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JOHN T. CONNOR, SECRETARY

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

ROBERT M. WHITE, *Administrator*

COAST AND GEODETIC SURVEY

JAMES C. TISON, JR., *Director*

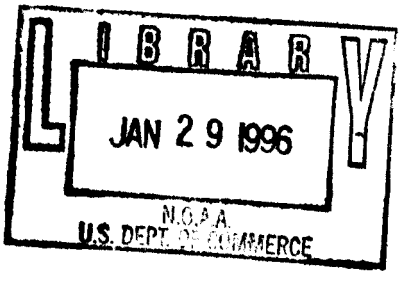
ANNUAL REPORT

OF THE

DIRECTOR OF THE COAST AND GEODETIC SURVEY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1965



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National Oceanic and Atmospheric Administration

Annual Report of the Director of the Coast and Geodetic Survey

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OFFICE OF THE DIRECTOR

The Director and the Deputy Director made inspections of most of the Bureau's ships, fixed offices, and observatories.

The Director attended the International Conference on Earth Science at the Massachusetts Institute of Technology; the IV United Nations Regional Cartographic Conference for Asia and the Far East at Manila; the Governor's Conference on Science and Technology at Maui, Hawaii; and the International Tsunami Conference at Honolulu, Hawaii, at which Dr. Stewart of the Office of Oceanography was elected chairman. With the other members of the Mississippi River Commission, the Director made both the annual high and low water inspections of the Mississippi River.

The Director and Deputy Director attended the christening of the Ship DISCOVERER in Jacksonville, Fla., on October 29, 1964.

During the fiscal year, the Bureau commented on 5 draft proposals, 36 bills, and 4 enrolled enactments. The following Public Laws of interest to the Bureau were signed by the President on August 14, 1964: P.L. 88-422, Uniformed Services Pay Increase; P.L. 88-426, Government Employees Salary Reform Act; P.L. 88-431, relating to the advance movement of dependents and household effects of the Uniformed Services; and P.L. 88-441, relating to the pricing of charts produced by the Bureau. S. 627, relating to the inspection of oceanographic research vessels, was passed by the Senate on April 29, 1965. Reorganization Plan No. 2 of 1965, which consolidated the Coast and Geodetic Survey and the Weather Bureau to form the Environmental Science Services Administration, was transmitted to the Congress on May 13.

Management and Organization Division

During the fiscal year, major activities of the Management and Organization Division included the following: conducting management studies, surveys, evaluations, reviews, and analyses; planning and effecting organizational improvements; developing and monitoring a production measurement program; coordinating the Bureau's 3-E Program; and disseminating information and instructions to Bureau units.

The management and Organization Division continued to provide organizational and functional planning for the reorganization of the Bureau's field activities along regional lines. Regional offices located at Norfolk, Va., Kansas City, Mo., San Francisco, Calif., and Seattle, Wash., are assuming operational supervision of mobile field parties,

survey vessels, and fixed installations, such as observatories, laboratories, and field offices. The regional offices are also providing the administrative and logistical support for the Bureau's field elements. This reorganization is facilitating field operations by providing operational supervision and decision-making at a lower and closer level, and is also effecting economies through consolidated and local procurement and through reduction of shipping and packing costs for supplies and equipment. But more important, the regional plan is producing a more closely knit field organization whereby all Bureau field operations within a particular region come under the cognizance and control of a regional officer who reports to the Bureau head. This integration of field operations is facilitating coordination of diverse activities, providing better utilization of Bureau resources, and effecting better organizational control.

Organizational and functional planning was provided for the following reorganizations in fiscal year 1965: (1) the establishment of a Seismological Research Group in the Seismology Division; (2) the establishment of a Satellite Triangulation Branch in the Geodesy Division; (3) the merger of the Photographic Branch and the Transfer and Process Branch, Reproduction Division, into a new branch named the Photo-Mechanical Branch; (4) the establishment of an oceanographic research function organizationally attached to the Norfolk Regional Office, known as the Land-Sea Interaction Laboratory; (5) the establishment of a new coordinating function--International Activities Officer; (6) the establishment of an Advanced Seismic Experiments Group at the San Francisco Regional Office; (7) the establishment of a staff function in the Office of the Director--Project Manager - Geodetic Satellite Program; (8) the consolidation of the functions of the New Ship Staff with those of the Facilities Division; (9) the redesignation of the Personnel and Safety Division as the Personnel Division, with the safety function transferred to the Administrative and Technical Services Division; (10) the transfer of the emergency planning coordination function from the Office of the Director to the Administrative and Technical Services Division; (11) the establishment of two additional staff offices under the Office of the Director--the Operations Research and System Analysis Group and the Resources Programming Group; and (12) the redesignation of the Management and Audit Division as the Management and Organization Division with the audit function transferred to the Office of the Director and renamed the Internal Audit Group.

