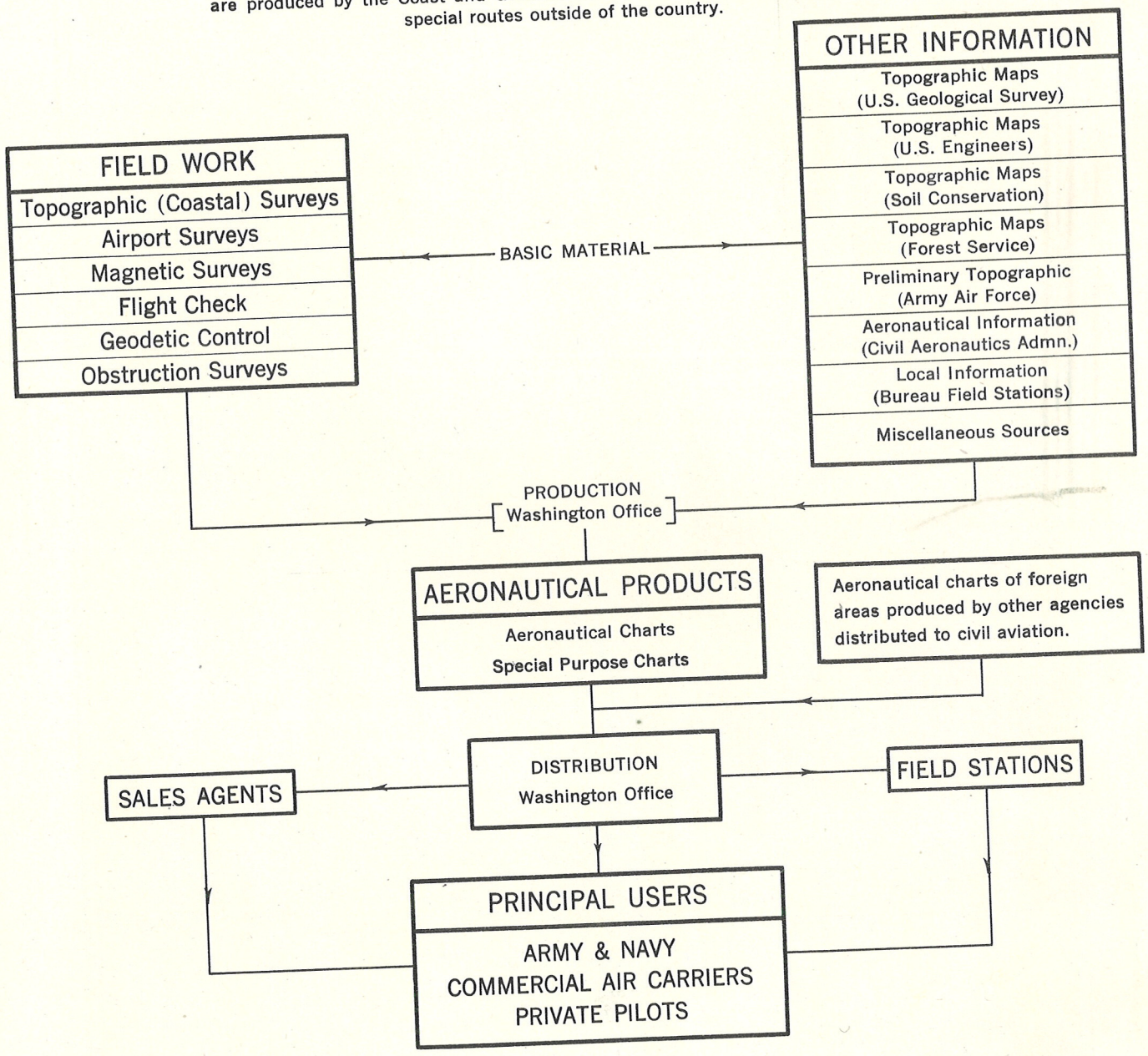


PLATE VI

AERONAUTICAL CHARTS

The Coast and Geodetic Survey compiles and prints aeronautical charts of the United States, its Territories, and possessions as required for civil aviation, and for military aviation where military needs are parallel to civil; and of international airways as required for United States civil aviation. Special emphasis is given to terrain features which best serve the pilot in determining his course. Every effort is made to include the outstanding landmarks in each locality. Although they are compiled primarily for air navigation, the charts also prove useful for many other purposes as the major series provide contoured maps at a uniform scale. The base chart is lithographed in color, and is overprinted with the aeronautical data in magenta and offset blue.

The topographic and cultural features appearing on the charts are compiled from the best information which is available. Relief on the major series is shown by contours, elevations, and a system of gradient tints employing shades of green and brown. The cultural features include shoreline, drainage, roads, railroads, cities and towns, and many prominent landmarks. Certain items which should be included in a topographic map are omitted in order not to obscure details of more importance to the navigator, whereas other features are exaggerated because they are valuable as landmarks.

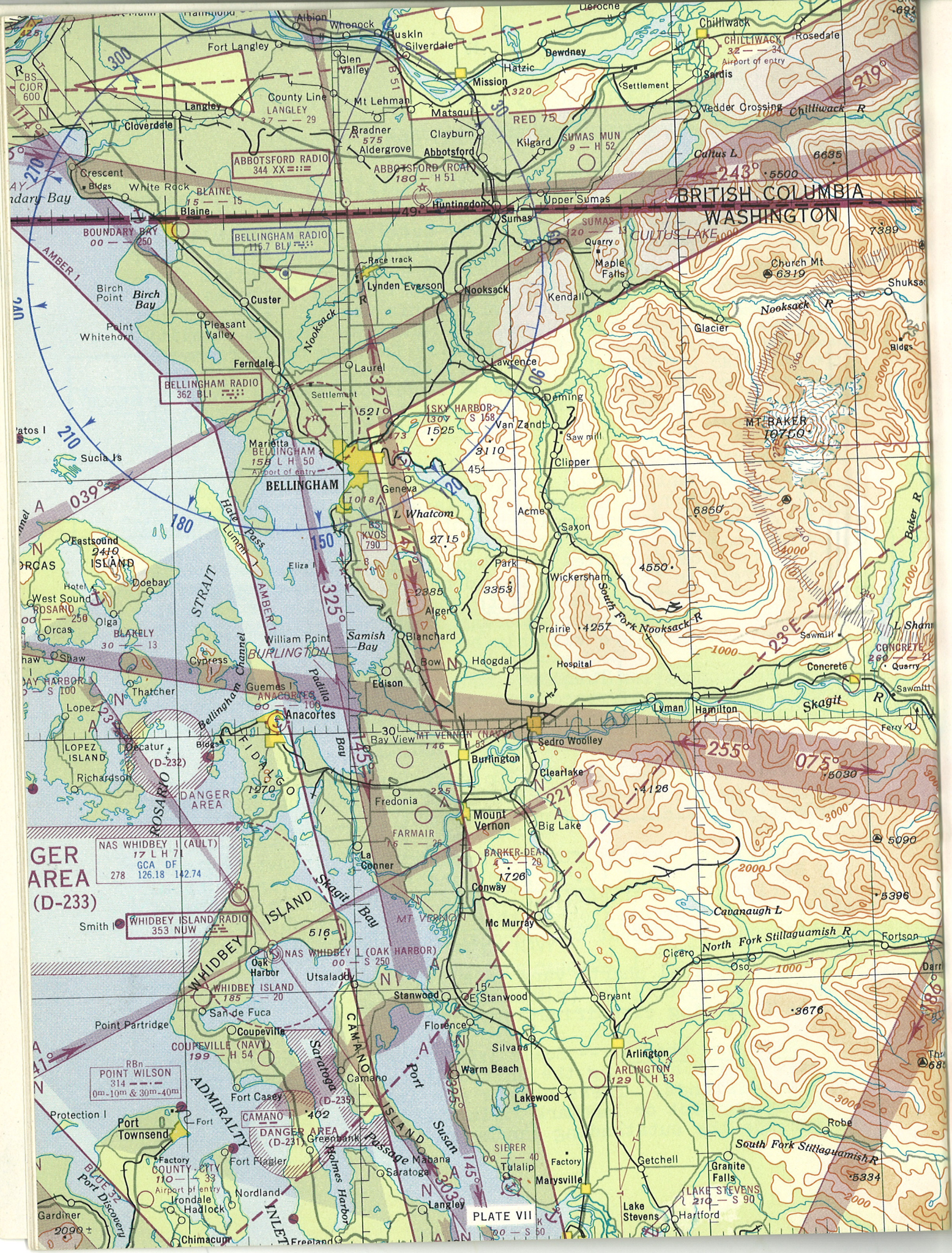
Aerodromes, low frequency radio aids, airways and control areas, restricted airspace, high-tension lines, and other aids or obstructions to air navigation are overprinted in magenta on the base chart.

Very high frequency radio data (including Omni-directional ranges) are overprinted in offset blue on Sectional, World Aeronautical, and Route Charts.

Complete coverage for the United States is available in the Sectional Chart (1:500,000) and the World Aeronautical Chart (1:1,000,000) series. Those interested in charts of these scales for uses other than aviation may obtain copies of base charts without the aeronautical overprints.

Aeronautical charts vary in scale from 1:31,680 (airport charts) to 1:5,000,000 (planning charts). These charts are of the following classifications:

Sectional Charts. -- Scale 1:500,000. There are 87 charts of this series covering the United States and 1 covering the Hawaiian Islands. These charts are intended primarily for piloting--contact or landmark flying; therefore, effort is made to include the outstanding landmarks in each locality.