The Division's production measurement staff completed studies in the Negative Engraving Branch and the Issue Branch, Office of Cartography. A preliminary study was completed in the Airport Survey Branch, Office of Physical Sciences. Studies are in progress in the Geodetic Data and Distribution Section, Office of Physical Sciences and the Tides and Currents Branch, Office of Oceanography.

The Management and Organization Division continued to monitor the Coast and Geodetic Survey's cost reduction program (3-E Program). During the fiscal year, savings goals were established and individual projects were assigned. The Division participated in a follow-up and comparison of progress on projects, a comparison of savings with goals, and preparation of semi-annual reports to the Department of Commerce.

The Division prepared 30 special and continuing reports. The Division also issued 9 new or revised organization-function charts, 6 General Circulars or amendments, 5 Informational Bulletins, and 31 additional or revised pages to the Coast and Geodetic Survey Regulations.

Internal Audit Group

Effective August 10, 1964, the internal audit function was transferred from the Office of Administration and established as a staff office of the Director. Several comprehensive audits were undertaken during the year and copies of reports on completed audits were issued to the Director and officials in the Department of Commerce and the General Accounting Office.

Two audit reports issued during the year were: Management and Financial Controls Over Ship Construction Activities, and The Training Activities of the International Technical Cooperation Group. Recommendations contained in these reports were designed to effect economies and increase the efficiency of Bureau operations; assure adherence to laws, regulations, policies and procedures; and improve the effectiveness of management controls. Other audits completed during the year, for which reports have been drafted, are reviews of selected activities of the Seattle Regional Office and of nautical chart distribution activities.

Considerable follow-up work on prior audits was performed to ascertain the adequacy of the corrective action taken on deficiencies, and to furnish advice to operating units in implementing the report recommendations. A memorandum report was submitted to the Director in July 1964, summarizing the status of corrective actions on the report on Review of Field Party 624, Cape Kennedy, Fla., issued in February 1964. A visit was made to Albuquerque, N. Mex., to determine the status of corrective actions on the report on Review of Activities of the Albuquerque Seismological Laboratory, issued in March 1964, and to make a special review of certain administrative aspects of a reimbursable project performed at the Laboratory. Audit work at the Washington Office was in process at the end of the fiscal year on the Albuquerque assignment, and a follow-up report is to be issued.

Numerous requests for information from various divisions were answered on an informal basis throughout the year, after researching applicable laws, regulations, and Comptroller General Decisions. Other miscellaneous projects were performed, including participation in a study of machine shop utilization at the Fredericksburg Observatory.

The Internal Audit Officer was appointed as a member of a task force in the Department of Commerce to develop a Departmental Audit Manual. He was also designated to represent the Bureau on a departmental working group to develop standards for auditors in the Department of Commerce.

The Internal Audit Officer attended the 14th annual symposium of the Federal Government Accounting Association (FGAA) held in Washington, D. C. Staff members attended various FGAA symposium seminars, which emphasized accounting, programming, and data gathering.

Commissioned Personnel

The authorized strength of the commissioned corps was increased from 215 to 240. Thirty-five new officers were appointed during the fiscal year.

The 15th through the 17th officer training classes were completed and the 18th class was begun. Eleven new officers were granted advanced standing upon initial appointment because of advanced degrees, previous commissioned service in the Armed Forces, or civilian work experience. The college-accreditation standard for appointment in the commissioned corps was revised, which resulted in our recruiters visiting many more colleges and universities.

One commissioned officer began advanced studies in oceanography, one in geodetic science, one in photogrammetry, one in seismology, and one in personnel and public administration. Four officers were selected to begin advanced studies in fiscal year 1966 in several different fields. In addition, one officer was awarded a Commerce Fellowship in fiscal year 1966 and will spend nine months in the National Bureau of Standards. Two commissioned officers entered fixed-wing flight training at the U.S. Army Aviation School, Fort Rucker, Ala., during fiscal year 1965. Three officers were given special training at Westinghouse in computer training.

International Technical Cooperation Group

The training of foreign nationals, in the various scientific and technical activities of the Bureau, was

conducted under the auspices of the Agency for International Development (AID), the Military Assistance Program (MAP), and under special government to government agreements.

Under AID, 12 participants were accepted for instruction in the following subjects: Aeronautical charts--Indonesia (2); geodetic surveying--Nigeria (1); photogrammetry--Afghanistan (2), Brazil (1), Guatemala (1), Nicaragua (1), Nigeria (1); seismology--Iraq (2); and tides and currents--Brazil (1).

From the previous fiscal year, 8 participants continued or completed their training programs as follows: Geodetic surveying--Greece (1); photogrammetry--Indonesia (6); and tides and currents--Guatemala (1).

In addition, 5 MAP carryovers from the 1964 fiscal year continued their training as follows: Bureau functions and operations--Venezuela (1); map and chart construction--Brazil (1); and photogrammetry--Chile (1), Venezuela--(2). At the request of the Venezuelan Embassy, 2 participants completed their training in photogrammetry and began additional training in aeronautical chart construction under a bilateral agreement.

The Bureau received 70 visitors from 20 countries as follows: Australia (2), Bolivia (1), Brazil (8), Canada (26), Chile (3), Colombia (2), England (8), Ethiopia (2), Finland (1), Germany (4), India (2), Indonesia (2), Korea (1), Netherlands (2), Nigeria (1), Peru (1), Republic of South Africa (1), Sweden (1), Uruguay (1), and Venezuela (1). These visits ranged from 1 to 9 days. In addition, 14 foreign nationals from various countries and assigned to the U. S. Naval Oceanographic Office visited the Bureau for 1 day.

The foreign participants in training attended the consecutive annual meetings of the American Congress on Surveying and Mapping and the American Society of Photogrammetry. Translations of technical materials and correspondence from Spanish to English were made for the various divisions. A special translation was prepared from English to Spanish of the program and official invitation for the ceremony held in Puerto Rico on the dedication of the San Juan Geophysical Observatory.

Staff activities included: Conferences with AID Program Development Officers on training operations; participation in the Department's meetings to discuss a new AID-Commerce agreement; completion of an AID questionnaire to determine services available and general financing methods required under international technical assistance; and a briefing of Department of State Foreign Service Officers on Bureau activities as part of their orientation prior to their overseas assignment. Information was furnished to the Special Assistant to the Assistant Secretary for Economic Affairs with respect to Bureau services,

training, guidance resources and other forms of assistance which the Department may be able to offer to the developing countries. One of the outstanding accomplishments of a foreign participant in training was the preparation of two publications, "Aerotriangulation Strip Adjustment Using Fortran and the IBM-1620 Computer", and "Electronic Computer Programs for Analytical Aerial Triangulation". These publications were compiled by an AID participant and were published by the Bureau.

The Systems Analysis Group

The Systems Analysis Group conducted and completed an investigation of the state-of-the-art of instrumental telemetering deep sea-buoys. The chief findings are:

1. Although the state-of-the-art would permit it, standardization is completely absent from this field. As long as the present individualism prevails, it is unattractive to private industry to take initiative of its own.

2. In the telemetry aspect, no frequency bands have been reserved yet on a permanent basis for communication to and from oceanographic buoys in the Ocean Data Service. This is a crucial problem.

3. As to instrumentation, there is still no ocean current meter available that has an unattended lifetime of two months or longer. This is another crucial problem.

The Systems Analysis Group prepared, at the request of the Assistant Secretary of Commerce for Science and Technology, a state-of-the-art report titled "Instrumented Telemetering Deep-Sea Buoys".