BRITISH COLUMBIA
WASHINGTON
BELLINGHAM
Bellingham Channel
Lummi Island
Eastsound
ORCAS ISLAND
West Sound
Doebay
Orcas
Olga
Shaw
Thatcher
Lopez
Decatur
LOPEZ ISLAND
Richardson
Eliza I
William Point
Samish Bay
Cypress
Guemes I
ANACORTES
Anacortes
Bay View
Edison
Bow
Blanchard
Alger
Prairie
Hoogdal
Hospital
Park
Wickersham
Acme
Saxon
Geneva
Marietta
Sucia Is
Birch Point
Birch Bay
Point Whitehorn
Custer
Pleasant Valley
Ferndale
Laurel
Settlement
Lynden
Everson
Nooksack
Deming
Van Zandt
Saw mill
Clipper
Lawrence
Kendall
Maple Falls
Glacier
Church Mt
6319
MT BAKER
10750
Nooksack R
South Fork Nooksack R
Baker R
Sumas
Upper Sumas
Huntingdon
Quarry
CULTUS LAKE
Cultus L.
6635
7389
Chilliwack
CHILLIWACK
Airport of entry
Rosedale
Sardis
Vedder Crossing
Chilliwack R
Dewdney
Hatzic
Mission
Settlement
Matsqui
Clayburn
Kilgard
Abbotsford
Mt Lehman
Bradner
Aldergrove
Glen Valley
Fort Langley
Albion
Whonock
Ruskin
Silverdale
Langley
County Line
LANGLEY
Cloverdale
Crescent Bldgs
White Rock
Blaine
BLAINE
BOUNDARY BAY
ABBOTSFORD RADIO
344 XX
ABBOTSFORD (RCAF)
180 — H 51
BELLINGHAM RADIO
115.7 BLI
BELLINGHAM RADIO
362 BLI
BELLINGHAM
Airport of entry
SUMAS MUN
9 — H 52
SUMAS
20 — 13
SKY HARBOR
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3110
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Padilla Bay
Samish Bay
Bay View
Skagit Bay
Port Susan
Saratoga Passage
Holmes Harbor
Camano I
Whidbey I
Smith I
Protection I
Port Townsend
Port Discovery
Gardiner
Oak Harbor
Utsaladdy
Coupeville
Point Partridge
San de Fuca
Fort Casey
Fort Flagler
Nordland
Irondale
Hadlock
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Clinton
Mutiny Bay
Double Bluff
Greenbank
Mabana
Saratoga
Camano
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129 L H 53
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Marysville
Getchell
Granite Falls
Lake Stevens
LAKE STEVENS
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Robe
Bryant
Cicero
Oso
North Fork Stillaguamish R
South Fork Stillaguamish R
Fortson
Darrington
Cavanaugh L
Big Lake
Mount Vernon
Conway
Mc Murray
La Conner
Fredonia
Burlington
Sedro Woolley
Clearlake
Lyman
Hamilton
Skagit R
Ferry
Concrete
Quarry
CONCRETE
Sawmill
L Shannon
Hale Pass
L Whatcom
Eastsound ISLAND
Blakely Island
Whidbey Island
Camano Island
Fidalgo Island
Guemes Channel
Bellingham Channel
Padilla Bay
Skagit Bay
Port Susan
Saratoga Passage
Holmes Harbor
Admiralty Inlet
Rosario Strait
Juan de Fuca Strait
DANGER AREA
(D-232)
DANGER AREA
(D-231)
DANGER AREA
(D-235)
NAS WHIDBEY I (AULT)
17 L H 71
GCA DF
278 126.18 142.74
NAS WHIDBEY I (OAK HARBOR)
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WHIDBEY ISLAND
185 — 20
WHIDBEY ISLAND RADIO
353 NUW
COUPEVILLE (NAVY)
199 — H 54
CAMANO I
COUNTY - CITY
110 — 33
Airport of entry
RBn
POINT WILSON
314
0m-10m & 30m-40m
SIERER
00 — 40
FARMAIR
76 — 26
BARKER-DEAN
6 — 20
MT VERNON (NAVY)
146 — L 53
SKY HARBOR
L307
BLAINE
15 — 15
BOUNDARY BAY
00 — 250
ROSARIO
00 — 250
BLAKELY
30 — 13
BAY HARBOR
S 100
ANACORTES
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PLATE VII
00 — S 50

World Aeronautical Charts. -- Scale 1:1,000,000. There are 43 charts of this series covering the United States and adjacent areas of Canada and Mexico. Alaska is covered by 15 charts of the series. The reduced scale necessitates the omission of some of the landmarks and topographic data of the Sectional Charts; however, ample detail remains to provide checks of the position determined by navigation methods.

Flight Charts. -- Scale 1:1,000,000. These are strip charts covering areas approximately 100 miles on both sides of principal air routes within the United States and Alaska, and including connecting routes. There are 37 charts of routes in the United States and 13 charts of routes in Alaska.

Local Charts. -- Scale 1:250,000. Twenty charts are published to date of the series covering metropolitan areas: San Juan, P.R.; Honolulu, T.H.; and 18 cities in the United States. These charts are designed to provide maximum landmark identification of congested areas around major air terminals.

Instrument Approach and Landing Charts. -- Scale of Approach Charts 1:250,000; scale of Landing Charts 1:31,680. These charts are designed primarily for use in an approach to an airport under instrument-flight conditions, and they depict let-down procedures based on the principal navigational aid for the airport. The Landing Chart is printed on the back of the corresponding Approach Chart. Each Approach Chart is centered on the radio facility for the designated terminal. There are over 400 charts of this series prepared for the principal air terminals of the United States.

Instrument Landing System Charts. -- The 88 presently published charts of this series cover principal United States air terminals having ILS installations. The charts are designed specifically for final instrument approaches of aircraft using very high frequency instrument-landing equipment.

Radio Facility Charts. -- This series comprises 65 separate charts covering the United States and 14 covering Alaska. The charts provide complete radio information to facilitate the planning and execution of cross-country flights in the United States. They are printed in green and black on standard size paper, 8 by 10½ inches.

Direction Finding Charts. -- Scale 1:2,000,000. These charts are designed specifically to facilitate the plotting of radio bearings. Magnetic compass roses are centered on the charted radio stations. Six charts cover the entire United States and three cover Alaska.

Planning Charts. -- Scale 1:5,000,000. Chart AP-9 covers the United States and chart 3069a covers Alaska. The charts are designed for use in planning routes between distant points, and show principal cities and towns, drainage, contours, and gradient tints, overprinted with aeronautical data.

Aircraft Position Charts. -- Scale 1:5,000,000. There are three charts of the series covering the North Atlantic, Western Europe and Northwest Africa, and the Caribbean area. The charts are designed for long-range air navigation operations over selected areas which require a special type of air navigation chart suitable for overseas operations by U. S. commercial air carriers.

Route Charts. -- Scale 1:2,000,000. There are nine charts of this series: 7 cover the United States; and 2 cover air routes from Chicago to Gander, Newfoundland; and from Shannon, Ireland, to Rome, Italy. The charts employ the oblique Mercator projection, which provides excellent properties for air navigation over the selected routes.

Obstruction Plans. -- About 400 plans have been published to date of principal United States airports. The series will include 550 plans when all now scheduled are completed. These plans show the runways and all obstructions protruding above a 40 to 1 glide angle from the end of the runways.

PUBLICATIONS OF GENERAL INTEREST

Other publications of a more general nature relating to aeronautical charting and air navigation published by the Coast and Geodetic Survey are:

TABLES FOR A POLYCONIC PROJECTION OF MAPS AND LENGTHS OF TERRESTRIAL ARCS OF MERIDIAN AND PARALLELS BASED UPON CLARKE'S REFERENCE SPHEROID OF 1866. Special Pub. 5. Sixth edition 1935. 1 illus.

GENERAL THEORY OF POLYCONIC PROJECTIONS. Oscar S. Adams. Special Pub. 57, Serial 110. 1934. 174 p. 49 illus.

ELEMENTS OF MAP PROJECTION WITH APPLICATIONS TO MAPS AND CHART CONSTRUCTION. Charles H. Deetz and Oscar S. Adams. Special Pub. 68. Fifth edition, revised 1944. 226 p. 89 illus. 15 plates.

TABLES FOR ALBERS PROJECTION. Oscar S. Adams. Special Pub. 130. Serial 378. 1927. 26 p.

CONFORMAL PROJECTION OF THE SPHERE WITHIN A SQUARE. Oscar S. Adams. Special Pub. 153. 15 p. 4 illus.

CARTOGRAPHY. Charles H. Deetz. Special Pub. 205. 1943. 91 p. 30 illus.

LAMBERT CONFORMAL CONIC PROJECTION TABLES. Standard parallels, 7° and 20°, 81 p.; 17° and 33°, 141 p.; 33° and 45°, 83 p.; 45° and 58°, 140 p.; 55° and 65°, 158 p.; 30° and 75°, 3 p. Volumes I and II--Tables with standard parallels for each 4° band of latitude from the equator to 80° latitude - computed with values for both "a" and "b" and "x" and "y" methods of construction.

OBLIQUE MERCATOR PROJECTION TABLES. In 19 bands providing world-wide coverage, each band has an effective width of 16 degrees of a great circle. This publication contains 187 pages of tables, explanatory text, mathematical formulas for deriving the tables, and a nomograph.

DISTANCE TABLES (Airline)

AIRLINE DISTANCES. C. A. Whitten. Special Pub. 238. 245 p. An extensive table of more than 120,000 airline distances between 492 cities in the United States which are authorized points on routes of domestic air carriers.

AERONAUTICAL CHARTS OF THE UNITED STATES OF AMERICA

PUBLISHED BY THE U. S. COAST AND GEODETIC SURVEY, WASHINGTON, D. C.

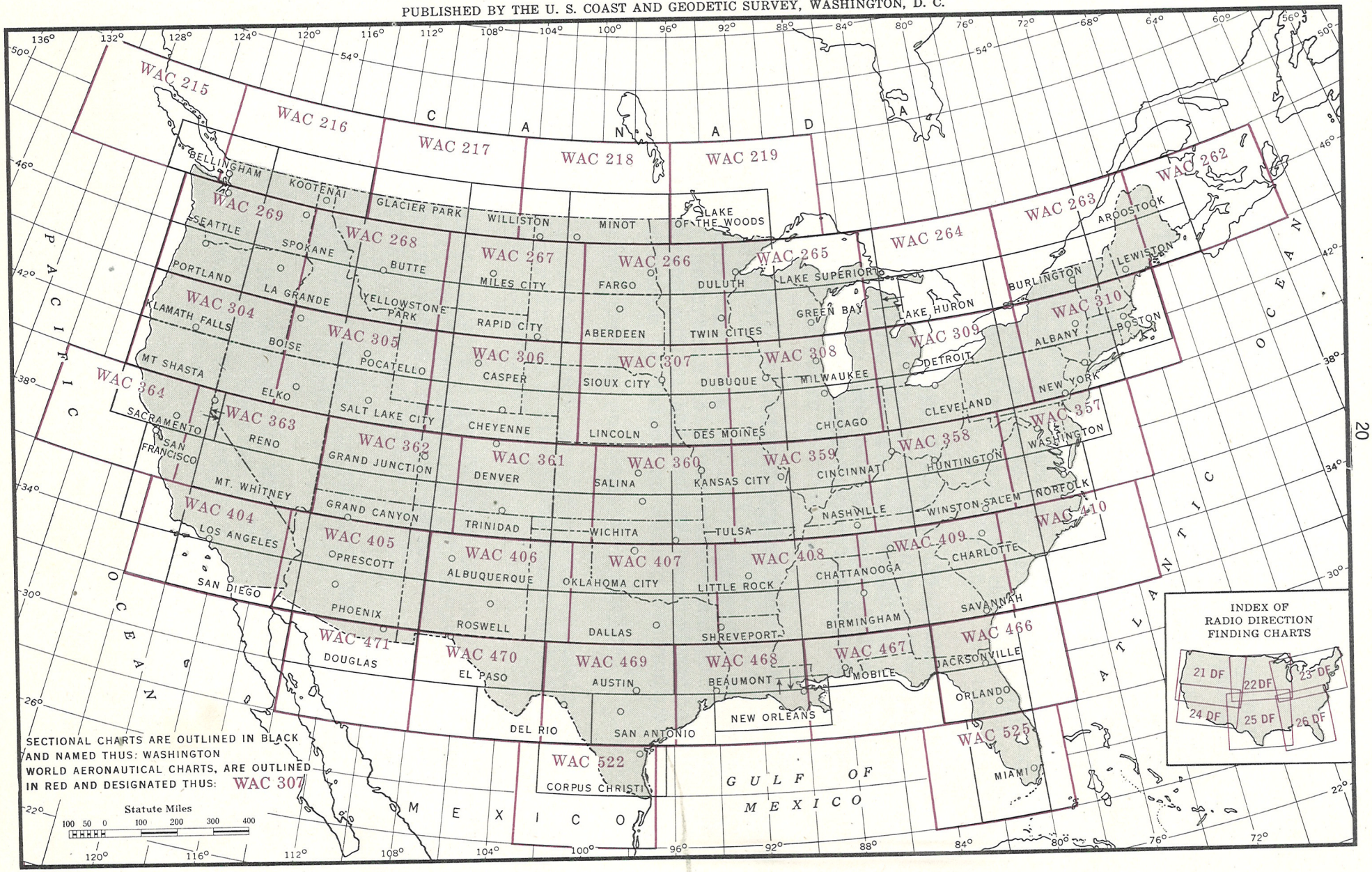

PLATE VIII

WORLD AERONAUTICAL CHARTS OF ALASKA AND NORTHWESTERN NORTH AMERICA

WORLD AERONAUTICAL CHARTS OF ALASKA AND NORTHWESTERN NORTH AMERICA

PUBLISHED BY THE U. S. COAST AND GEODETIC SURVEY, WASHINGTON, D. C.

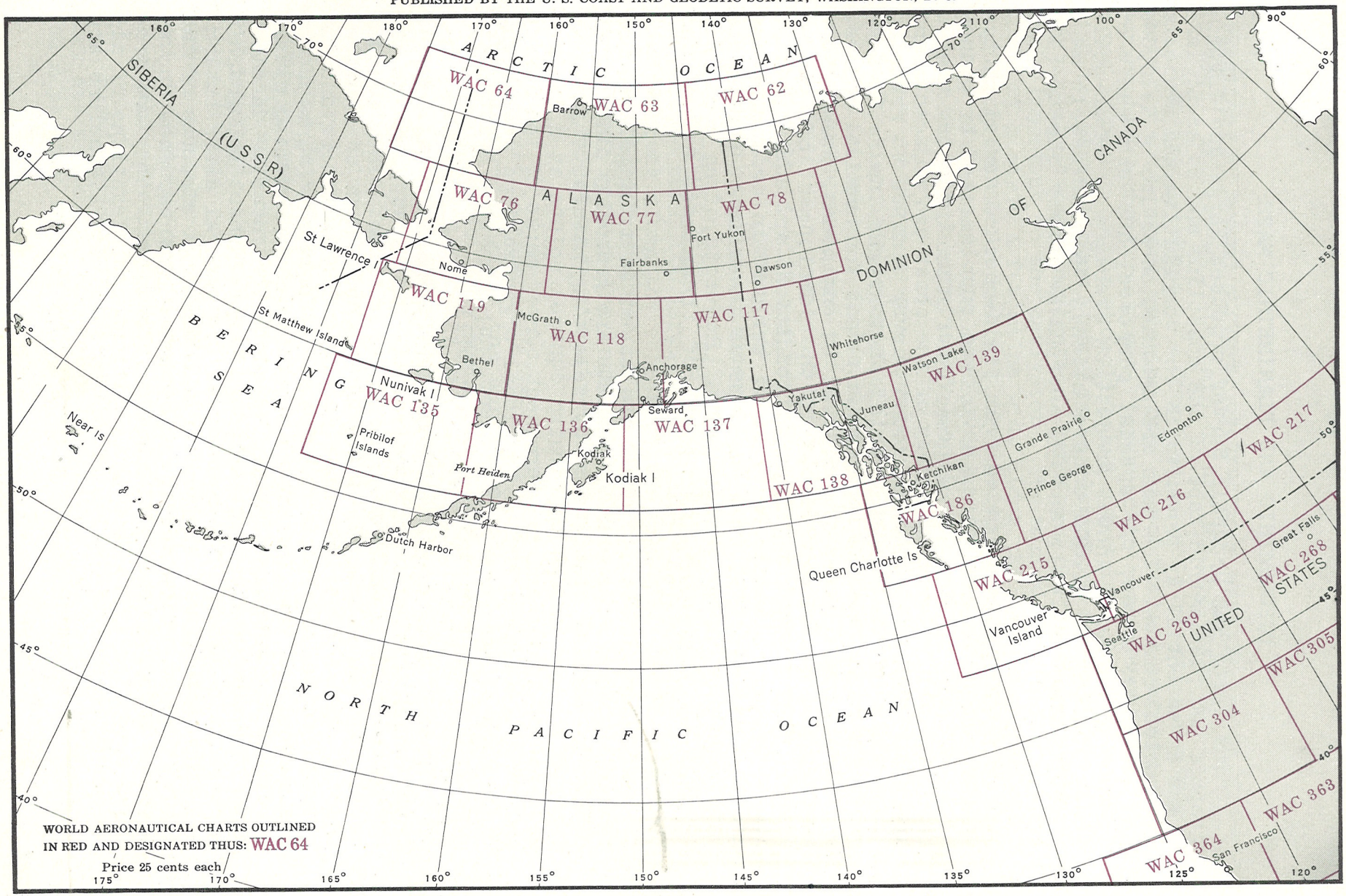

PLATE IX

TOPOGRAPHIC AND PLANIMETRIC MAPS

The Coast and Geodetic Survey produces large-scale topographic and planimetric maps of the coastline and adjacent land areas as essential by-products in the compilation and revision of nautical charts. The maps are produced on scales of 1:10,000 and 1:20,000; a few, for special purposes, are on a scale of 1:5,000 or larger. Annual production averages 50 large-scale topographic maps (1,800 square miles), 45 planimetric maps (1,500 square miles), and 35 shoreline survey sheets (400 linear miles).

These maps are compiled from field-checked aerial photographs, which in many cases have been supplemented by plane-table surveys of the shoreline. Experience indicates that a basic aerial photographic survey of the coast and adjacent land areas can cost less than a ground survey limited to revision along the shoreline only. Aerial photographs insure an adequate amount of reliable topographic detail for nautical charts, and also furnish basic information to engineers, county surveyors, and others interested in the development of coastal areas. They present a picture of conditions and advantages so complete and reliable as to be of benefit in promoting the growth to be expected from the immense investments for inside waterways and harbor improvements. Requests often come from commercial companies for copies of these maps before the originals are received for reproduction.

All maps of this series are based on triangulation or traverse control. Recoverable objects are generally distributed either by marking stations or by selecting natural objects at intervals close enough to furnish control points at a maximum distance of 1 mile apart. Permanent survey marks of the Survey and other Federal agencies and local organizations are shown. These maps are on polyconic projections; some show state plane coordinates, and in the future all will.

Types of maps produced by the Survey are: (1) Topographic maps, which include contours, of the lands adjacent to the navigable coastal waters of the United States. They provide complete topographic data for the compilation of nautical charts. (2) Planimetric maps complete for all shore and inshore details, except contours. (3) Shoreline surveys for areas requiring revision of the shoreline where existing planimetric or topographic maps are adequate for interior details. Shoreline surveys are registered in the permanent topographic surveys file but are not reproduced for general distribution. (4) Airport obstruction plans for all important airports of the United States, which are special-purpose charts, show runway patterns and other essential airport information. They are produced specifically to show the positions and elevations of all obstructions within 3 miles of runway termini. Elevations are

determined by ground surveys; obstructions are located by field surveys, usually with the aid of aerial photographs.

Topographic Maps. -- Compiled on a $7\frac{1}{2}$-minute quadrangle basis for areas where existing maps do not contain adequate data for nautical chart purposes, topographic maps cover land features adjacent to the shoreline and other land features essential to nautical charts as aids in alongshore navigation. With the advent of radar navigation, landforms are becoming increasingly important to the navigator. The mapped area usually consists of a strip a few miles wide along the coastline, extending along the entire seacoast, around bays, and up rivers to the head of navigation. In special cases, the maps include inland areas to meet specific requirements.

The quadrangles are usually compiled from aerial photographs by stereoscopic mapping instruments, or occasionally they may be derived by a combination of graphic compilation from aerial photographs and planetable surveys. After the manuscripts have been completed by the Coast and Geodetic Survey, including field-edit and review, they are turned over to the U.S. Geological Survey for publication as basic components of the standard topographic series of the United States.

Planimetric Maps. -- The Coast and Geodetic Survey has published more than 1000 large-scale planimetric maps covering extensive areas along the coasts of the country. Their compilation from aerial photographs has expanded to include surveys of the coastal regions and intracoastal waterways of most of the Atlantic coast and extensive areas of the Gulf and Pacific coasts.

Planimetric maps serve admirably as base maps for coordinating and compiling all the surveys of a locality. There is a great need, particularly among county engineers, for an accurate base map coordinated with the geodetic datum at a scale large enough to show the details of developments on which other survey and map data can be plotted without risk of accumulated error. The planimetric maps show all the important features--except contours--which are distinguishable on the aerial photographs in their true relation to geodetic control. Features include shoreline detail; drainage; and cultural details such as towns, buildings, roads, railroads, field boundaries, and landmarks. The cadastral surveys of a region are frequently connected to the details so that they can be plotted on the planimetric maps with a minimum of expense for resurveys. Special construction surveys may also be plotted with equal facility; more intelligent development may be expected of the localities where surveys have been coordinated and mapped in this way.

Planimetric maps do not contain hydrographic information. They are printed in one color (black), without scale reduction. The maps vary in size but are generally about 26 by 44 inches,

and are distributed at 75 cents each by the Coast and Geodetic Survey. Indexes showing the areas covered, with each map identified for ordering, may be obtained upon request.

Planimetric and shoreline surveys of areas of low relief are mapped from nine-lens photographs by radial plotting and graphic compilation methods. The control ordinarily consists of existing first- and second-order triangulation.

Photogrammetric Methods and Equipment. -- Aviation has simplified the production of aerial photographs for a given area. This development paved the way for photogrammetric methods of mapping to replace in large part ground planetable surveying which was formerly used almost exclusively by the Survey. The more economicial and expeditious method of photogrammetry was first used in surveying the Alaska-Canada boundary in the 1890's. At that time photographs were taken from the ground at points of known position and used in lieu of planetable observations to determine the positions of minor points of detail. Although this method of terrestrial photogrammetry was used with considerable success, it was not generally adopted, and was not used again until 1918, when some aerial photographs became available for experimental surveys. Photogrammetry, which is more complete in coverage and less tedious in application, soon demonstrated superiority over ground planetable surveying, and since 1928 has developed rapidly as the method now used for nearly all of the Bureau's topographic surveys.

In producing maps from single-lens photographs, considerable expensive ground control was required to combine a large number of photographs into an accurate plot. To overcome these difficulties, personnel of the Survey designed a nine-lens aerial camera and associated equipment. The camera has nine lenses of $8\frac{1}{4}$-inch focal length and produces at each exposure nine separate images on one piece of film. The images are transformed and combined into a composite photograph approximately 35 inches square, affording an excellent detailed view of the ground. At an altitude of 7,000 feet, an area of 32 square miles is covered. This coverage increases to over 300 square miles at an altitude of 22,000 feet. Ground control necessary for aerial photographic surveys is thereby reduced, with a corresponding reduction in the cost of mapping from photographs. This is especially true where transportation is difficult and costly.