Office of Public Information

The purpose of the public information program of the Coast and Geodetic Survey was to make the public more aware of the Bureau's important role as the nation's oldest scientific body, of its expanding programs, of the major part it was playing in the advancement of the nation's interests in such varied fields as astronomy, cartography, geodesy, geomagnetism, gravimetry, oceanography, photogrammetry, and seismology.

Every avenue open for communicating with the public was utilized, including the press associations; metropolitan and small daily newspapers; rural papers (weekly and bi-weekly); Congressional newsletters; press conferences; interviews with Bureau personnel; "Open House" aboard ships; feature stories for Sunday supplements; exhibits, boat shows,

scientific expositions, etc. In addition, an effort was made to acquaint Members of Congress more fully with the Bureau's programs and activities.

Scientific and Technical Publications Group

During the fiscal year, the staff of the Scientific and Technical Publications Group prepared, compiled, edited, disseminated, and exchanged scientific and technical material of the Coast and Geodetic Survey in all forms as follows:

The first volume of the comprehensive publication, The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks--Operational Phases, editorially prepared by this staff, was submitted to the Government Printing Office. This is the first of three definitive volumes on the Alaskan earthquake. The volume provides a summary of the total mobilization effort undertaken by the Bureau to meet the exigencies created by this earthquake. Separate reports discuss the various operational, ship deployment, field survey, and data acquiring activities undertaken as part of a coordinated geophysical research program.

Cooperation was pursued with the National Academy of Sciences in plans for the preparation of a comprehensive, consolidated report on the 1964 Alaskan earthquake. Contributions to this report are to be made by this Bureau, the Geological Survey, the Corps of Engineers, private industry, and various universities.

During the year, the following publications and reports were released pertaining to hydrography, oceanography, and seismology: Manual of Tide Observations; Soviet Oceanography 1964: A Trip Report; Tsunami! The Story of the Seismic Sea-Wave Warning System; and Assistance and Recovery in Alaska, 1964.

As part of a continuing series of Coast Survey publications to present new practices and techniques related to the scientific and technical activities of the Bureau, three Technical Bulletins were issued. These were: Aerotriangulation Strip Adjustment; Satellite Triangulation in the Coast and Geodetic Survey; and Aerotriangulation: Image Coordinate Refinement. A Technical Bulletin on Instrumented Telemetering Deep-Sea Buoys was in press.

The report of this office to the Elliott Committee, in connection with the scientific and technical information activities of the Coast Survey and its Scientific Information, Communication, and Exchange Program, was incorporated in Study No. IV, Documentation and Dissemination of Research and Development Results--Report of the Select Committee on Government Research of the House of Representatives, 88th Congress, 2nd. Session.

A revised edition of a 1957 pamphlet, which was retitled United States Coast and Geodetic Survey--Its Products and Services, was prepared and issued. The publication presents a short historical introduction covering the Coast and Geodetic Survey, and describes the varied functions, products, services, and activities of the Bureau.

Four mailing pieces, handouts, and posters, supporting the cooperative communications efforts of the Coast Survey and the Weather Bureau to enhance the tsunami-warning dissemination program, were prepared by the staff. In addition, six Scientific Information Releases were written for submittal to various interested professional journals. A brochure was issued relating to the activities of the USC&GS ship PIONEER: Welcome Aboard! International Indian Ocean Expedition 1964.

Summaries of the past year's activities of the Bureau were written by the staff for the Annual Report of the Secretary of Commerce 1964, and to Report to the Congress from the President of the United States--United States Aeronautics and Space Activities-1964.

Numerous publications in the Bureau's unpriced report literature were forwarded throughout the year to the central depository service of the Clearinghouse for Federal Scientific and Technical Information. These documents have thus been made available for further dissemination and for permanent preservation in microfilm form.

The Scientific and Technical Publications Group disseminated to interested Bureau personnel nine translations of scientific publications from the Russian language, completed under the sponsorship of the Coast and Geodetic Survey's Scientific Information, Communication, and Exchange Program through the Israel Program for Scientific Translations.

A number of publications were in the Government Printing Office for final printing at the conclusion of the fiscal year. These include: Volume 2 of the International Indian Ocean Expedition, USC&GS Ship PIONEER--1964; Bilby Steel Tower for Triangulation; Second-Order Astronomical Position Determination; Earthquake Investigations in the Western United States, 1931-1964; and Roberts Radio Current Meter Manual.