Stereoscopic plotting instruments have been designed especially for use with the nine-lens prints. Stereoscopic pairs of rectified aluminum-mounted photographs are used on these plotting machines, known as Reading plotters, named after their designer, Capt. O. S. Reading, Coast and Geodetic Survey. A

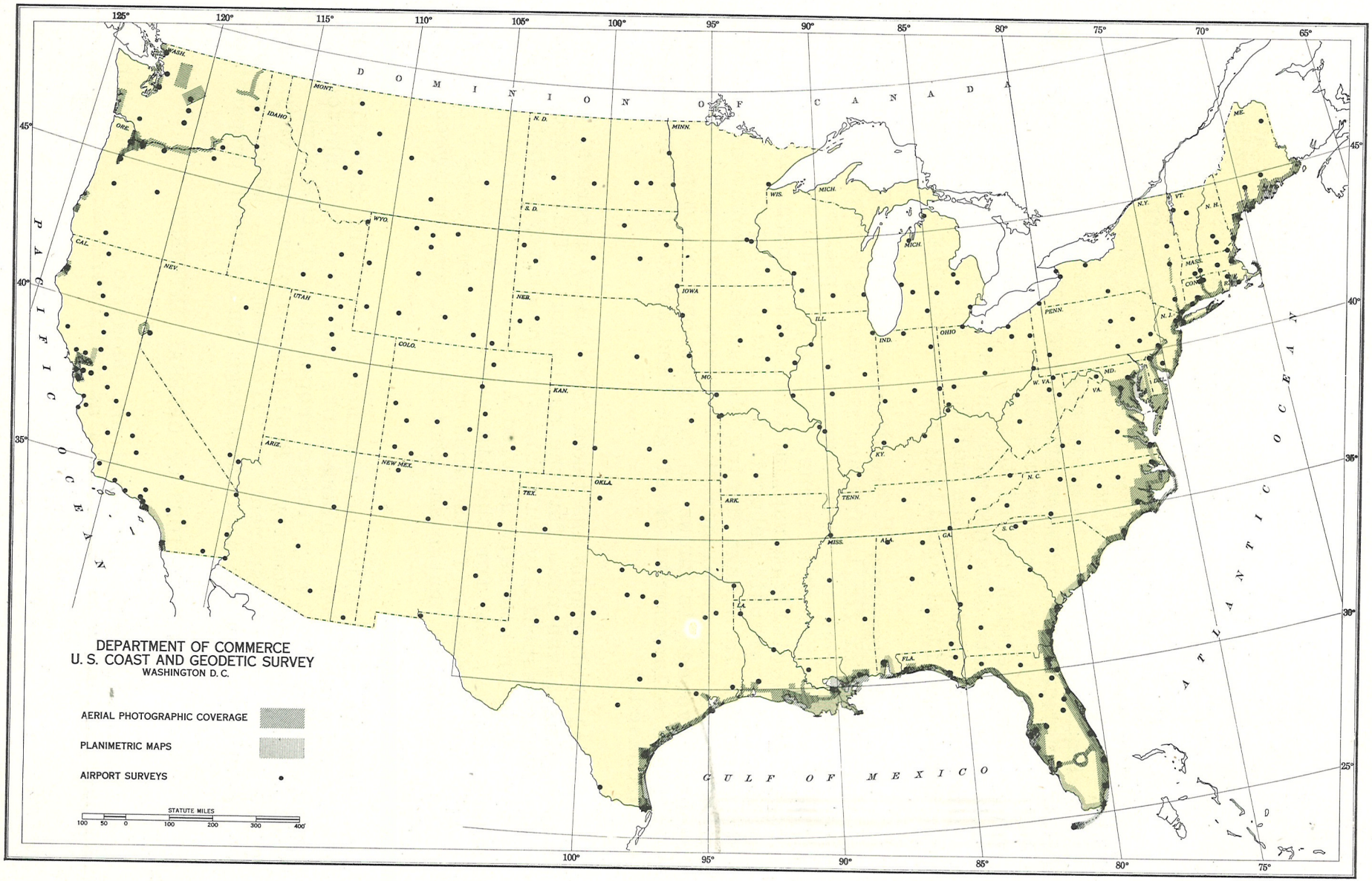
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
WASHINGTON D. C.
AERIAL PHOTOGRAPHIC COVERAGE
PLANIMETRIC MAPS
AIRPORT SURVEYS
STATUTE MILES
100 50 0 100 200 300 400
DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
WASH.
ORE.
CAL.
IDAHO
NEV.
MONT.
WYO.
UTAH
COLO.
ARIZ.
NEW MEX.
N. D.
S. D.
NEB.
KAN.
OKLA.
TEX.
MINN.
IOWA
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND.
OHIO
KY.
TENN.
MISS.
ALA.
GA.
FLA.
S. C.
N. C.
W. VA.
VA.
PENN.
N. Y.
MD.
DEL.
N. J.
CONN.
R. I.
MASS.
VT.
N. H.
ME.
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°

PLATE X

visual relief model is obtained by the simultaneous examination of an overlapping pair of photographs and, by means of automatic parallax-analyzing mechanisms and scale correctors, heights and contours are accurately measured and traced.

Topographic maps are compiled from single-lens photographs by a Zeiss stereoplanigraph, three Bausch and Lomb multiplex units, and two Kelsh plotters. The stereoplanigraph, used with single-lens photographs for horizontal and vertical bridging or aerial triangulation between ground control stations, is more accurate than other instruments of the Survey, and it is extremely flexible with regard to scale of compilation. In some applications, data obtained with the stereoplanigraph are used as control for adjusting the multiplex and the Kelsh plotters, with which the final detailing and contouring are done.

Aerial Photography. -- The Bureau maintains its own personnel and equipment for taking and processing aerial photographs used for chart correction, topographic and planimetric mapping, and airport obstruction plans. The equipment includes three single-lens aerial cameras, a nine-lens camera, and a well-appointed photographic laboratory. The photographic crew usually operates in Alaska during the summer months and in the United States the remainder of the year. The extent of photographic coverage is shown on an accompanying map. (Contact prints and enlargements of single-lens aerial photographs may be purchased.)

Aerial photographs are taken from a B-17 aircraft, equipped with a plexiglass nose for the navigator. This sturdy long-range plane, especially suitable for the Survey's photography, particularly in sparsely settled Alaska, is equipped with two camera mounts, one for the nine-lens camera and one for the single-lens cameras. It is owned and operated by the U.S. Coast Guard, but the navigator and photographer are employees of the Survey.

Graphic compilation of planimetric maps and shoreline surveys from single-lens enlargements and nine-lens photographs comprises a relatively large proportion of the work of the Division of Photogrammetry. Radial line plots are very carefully made with transparent vinylite templets, which are corrected graphically for paper shrinkage during their preparation.

PUBLICATIONS OF GENERAL INTEREST

Publications by the Coast and Geodetic Survey relating to topographic surveys are listed as follows:

TOPOGRAPHIC MANUAL. O. W. Swainson. Special Pub. 144. 1928. 125 p. 40 illus.

TOPOGRAPHIC MANUAL. Part II. L. W. Swanson. Special Pub. 249. 1949. 570 p. 192 illus. A statement of the Bureau's general requirements for photogrammetry and topographic surveying. Part I, to be published at a later date, will contain detailed instructions for field topographic surveys, including planetable surveys, without using aerial photographs, and photogrammetric field surveys made for the compilation of maps from aerial photographs. When published, Part I will supersede Special Pub. 144.

GEODETIC CONTROL SURVEYS

GENERAL STATEMENT

The surveying and mapping of large areas require the consideration of the geoid--the curvature of the sea level surface of the earth. Basic surveys which take into account the size and shape of the earth are called geodetic surveys.

The geodetic work of the Coast and Geodetic Survey consists of several types of surveying operations, which require the highest degree of accuracy. The resulting data are used as the basis or control for maps, charts, intermediate and local surveys, and for various engineering projects, both public and private.

The operations include the determination of latitudes and longitudes by triangulation and traverse; the determination of elevations by leveling; astronomic observations for latitude, longitude, and azimuth in conjunction with triangulation and traverse; and gravity observations for determination of the figure of the earth.

HORIZONTAL CONTROL

Triangulation is a very efficient method for making surveys over extensive areas. It avoids the tedious time-consuming, expensive operation of measuring the lengths of all lines that enter into a survey. It consists of a system of connected triangles with all angles carefully observed, but with only an occasional length actually measured on the ground. Each measured length is known as a base. An intricate network of arcs or chains of triangulation has been extended over the United States. The areas between the arcs are being filled with a spiderweb effect to locate points at closer intervals. These points, designated as triangulation stations, are located by surveys of first-, second-, and third-order accuracy, and the geographic positions are adjusted on the North American 1927 datum.

The United States has been covered in large part by a network of triangulation (see diagram). The geographic positions have been determined for approximately 150,000 stations in the United States and Alaska. They consist of marked or monumented points and prominent objects, such as water tanks, church spires, cupolas, chimneys, et cetera. Engineers and surveyors may begin and end local surveys on these stations, and by using plane coordinates in their computations employ only the usual formulas and tables of plane surveying. Plane coordinates are computed on the state systems for all stations in the United States for which positions have been adjusted on the North American 1927 datum.

DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
GEODETIC SERVICE

GEOGRAPHIC POSITIONS (latitude and longitude of monumented stations), elevations of bench marks, and related data, essential for charting, mapping, and other engineering projects, are provided by the Coast and Geodetic Survey throughout the United States and its possessions.