"TSUNAMI!",a 29-minute color documentary film on the seismic sea-wave warning system, was completed. The working script, assembly of stock footage, and camera directions were prepared by the staff. The motion picture was filmed on-location in Los Angeles and Crescent City, Calif., and in Honolulu, Hawaii, under contract with a commercial producer. Release prints were made available for distribution to regional and field offices of the Bureau and for loan to numerous outside users.

A motion picture film report for Bureau use in connection with the U. S. Civil Service Commission's Incentive Awards Program--"Project Thrift"--was also produced. This 10-minute promotional film, "NOT OURS TO WASTE", was shown in all components of the Bureau.

A complete summary of the scientific and technical activities of the Coast and Geodetic Survey, prepared by this office, was published in A Directory of Information Resources in the United States--Physical Sciences, Biological Sciences, Engineering, issued by the National Referral Center for Science and Technology, Library of Congress.

OFFICE OF OCEANOGRAPHY

OPERATIONAL ACTIVITIES

Atlantic and Gulf Coasts and Puerto Rico

The ships HILGARD & WAINWRIGHT wire drag operations off the coast of Texas, using visual control inshore and electronic methods offshore. Wire drag support was given the HYDROGRAPHER to disprove several erroneous soundings. Operations were conducted to locate a lost cabin cruiser off Pass Christian, Miss. A large area was dragged with negative results. A sunken drydock section near the Galveston Channel entrance was located by wire-drag and Scuba divers investigated the obstruction, confirmed its identity, obtained a least depth by hand lead, and took several underwater photographs. Since this obstruction was a definite menace to navigation, all pertinent information was furnished to the Coast Guard. Twenty-four items of obstruction were investigated and the existence of five were disproved. Qualified Scuba divers were of assistance in obtaining least depths over wrecks and obstructions.

Hydrographic Field Party 242. Operations by the Hydrographic Field Party were terminated at Lake Mead, Nev. Processing on the Lake Mead survey sheets was completed and copies furnished the Bureau of Reclamation. The party established headquarters at the Galveston Municipal Airport. A tide staff was installed at Offatts Bayou and launch hydrography started. Two launches were in operation; one in the vicinity of Point Bolivar, and the other worked offshore from Galveston Island. The basic hydrography along the outside coast north and south of Galveston Bay entrance was completed. Launch and skiff hydrography continued in Galveston Lower Bay.

East Coast Tide Party. The East Coast Tide Party completed servicing control tide stations in Virginia, Maryland, and Washington, D. C. A Fisher-Porter gage was installed at Bridgeport, Conn. Considerable work was completed on the gages at Eastport and Bar Harbor, Maine. The Fisher-Porter gage at Nantucket, Mass., was replaced with a gage having a 6-minute timer. Tide gages at Woods Hole, Mass., and Bridgeport, Conn., were also replaced with 6-minute timers. A request was received for the installation of a tide staff at the tower of the Buzzards Bay Entrance Light, but the party was unable to complete this installation inasmuch as the wooden fenders, bottom section of stair wall, and the landing platform had been washed out by storms. The tide house was repaired at the Boston Gage. Upon a request from the University of Rhode Island, a tide gage was installed at the Marine Laboratory in Kingston, one bench mark established, three recovered, and all leveled to the staff. A double bubbler tide gage