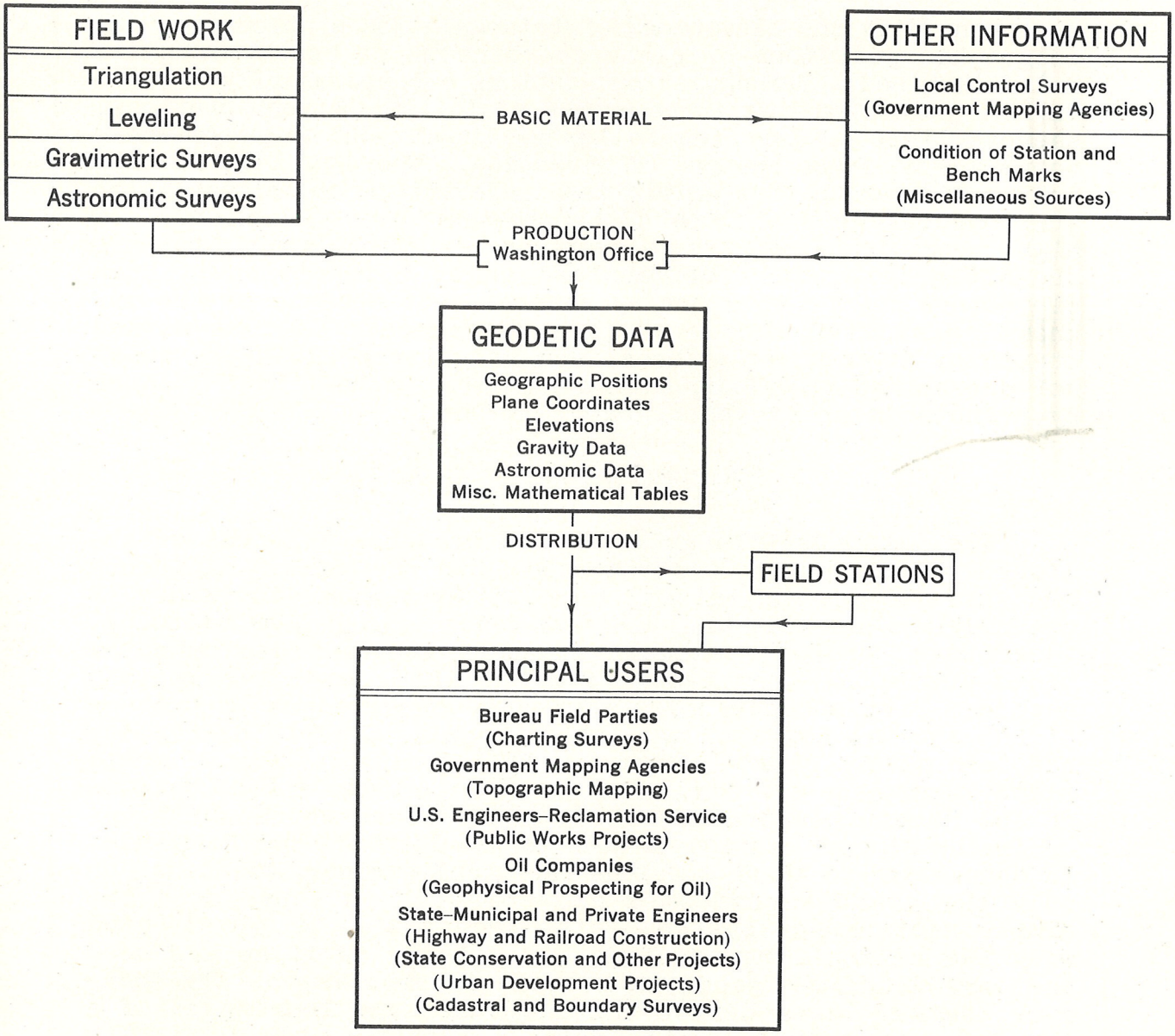

PLATE XI

Marked stations normally consist of bronze triangulation station disks set in concrete, bedrock, or existing permanent structures. Each station is usually referenced by two similar marks designated as reference marks located nearby. Usually an azimuth mark, similarly marked and visible from the station, is located at least 1/4 mile distant to furnish convenient azimuth control for local surveys. Only the azimuth from the station to this mark is observed; the distance is not determined and the azimuth is not observed from other stations.

Generally the elevations of triangulation stations and the geographic positions or plane coordinates of bench marks are not determined. Triangulation stations are necessarily located on high points so that there may be visibility between stations, whereas lines of leveling follow railroads and highways where there are no sharp changes of elevation. Therefore, it is only in rare instances that spirit-level elevations of triangulation stations or the positions of bench marks are determined. In high, mountainous country, elevations of triangulation stations are often determined by vertical-angle observations. Such elevations may be in error by several feet because of the unknown refractive effect of the atmosphere. Various marked stations, prominent features, and structures along the coast not determined by triangulation or traverse have been located by planetable or air-photographic methods.

HORIZONTAL CONTROL DATA

The data for triangulation and traverse stations established by the Survey are available for the use of engineers and surveyors. The initial computations and adjustments of observations are made with geodetic factors producing latitudes, longitudes, geodetic azimuths, and lengths. These computations are rather formidable for the local engineer who may have had little opportunity to become experienced in the use of the special formulas and tables required. This difficulty has been almost entirely overcome by the introduction of state plane coordinate systems. The data for triangulation stations of the Bureau now include the "x" and "y" plane rectangular coordinates of each station as well as the latitude and longitude. In connecting to these stations the local engineer may consider only the plane coordinates and compute his surveys on the simple rectangular system. His surveys will be coordinated with the national net just as effectively as if he had used the more difficult geodetic method of computation. Furthermore, he may later derive the latitudes and longitudes of a few important points of his survey without too much difficulty by converting from one system to the other. For this purpose, plane coordinate projection tables for each state may be obtained from the Bureau.

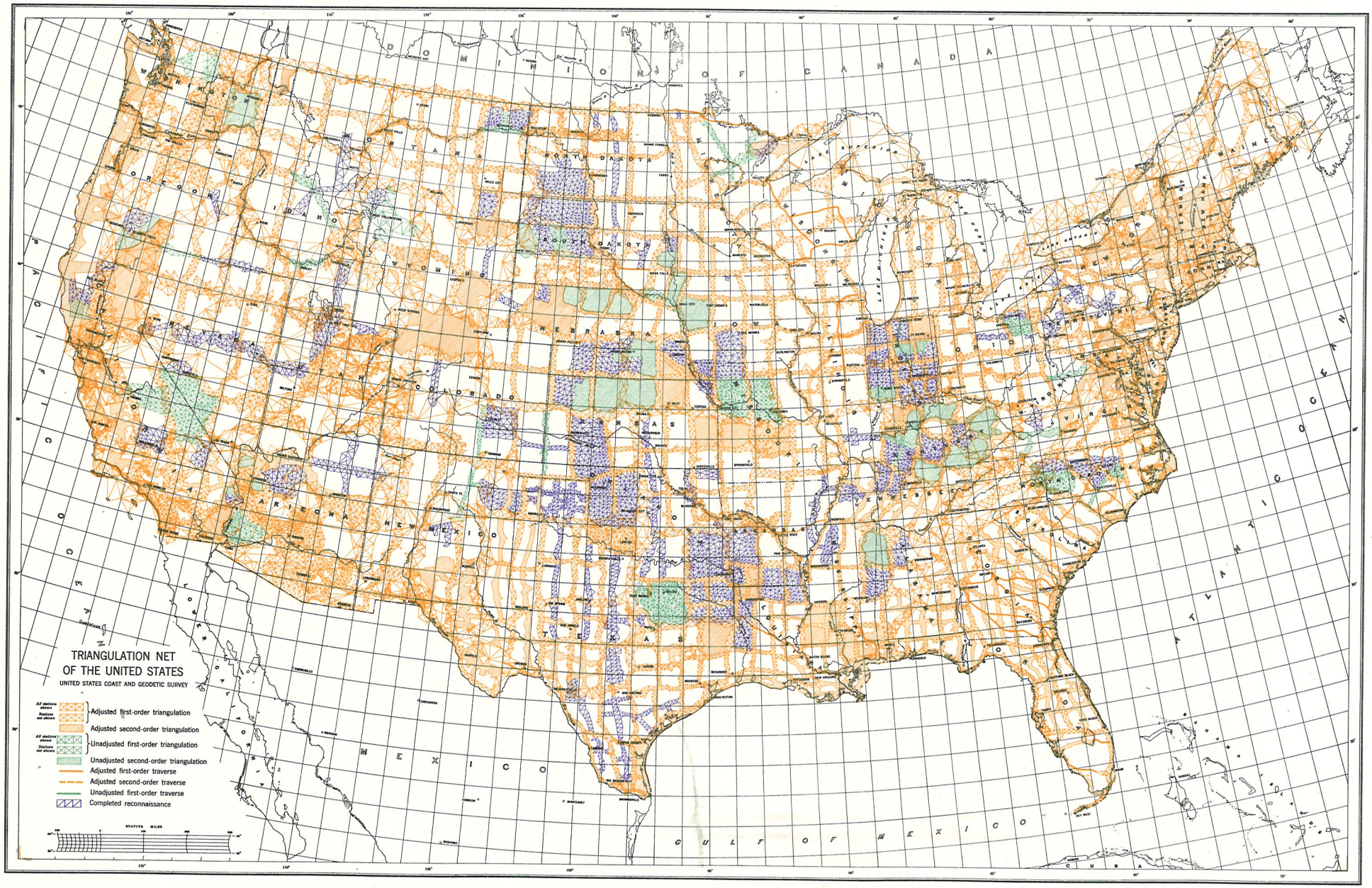
TRIANGULATION NET
OF THE UNITED STATES
UNITED STATES COAST AND GEODETIC SURVEY
All stations shown
Stations not shown
Adjusted first-order triangulation
Adjusted second-order triangulation
All stations shown
Stations not shown
Unadjusted first-order triangulation
Unadjusted second-order triangulation
Adjusted first-order traverse
Adjusted second-order traverse
Unadjusted first-order traverse
Completed reconnaissance
STATUTE MILES
DOMINION OF CANADA
MEXICO
GULF OF MEXICO
CUBA
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW JERSEY
DELAWARE
MARYLAND
ATLANTIC OCEAN

PLATE XII

The geodetic data are in lithoprint form and are available for distribution without cost. Included are the latitudes, longitudes, and plane coordinates of the stations, the geodetic lengths and azimuths of the lines between contiguous stations, and the detailed descriptions of their locations. The geodetic azimuths or directions of the lines should not be confused with the plane coordinate directions which may differ considerably. The convergence of the meridians is considered in deriving the geodetic azimuths, whereas the plane or grid azimuths are referred to one central meridian. In order to make data available in the shortest possible time, and in flexible form so that additions and necessary corrections can be made, a loose-leaf system is used.

Descriptions. -- Station descriptions are lithoprinted by arcs and areas as the work is done, and are available by individual pages or by groups of pages assembled by projects which are arbitrarily numbered. The station descriptions are arranged geographically along the arcs or by counties for area coverage.

Geographic Positions. -- The latitudes and longitudes of stations and lengths and azimuths of observed lines between them are lithoprinted, when the adjusted data become available, by arcs or areas and the pages are assembled in volumes by states. It should be noted that these data are not necessarily assembled in the same area coverage as the descriptions.

Plane Coordinates. -- The "x" and "y" coordinates are lithoprinted for all stations in the United States which have been adjusted on the North American 1927 datum. Plane azimuths to azimuth marks and, in the more recent lists, the difference between the plane and geodetic azimuths are included. Plane coordinates are computed from the geographic positions and are generally listed in the same sequence within states or zones. The plane-coordinate data are not necessarily assembled in the same area coverage as the descriptions.

Triangulation Diagrams and Indexes. -- Triangulation and traverse stations are plotted on state base maps of convenient scale as graphic indexes of the location of the stations and the lines observed in the field work. Indexes of triangulation data are available for each state giving volume and page numbers for geographic positions, and plane coordinates and descriptions, respectively.

VERTICAL CONTROL

Leveling, the operation of determining the difference of elevation between any two points on the surface of the earth, has been extensively carried on in the United States by the Coast and Geodetic Survey. Elevations resulting from leveling may be computed relative to some arbitrary or natural level surface called a datum. The datum used by the Survey is the mean level of the sea, and the elevations are referred to as being based on the "Sea Level Datum of 1929" as the primary adjustment of the first-order level net was computed at that time.

Most of the level lines run by the Survey follow the routes of highway and railroad systems for economic reasons. To perpetuate the leveling, brass-disk bench marks are established along the route of the lines at intervals of 1 to 3 miles, except in towns and cities, where several are usually placed. On each bench-mark disk is an appropriate legend and the letter and number forming the designation. They are set in the top of specially made stone or concrete posts, in the walls of substantial buildings, in any solid masonry structure, in outcrops of rock, et cetera. The elevations of a number of unmarked points, such as the intersection of highways and the top of the rail in front of a railroad station, are also determined.

The Coast and Geodetic Survey level lines are generally of first- and second-order accuracy. Only a very small amount of third-order leveling has been run by this organization. The most accurate method of leveling is first-order. An idea of the accuracy attained in first-order leveling is given by the fact that on an average a circuit 100 miles in length closes with an error of only slightly over 1 inch.

The elevations of more than 275,000 bench marks in the United States have been determined by the Coast and Geodetic Survey on approximately 380,000 miles of first- and second-order leveling.

LEVELING DATA

The Coast and Geodetic Survey's data for leveling are available in lithoprint form. These include descriptions and locations of bench marks and elevations above mean sea level. The data are printed for lines of leveling. Each line has a distinctive number, which is shown on state maps of convenient size. The index maps and lithoprinted data concerning leveling are available from the Coast and Geodetic Survey upon request.

ASTRONOMY AND GRAVITY

A continuous program of field astronomic observations is maintained. These observations are used to control orientation of triangulation networks, and, in conjunction with gravimetric data, to provide increasingly more information on the size and shape of the earth. Approximately one thousand astronomic stations have been established under this program.

The gravity activities of the Survey include pendulum observations at more or less regular intervals throughout the country to provide a system of gravity control, and, in recent years, the use of gravity meters to obtain more detailed gravity coverage. Gravity anomalies are computed according to various hypotheses, and the resulting data are used in studies of the figure of the earth. These data are also widely used by geophysicists and geologists in interpretations of density distributions in the earth's crust.

LATITUDE OBSERVATORIES

As the earth rotates, the axis of rotation points very nearly but not exactly to a fixed point in the heavens. Imagine a line through the center of the earth and the celestial North Pole, then this line would describe an irregular curve of a 14-month period around the mean North Pole. The largest distance between this curve and the mean Pole is of the order of 0".3 to 0".4, or 30 to 40 feet.

All astronomical observations are directly affected by this variation of the Pole. In order to correct astronomical observations for the variation of the Pole, a continuous record of its wandering or variation must be available. No theory has been developed by which the variation of the Pole can be predicted to any degree of accuracy.

In 1899, five international latitude observatories were established for the purpose of keeping a continuous account of the variation of the Pole. All observatories are on the same parallel of North latitude, $\phi = 39^{\circ}\ 08'.2$. This assures the use of the same set of stars by each station, thus eliminating any errors in positions of the star places, and also insuring that the conditions for observing are almost identical for the same set of stars at all stations. The five observatories are located at Ukiah, Calif.; Gaithersburg, Md.; Carlo Forte, Italy; Kitab, Russia; and Misuzawa, Japan. The first two, in the United States, are maintained by the Coast and Geodetic Survey.

PUBLICATIONS OF GENERAL INTEREST

Publications by the Coast and Geodetic Survey covering the methods by which triangulation and leveling are carried on, or special subjects connected with either methods or results, are:

FORMULAS AND TABLES FOR THE COMPUTATION OF GEODETIC POSITIONS. Special Pub. 8. Seventh edition. The method of computing geodetic positions by the use of logarithms is explained and the tables used in the computations are given.

APPLICATION OF THE THEORY OF LEAST SQUARES TO THE ADJUSTMENT OF TRIANGULATION. Special Pub. 28. The purpose of this publication is to illustrate the application of the method of least squares to the problems arising in the adjustment of triangulation.

INSTRUCTIONS TO LIGHTKEEPERS ON FIRST-ORDER TRIANGULATION. Special Pub. 65. This manual describes the lightkeeper's duties in tending signal lights and describes his instruments, their use and care.

MANUAL OF FIRST-ORDER TRAVERSE. Special Pub. 137. This volume summarizes the methods used in executing first-order traverse. It contains detailed instructions for the various operations in the conduct of field work, describes the records and computations to be made in the field; explains in detail the office computation, including the least squares adjustment; and contains a number of tables needed in making the computations.

MANUAL OF TRIANGULATION COMPUTATION AND ADJUSTMENT. Special Pub. 138. The purpose of this publication is to explain the methods used by the Coast and Geodetic Survey in the office computation and adjustment of triangulation.

MANUAL OF SECOND- AND THIRD-ORDER TRIANGULATION AND TRAVERSE. Special Pub. 145. This publication contains a description of the specifications and criteria for second- and third-order triangulation, traverse, and base measurement, with detailed instructions for field and office operations and specimens of field records and office computations.

BILBY STEEL TOWER FOR TRIANGULATION. Special Pub. 158. (Rev. 1940, Ed.). The design and use of the portable steel tower for triangulation work was one of the foremost advances made in recent years by the Coast and Geodetic Survey in its endeavor to reduce the cost of its work while maintaining or improving its accuracy. The Bilby tower is much less expensive than the wooden tower formerly used and can be promptly erected to the height needed, and readily dismantled and moved by truck

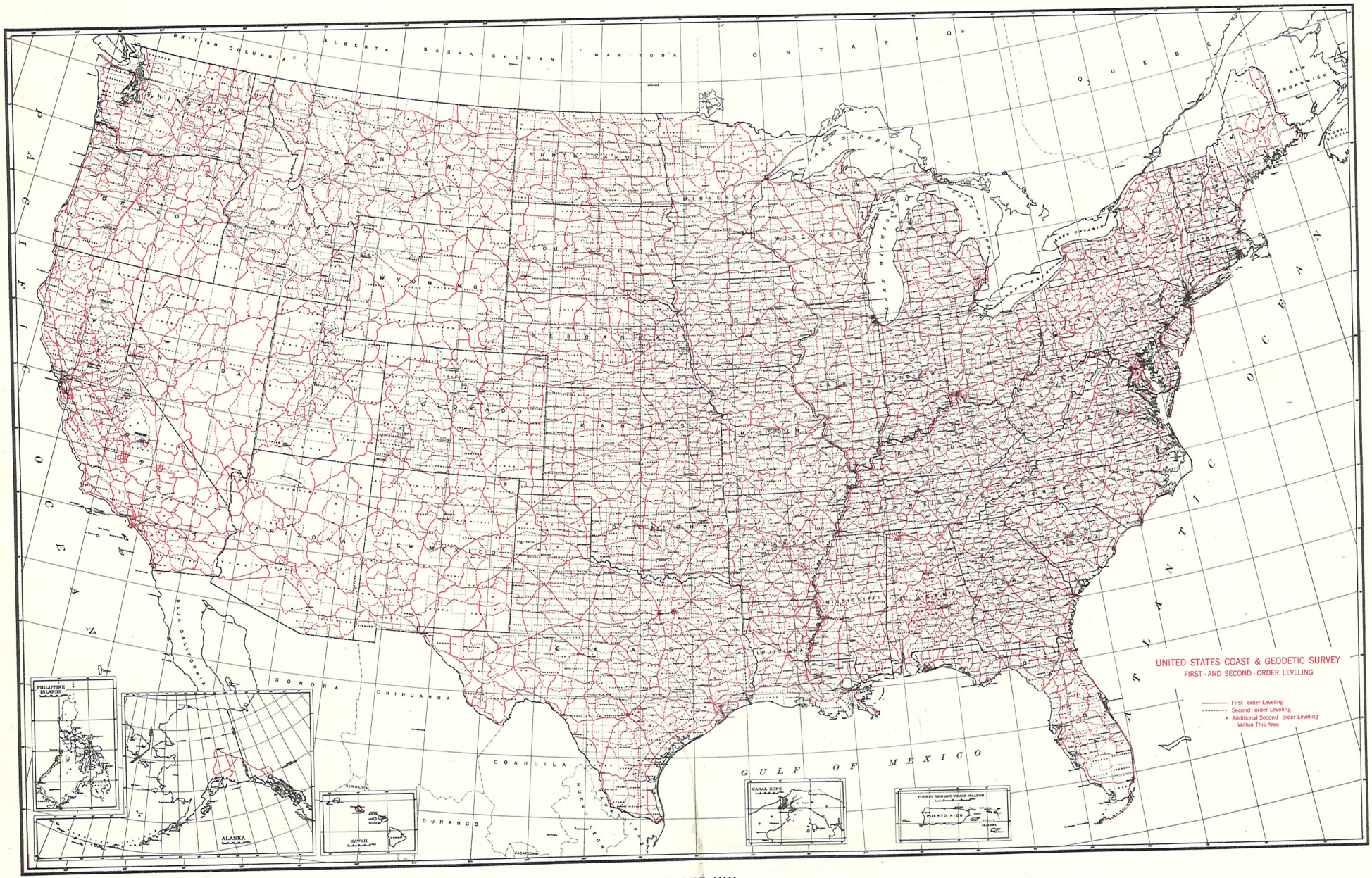
UNITED STATES COAST & GEODETIC SURVEY
FIRST - AND SECOND - ORDER LEVELING
First - order Leveling
Second - order Leveling
Additional Second - order Leveling Within This Area
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEW BRUNSWICK
NOVA SCOTIA
PRINCE EDWARD ISLAND
LAKE SUPERIOR
LAKE MICHIGAN
LAKE ONTARIO
LAKE ERIE
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW JERSEY
DELAWARE
MARYLAND
BAJA CALIFORNIA
SONORA
CHIHUAHUA
COAHUILA
NUEVO LEON
DURANGO
ZACATECAS
SINALOA
PHILIPPINE ISLANDS
ALASKA
HAWAII
CANAL ZONE
PUERTO RICO AND VIRGIN ISLANDS
PUERTO RICO

PLATE XIII

to the next station. This publication contains not only illustrations, drawings, and specifications for the construction of these steel towers but also comprehensive instructions for organizing a field building party, including personnel and outfit. It describes the method used for marking stations, and other operations required in cooperating with the observing party.

MANUAL OF PLANE COORDINATE COMPUTATION. Special Pub. 193. This is a description of the two types of conformal projections that have been used as bases for the state systems of plane coordinates.

MANUAL OF TRAVERSE COMPUTATION ON THE LAMBERT GRID. Special Pub. 194. A supplement to Special Pub. 193, this manual contains a more complete account of the system of plane coordinates based on the Lambert projection.

MANUAL OF TRAVERSE COMPUTATION ON THE TRANSVERSE MERCATOR GRID. Special Pub. 195. This is a companion volume to Special Pub. 194 and serves the same purpose for the transverse Mercator projection.

MANUAL OF RECONNAISSANCE FOR TRIANGULATION. Special Pub. 225. Reconnaissance is essentially the design of triangulation. It includes the selection of sites for stations, the testing of lines for visibility, the determination of required signal heights, and the collection of local information which will expedite the work of the building and observing parties. Instructions for this important operation in triangulation surveys are included in this manual.

CONTROL LEVELING. Special Pub. 226. Describes in non-technical language the precise leveling operations of the Coast and Geodetic Survey. Includes descriptions of instruments, methods of field operations and office adjustments, history of the level net, and other special information on leveling.

HORIZONTAL CONTROL DATA. Special Pub. 227. Gives essential facts about the Survey's horizontal control method in simple non-technical language. Explains horizontal control data and their uses.

NATURAL SINES AND COSINES TO EIGHT DECIMAL PLACES. Special Pub. 231. This eight-place table with an interval of one second is useful in computing geographic positions by calculating machine.