was installed on the Steel Pier at Atlantic City, N. J., with two tide staffs installed; one inshore and one offshore. Gages were serviced at Montauk and Plum Island, N. Y., and at Sandy Hook and Atlantic City, N. J. New bench marks were established at Plum Island and Atlantic City. Tidal installations at Smyrna and Lewes, Del., were serviced. In Texas, the tide station at South Padre Island was serviced but was later secured when the temporary catwalk was destroyed by storms; at Padre Island a tide gage and the electrical hookup for remote readings to the Weather Bureau Office at Brownsville were installed; at Laguna Heights tide station a new fiberglass tide staff was installed and leveled to the tide staff at Port Isabel turning basin; electric power and a Bristol remote system, for the transmittal of readings to the Army Enginers Office in Corpus Christi, were installed at the Port Aransas tide house; a fiberglass staff was installed at Sabine Pass; and the tide gage houses at Pier 21 and at Freeport were repaired. The remote recorder at Grand Isle, La., was inspected. The station at Cedar Key, Fla., was removed to a new location on the same pier. The installation of a primary tide station at St. Marks was completed and the observer instructed. Station servicing was completed in the Tampa area and the party moved to south Florida and a staff was relocated at Key West; the float and tape gage wells at Miami Beach were serviced and a twin circuit Bristol Transmitter was installed to accommodate the new receiver at the University of Miami Marine Laboratory; three tidal bench marks were recovered at Port Everglades; a new staff installed at Fernandina Beach; and piling placed under the tide house at Mayport. A fiberglass staff was installed at Charleston, S. C.; the tide house at Myrtle Beach was painted; the float well repaired at Wilmington, N. C.; the gage at Beaufort, N. C., was serviced and all tide stations between Norfolk and Baltimore were inspected and serviced. At Reedy Point, Del., the standard gage was removed. Existing conditions and facilities for locating a standard tide gage at Cape May, N. J., were inspected.

Florida Tide Party, a new field survey unit, commenced operations February 8, 1965, on a 2-year tidal survey of the Florida West Coast between Naples and Fort Myers. Fisher-Porter Analog-to-Digital Recorder (ADR) gages were installed at Matanzas Pass, Little Hickory Island, Carlos Point, Iona Shores, Matlacha Pass, Tropical Homesites Landing, Coconut Point, and Pineland; a Bristol bubbler gage was installed at the Cape Coral Bridge; at Naples both standard and ADR gages were installed; a bubbler gage was installed at Punta Rasa; and a standard gage installed in a new tide house at Fort Myers. A bubbler gage was installed on Captiva Island and two bench marks set and levels run. At the close of the fiscal year, all gages were recording properly and excellent records were obtained.

The ship EXPLORER resumed oceanographic operations off Cape Hatteras. A special investigation of a reported grounding off Chesapeake Bay entrance was made and the chart found to be correct. A reported magnetic anomaly between Cape Henry and Cape Hatteras was observed by running four lines of compass comparison. It was found that the deviation tables were poor and, consequently, comparisons were not good. In Charlotte Amalie Harbor, St. Thomas Island, wire drag work over reported 8- and 16-foot depths was completed on the working grounds off Cape Hatteras but the trips of the EXPLORER were cut short by hurricanes Dora, Ethel, Gladys, and Isabel. The EXPLORER ran a deep sea trackline from Norfolk to San Juan, P. R. En route, the magnetometer was towed, drift bottles were cast, and BT observations were made. Surveys were made in the vicinity of Cape San Juan and San Juan Harbor; in Roosevelt Roads, Ensenada Honda, and a 21-day current survey in Passage de Viequex. In Charlotte Amalie Harbor, St. Thomas Island, wire drag work over reported 8- and 16-foot depths was completed. The magnetometer was towed on 604 nautical miles of trackline survey in cooperation with Dr. T. W. Donnelly, Associate Professor of Geology, Rice University. A hydrographic trackline from Puerto Rico to Norfolk was run with magnetometer and oceanographic observations made en route.

The ship MARMER continued the Chesapeake Bay Circulatory Survey. Twenty-nine stations and ten 100-hour current stations were completed in the bay and the project terminated. Three stations in James River and a set of five 15-hour stations transecting Burwell Bay were occupied simultaneously for the Virginia Institute of Marine Science. On a cooperative project with the Virginia Institute of Marine Science in the Rappahannock River, the ship completed ten current stations and six 25-hour sediment and water sampling stations. In Long Island and Block Island Sounds the MARMER conducted operations for a circulatory survey, twenty 100-hour current stations were observed. Dr. Takashi Ichiye, Lamont Geological Observatory, conducted dye diffusion experiments from the MARMER.

The ship HYDROGRAPHER installed a bubbler gage on Sabine Bank Light. Launch and ship Raydist-controlled hydrography was conducted in the vicinity. The ship was engaged in the seismic study, Project Dribble. Raydist-controlled survey operations were conducted off Cape Kennedy. The ship ran a track line along the axis of the Gulf Stream to provide a profile of the bottom and sill. Gravity cores were obtained in the Strait of Florida, and a thermistor was towed to record temperature differential along the Gulf Stream.

The ship PEIRCE continued work at the entrance to Winyah Bay, S. C. Later, surveys were started on north of Winyah Bay entrance, using Hi-Fix control. Good pro-

gress was made with ship and launch hydrography, except when interrupted for short times by hurricanes Dora, Hilda, and Isabel. A good will public relations cruise of five hours was made with several Savannah officials, dignitaries, wives, and news media representatives aboard. Later on, open house was held with over 100 visitors coming aboard. Three Hi-Fix shore control stations were located and the ship operated Hi-Fix with the Hyperbolic system for the first time. The ship also operated with the semiautomatic data logger equipment. A Digital Equipment Corp. PDP-5 Computer was installed to speed up plotting of hyperbolic curves by converting fixes to x-y coordinates. The ship also worked off Folly Beach, S. C. Two 100-hour current stations were observed off Folly Beach.

Combined operations continued by the ship WHITING in the vicinity of Edgartown Harbor, Martha's Vineyard, Mass. Three 100-hour current stations were observed in Edgartown Harbor. Open house was held July 9 for the selectmen, county commissioners, and the townspeople. The WHITING planted and later recovered open-ocean tide gages in depths of 840, 700, and 250 feet, 60 miles apart, along the edge of the Continental Shelf. Photo-hydro support for hydrographic operations was completed by photo party No. 6420. Hydrography was completed in upper Muskeget Channel, outside Katama Bay on the south, and along the south side of Nantucket Island. A reported obstruction was investigated in Vineyard Haven and found to be in the position as charted, and the depth as indicated on Chart 261. Mr. Everett Whiting and family, who have a farm on Martha's Vineyard, were visitors on board October 12, 1964. Everett Whiting is a direct descendant of Henry Laurens Whiting for whom the ship WHITING was named. Henry Laurens Whiting had served the Coast and Geodetic Survey almost 60 years, from July 18, 1838, during the term of the first Superintendent, Hassler, to February 1897, in the term of Superintendent Duffield. Two 100-hour current stations were completed, and tide gages and two hiran stations recovered. Prior to closing the field season, profiles originally run in 1891 were re-run seaward from the south shore of Nantucket Island. In Norfolk, the ship received aboard Engineering Division personnel and Decca representatives, to assist ship technicians in preparation for Hi-Fix tests. After equipment was tested, the ship spent 2 days in lower Chesapeake Bay on various methods of conning the ship and launches in simulated hydrography, using the hyperbolic Hi-Fix system. A gravity survey was made along the east coast, between Cape May and Cape Hatteras. All of the upper mantle stations (136 original, and 36 additional) were occupied and a week was spent occupying the Chesapeake and Wallops Island gravity ranges.

Pacific Coast, Alaska, and the Pacific Ocean

The Pacific Tide Party continued liaison duties in connection with the Pacific Tide Program. Tide station

inspections were completed at Nawiliwili, Kanai; Pago Pago, American Samoa; and Canton Island. Telemetering transmitters and remote recorders were installed at Honolulu and Nawiliwill. Tide stations at Marcus and Wake Islands were inspected and at Marcus Island the installation was reinforced against damage during the typhoon season, August through October. Tide stations seismic sea wave detectors were inspected and serviced at Mokuoloe Island, Midway Island, and Hilo, Hawaii. Servicing and repairs were made at tide stations on Guam and Truk. On October 30, 1964, the Coast Guard Cutter BERING STRAITS released an unarmed torpedo that ran seven miles before running aground in front of the Hilton-Hawaiian Hotel. The tide party furnished chart information, geographic position of the Hotel, bearing, and distance torpedo traveled, to the investigating committee from Pearl Harbor Naval Ammunition Depot. Tide stations at Eniwetok, Kwajalein, Johnston and Kahului were inspected and serviced. Inspection and servicing of tide stations and seismic sea wave warning systems were completed at Christmas Island; Canton Island; Pago Pago, Samoa; and Hilo, Honolulu, and Kahului, Hawaii. A bubbler gage and a new tide staff were installed at Kahului. The Christmas Island tide station was inspected and the necessary technical information needed for establishing communications for the Seismic Sea Wave Warning System between Honolulu and Christmas Island was obtained. The tide station at Mokuoloe was serviced and inspected. A telemetering transmitter and remote recorder were installed at Guam.