THE STATE COORDINATE SYSTEMS (A Manual for Surveyors.) Special Pub. 235. The primary purpose of this manual is to present the simplification of the use of the state plane

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coordinate systems by engineers and surveyors who may wish to connect their surveys to the national control net without the difficulty of making geodetic computations.

MANUAL OF GEODETIC ASTRONOMY. Special Pub. 237. This is a manual for field and office use, describing the methods used in the observation and computation of astronomical determinations connected with geodetic surveys. It deals especially with the use of the Bamberg broken-telescope transit instrument for determining latitude and longitude, and also for determining azimuth in high latitudes.

MANUAL OF GEODETIC LEVELING. Special Pub. 239. This manual contains the general instructions and procedure for geodetic leveling as practiced by the Coast and Geodetic Survey.

MANUAL OF LEVELING COMPUTATION AND ADJUSTMENT. Special Pub. 240. This is strictly an office manual describing in detail the methods of computing and adjusting first- and second-order leveling.

NATURAL TABLES FOR THE COMPUTATION OF GEODETIC POSITIONS. Special Pub. 241. The method of computing geodetic positions by the use of natural functions is explained and tables used in the computations are given.

DEFINITIONS OF TERMS USED IN GEODETIC AND OTHER SURVEYS. Special Pub. 242. Gives authoritative definitions, principally of geodetic survey terms.

PENDULUM GRAVITY DATA IN THE UNITED STATES. Special Pub. 244. This publication contains the descriptions, positions, elevations, observed values of gravity, and gravity anomalies for all pendulum gravity stations established in the United States between 1891 and 1949. Included is a short discussion of the gravity ties between the gravity base stations in Washington, D.C., and the absolute-gravity station in Potsdam, Germany.

SINES, COSINES, AND TANGENTS; TEN DECIMAL PLACES, WITH TEN-SECOND INTERVAL; 0° - 6°. Special Pub. 246. This trigonometric table was compiled primarily for use in computing state plane coordinates on the Lambert projection.

TIDE AND CURRENT DATA

The tidal work of the Bureau had its origin in the necessity for reducing to a common level, or datum plane, soundings taken at different stages of the tide during hydrographic surveys. At the present time this work has developed in the following fields: The determination of mean sea level and other tidal datum planes for surveying and engineering purposes and the establishment of a system of tidal bench marks to which these planes are referred; the prediction of tides and currents and the publication of annual tide and current tables which include these predictions, together with other tide and current data; the publication of current charts for harbors and other waterways, which show the velocity and direction of the current at different hours; the publication of tide and current observational data, in general, as a matter of record, and to afford material for a study of various problems involving the tidal phenomena; the observation of the temperature and density of sea water at tide stations; and the study of seiche, seismic sea waves, storm tides, and other oceanographic phenomena which either relate to tides or are recorded incident to obtaining the tide record.

The primary object of the current work of the Bureau is the determination of navigational data, such as the velocity and direction of the currents; the determination of places where swift and dangerous tidal currents exist; and the determination of the time of occurrence of slack waters when such places may be passed through safely.

Tide and current surveys have been made in a number of important harbors and waterways in the United States. The data derived from these surveys are made available, through a series of special publications which give in considerable detail the results of the observational data, as follows:

Special Pub. 111.	Tides and Currents in New York Harbor (1935)
Special Pub. 127.	Tides and Currents in Southeast Alaska (1927)
Special Pub. 142.	Tides and Currents in Boston Harbor (1928)
Special Pub. 150.	Tides and Currents in Portsmouth Harbor (1929)
Special Pub. 162.	Tides and Currents in Chesapeake Bay (1930)
Special Pub. 174.	Tides and Currents in Long Island and Block Island Sounds (1932)
Special Pub. 180.	Tides and Currents in Hudson River (1934)

Special Pub. 208. Currents in Narragansett Bay, Buzzards Bay, Nantucket and Vineyard Sounds (1938)

Special Pub. 211. Currents in St. Johns River, Savannah River, and Intervening Waterways (1938)

TIDE AND CURRENT TABLES

Tide Tables. -- Advance information relative to the rise and fall of the tide is given in annual tide tables. These tables include the predicted times and heights of high and low waters for each day in the year for a number of reference stations and differences for obtaining similar predictions for numerous other places.

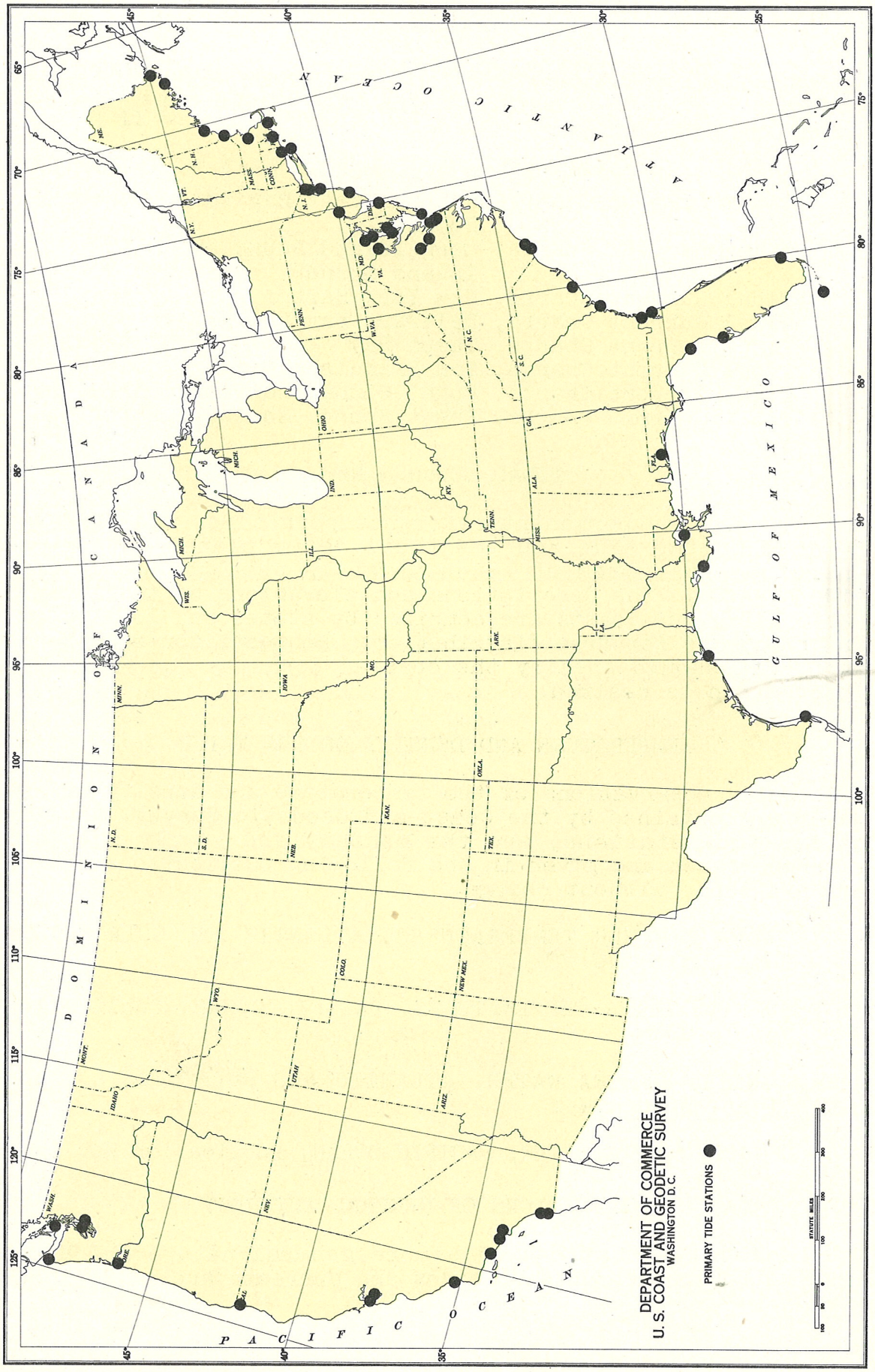
Current Tables. -- Accompanying the rise and fall of the tide is a periodic horizontal flow of the water known as the current. Advance information relative to these currents is made available in annual current tables which include daily predictions of the times of slack water and the times and velocities of strength of flood and ebb currents for a number of waterways, together with differences for obtaining predictions for numerous other places.

Publications issued annually are:

Tide Tables, Europe and West Coast of Africa (including Mediterranean Sea)
Tide Tables, East Coast, North and South America (including Greenland)
Tide Tables, West Coast, North and South America (including Hawaiian Islands)
Tide Tables, Central and West Pacific Ocean and Indian Ocean
Current Tables, Atlantic Coast, North America
Current Tables, Pacific Coast, North America, and Asia

TIDAL CURRENT CHARTS

Each of these publications consists of a set of 12 charts which depict, by means of arrows and figures, the direction and velocity of the tidal current for each hour of the tidal cycle. The charts, which may be used for any year, present a comprehensive view of the tidal current movement in the respective waterways as a whole and also supply a means of readily determining for any time the direction and velocity of the current at various localities throughout the water areas covered.


DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
WASHINGTON D.C.
PRIMARY TIDE STATIONS
STATUTE MILES
DOMINION OF CANADA
ATLANTIC OCEAN
GULF OF MEXICO
PACIFIC OCEAN

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The New York Harbor tidal current charts are to be used with the annual tide tables. The other charts require the annual current tables.

Tidal Current Charts, Boston Harbor
Tidal Current Charts, Narragansett Bay to Nantucket Sound
Tidal Current Charts, Long Island Sound and Block Island Sound
Tidal Current Charts, New York Harbor
Tidal Current Charts, Delaware Bay and River
Tidal Current Charts, Tampa Bay
Tidal Current Charts, San Francisco Bay
Tidal Current Charts, Puget Sound, Northern Part
Tidal Current Charts, Puget Sound, Southern Part

TIDAL BENCH MARKS

To provide permanent reference points for the observed heights of the tide and the tidal datum planes determined therefrom, a system of bench marks is established at each tide station. The descriptions and elevations of these bench marks along our coasts are compiled by states and localities, and published for free distribution. Requests for such bench mark data should specify the coastal locality for which the information is desired.

TEMPERATURE AND DENSITY OF SEA WATER

Daily observations of the temperature and density of sea water are obtained by the Coast and Geodetic Survey, usually at its tide stations, and the monthly and yearly mean and extreme values are given in the following publications, which are available without charge.

SURFACE WATER TEMPERATURES, ATLANTIC AND GULF COASTS Publication No. TW-1

SURFACE WATER TEMPERATURES, PACIFIC OCEAN, Publication No. TW-2

DENSITY OF SEA WATER, ATLANTIC AND GULF COASTS, Publication No. DW-1

DENSITY OF SEA WATER, PACIFIC OCEAN, Publication No. DW-2

PUBLICATIONS OF GENERAL INTEREST

Other publications of a more general nature which are related to the subjects of tides and currents are as follows:

MANUAL OF HARMONIC ANALYSIS AND PREDICTION OF TIDES. Paul Schureman. Special Pub. 98. Revised 1940. 321 p. 34 illus.

MANUAL OF TIDE OBSERVATIONS. Special Pub. 196. Revised edition (1941). 96 p. 30 illus.

MANUAL OF CURRENT OBSERVATIONS. Special Pub. 215. Revised 1950. 93 p. 36 illus.

TIDE AND CURRENT GLOSSARY. Paul Schureman. Special Pub. 228. Revised 1949. 43 p.

COASTAL CURRENTS ALONG THE ATLANTIC COAST OF THE UNITED STATES. F. J. Haight. 1942. 77 p. 35 illus. 15 tables.

TIDAL HARMONIC CONSTANTS, ATLANTIC OCEAN, INCLUDING ARCTIC AND ANTARCTIC REGIONS. Pub. TH-1. 1942. 141 p.

TIDAL HARMONIC CONSTANTS, PACIFIC AND INDIAN OCEANS. Pub. TH-2. 1942. 133 p.

CHART. - SEISMIC SEA WAVE TRAVEL TIMES TO HONOLULU.

The chart shows by a series of concentric circular lines overprinted in red the time required for a seismic sea wave to travel from an epicenter anywhere in the Pacific Ocean to Honolulu.

MAGNETIC DATA

The magnetic work of the U.S. Coast and Geodetic Survey, begun as one of the essential operations in the preparation of nautical charts of coastal waters, has been extended to cover the interior of the United States, thus answering the needs of the land surveyor, the airman, the geophysical prospector using magnetic methods, and the scientist working on problems associated with terrestrial magnetism.

Surveying by compass, though not to be compared with more accurate methods, does have advantages of speed and simplicity, and is sometimes the best means of retracing old lines. Many of the early surveys were run with the compass.

The compass does not, in general, point to true (geographic) north, nor is its direction at any one place constant. Hence, a knowledge of the magnetic declination (compass variation) and its changes is required by those who use the compass.

The Coast and Geodetic Survey has made a magnetic survey of the United States, in which observations have been made at nearly every county seat and at many other places. In addition, the changes of the earth's magnetism have been determined from the repeat observations made at about 150 selected stations distributed over the country, and from the continuous photographic records of magnetic declination and intensity made at magnetic observatories maintained by the United States and adjoining countries. The observatories operated at the present time by the Coast and Geodetic Survey are at Cheltenham, Md.; Honolulu, T.H.; San Juan, P.R.; Sitka, Fairbanks, and Barrow, Alaska; and Tucson, Ariz. (See Plate I.)

The magnetic survey of the United States dates back over a century. The observations were at first confined to the coastal regions, as they were intended to provide magnetic data for nautical charts. The work was later extended to the interior of the country, and was greatly expanded and intensified at about the turn of the century. There are now more than 8500 stations at which observations of one or more magnetic elements have been taken. In many regions they bring out clearly the widespread irregularities that effect the magnetic lines.

Information on the gradual change in direction of the compass needle, essential in working with old surveys, has been derived from many sources, including the reports of observations made in very early times in various regions. Tables of this secular change are available, together with explanations of their use. This change cannot be predicted, nor can it be reduced to any simple mathematical law or formula.

Due to the local irregularities already mentioned, it is not possible to give an accurate value of the declination at a specific point unless it has been actually measured at that point. Lacking actual observations, the best estimate may be obtained from the latest isogonic chart of the United States. A value so obtained may be regarded as a kind of normal or mean value for a fair-sized region around the point in question. There is perhaps an even chance that the chart value will be within one-half degree of the actual value. The value is intended as a mean for several days, eliminating diurnal and irregular fluctuations.

The daily variation of declination in the United States is characterized by an easterly motion of the north end of the needle in the morning, with an easterly extreme about 8 or 9 a.m., local time; then a westerly motion, with a westerly extreme about 1 or 2 p.m.; then an easterly motion for 4 or 5 hours. From dusk to the early morning there is little change. The average amplitude of the swing from morning to afternoon is usually between 5" and 10" of arc, being greater in summer than in winter, and greater at the 11-year peak of sunspot activity than at its trough. Both the amplitude and the times of the extremes are also subject to some fluctuation from day to day. Similar but opposite changes are found at corresponding latitudes in the Southern Hemisphere.

Aside from this systematic daily variation, the direction of the needle occasionally undergoes erratic fluctuations which, if sufficiently severe, constitute a magnetic storm. The surveyor should be on the lookout for such an occurrence. Any unusual activity of the compass needle may have this explanation. Surveys made during the progress of a magnetic storm could be seriously in error, as the declination is then usually changing rapidly, and departures from normal of as much as half a degree may easily occur in the middle latitudes. During the great magnetic storm of September 18 and 19, 1941, the maximum range of the fluctuations amounted in this region to more than 4° of arc. A magnetic storm may last many hours (sometimes several days) and the more severe ones are known to extend from pole to pole over the entire globe. They are usually associated with the appearance of aurora and with other phenomena of the ionosphere. They have no apparent relation to the weather.

The following publications are illustrative of the material that is provided in this field:

MAGNETIC DECLINATION IN THE UNITED STATES, 1945. Samuel A. Deel. Serial 664. 67 p. 4 illus. Includes tables of secular change and directions for finding the true meridian, also a copy of Chart 3077 for 1945.

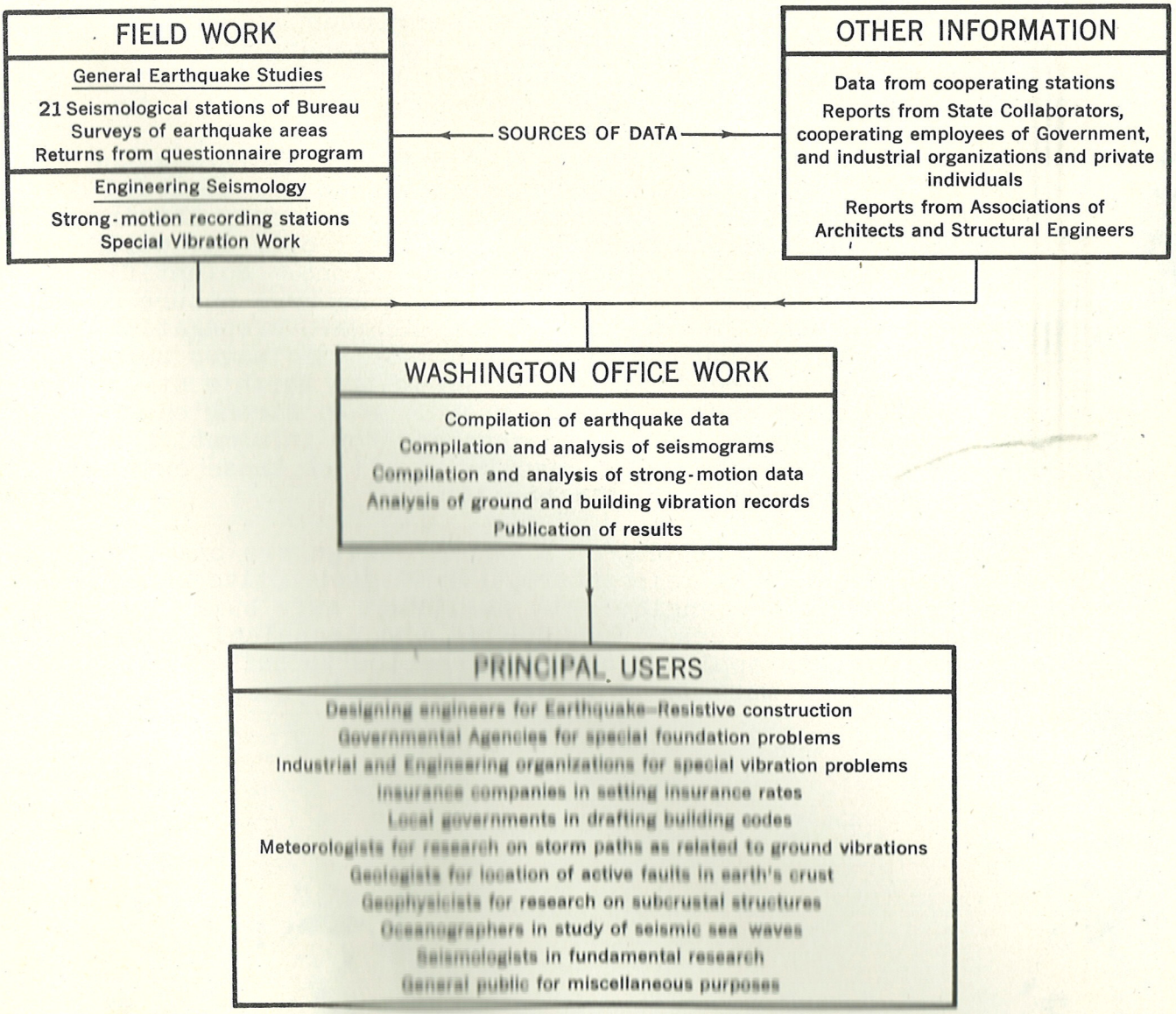
UNITED STATES MAGNETIC TABLES AND MAGNETIC CHARTS FOR 1945. Samuel A. Deel and H. Herbert Howe. Serial 667. 137 p. 5 illus. Includes observed values and positions of the stations.

MAGNETISM OF THE EARTH. Albert K. Ludy and H. Herbert Howe. Serial 663. 83 p. 39 illus. (1945) A general review of the whole field.

ISOGONIC CHART FOR 1950, UNITED STATES. (Chart 3077) Scale 1:5,000,000.

DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
SEISMOLOGICAL SERVICE

EARTHQUAKE HISTORY, seismograph operation and earthquake location, mapping of earthquake areas, recording and analyzing destructive earthquake motions for use in design of earthquake-resistant structures. Special studies of general vibrations affecting foundations and structures.



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SEISMOLOGICAL DATA

In 1925 the Coast and Geodetic Survey was designated by law to make reports and investigations in seismology. The purpose of this work is to map earthquake areas and evaluate earthquake risk through the operation of seismographs and the systematic collection of earthquake information; to furnish authentic earthquake information to the public; to furnish important data to geophysicists working on research problems; to furnish the basic ground-motion data on destructive earthquakes for the use of the structural engineer in designing structures in earthquake areas; and to investigate the scientific aspects of earthquakes for a better understanding of the principles underlying their cause, frequency, and distribution.

In order to map earthquakes the Survey supervises the operation of 28 Bureau and cooperating stations and also utilizes data from about 153 other stations. The Survey obtains telegraphic data from seismograph stations all over the world and issues prompt reports on earthquake locations. Scientific study of these data yields information on the true nature of earthquake phenomena, the nature of seismic wave propagation, and the physical structure of the Earth. Seismic waves serve as a kind of X-ray to reveal complexities in the Earth's structure which would otherwise never be known. When strong earthquakes occur the shaken areas are canvassed for information on damage and other effects. The results of all of these operations are published in periodic reports.

Fifty-two seismographs of special design are operated in earthquake areas to obtain information on destructive ground motions needed by the engineer to construct safe buildings, bridges, dams, et cetera. Because of the technical difficulties involved in applying this information to building design, the project must be considered still in the research stage.