Operations by Hydrographic Field Party 242 continued in Lake Mead, Nev. The continuous dropping of the lake level hampered hydrography progress and necessitated the re-establishment of the tide gage at Boulder Wash, Nev., and discontinuance of the tide staff at Echo Bay. A staff was removed at Grand Wash, and a gage with staff removed at Hualpai, Wash. Field work was carried to elevation 1150 for the completion of adequate boat sheet detail. Field work was completed on October 16, 1964. The completed contour sheets were turned over to the Bureau of Reclamation and the tide gage at Boulder Wash was removed prior to the party's departure.

The ship PATTON continued surveys along the south side of Revillagigedo Island, southeastern Alaska. Hydrographic operations were completed in Thorne Arm and operations moved to Tongass Narrows. The ship modified the tide gage installation for the Seismic Sea Wave Warning System at Cape Decision. Later the ship had to return to Cape Decision to restore the tide gage to operation after the staff and orifice were destroyed by heavy seas. Standard tide stations were inspected and serviced at Ketchikan, Juneau, Skagway, and Sitka, with five nautical and one aeronautical chart sales agencies being inspected. A special survey was made in Duncan Canal for the Alaska Barite Company. Hydrography was done on the Keku Strait

working grounds, along the east side of Sumner Island and around Strait Island.

The ship BOWIE resumed observations on the Puget Sound tidal current survey. The ship occupied current stations in Haro Strait, Strait of Juan de Fuca, Bellingham Bay, Echo Bay, and waters adjacent to the Whidbey Island Naval Air Station. A total of 36 current stations was observed during the first and second quarters of the fiscal year. Current survey operations in San Juan Islands and Strait of Juan de Fuca included the following: a Geodyne and a Braincon current meter were planted at two 29-day stations south of Belle Rock Light, in Rosario Strait; eleven Roberts Radio current meters were observed in the vicinity of Port Townsend, Protection Island, and Sucia Island; and three other stations were observed. Eleven 100-hour stations were observed.

The ship HODGSON was engaged on Alaska Earthquake Damage Surveys. Portable tide gages were reinstalled in Prince William Sound at Comfort Cove, Port Chalmers, and Chenega Island and were serviced twice a week. The remainder of each week was devoted to triangulation in Unakwik Inlet. Two 2-man teams ran levels and removed gages on the Alaska Peninsula. Kodiak Island gages were left in place until August 31, and were then removed and shipped to Anchorage by the tide observers. The bubbler gage at Valdez was moved to a new location. Tellurometer measurements were made at Montague Straits. A portable tide gage was installed at Yakutat. The ship obtained surface samples at hourly intervals en route from Yakutat to Juneau for the University of Alaska. Photogrammetric targets for the tide controlled photography were located in Lower Orca Inlet and associated tidal flats. At Seward, the chart agency was inspected and the standard tide gage re-levelled and serviced. Phototargeting work in the Knight Island, Latouch Island, and Chenega Island areas and tide controlled photography in Orca Inlet were done. The ship proceeded to Valdez to commence photofield inspection in Valdez Arm and at Tatitlik Narrows. At Valdez, the standard tide gage was re-installed on the new city dock.

The ship LESTER JONES continued tidal and hydrographic operations in Glacier Bay, Alaska. An investigation of a shoal near Tee Harbor was completed and verified results obtained by BOWIE in 1961. When work was terminated in Glacier Bay the portable tide gage in Bartlett Cove, Glacier Bay, was temporarily transferred to the National Park Service. Chart agencies and tide gages were inspected at Tenakee Springs, Sitka, and Port Protection. Recovery and photoidentification of horizontal control and shoreline inspection was continued in Keku Strait. The ship departed for the working grounds in Prince William Sound. A stop was made at Yakutat, Alaska, to replace the portable tide gage. Work commenced on the project to re-establish tidal reference data in Prince William

Sound, Kenai Peninsula, and Kodiak Island. Standard tide gages at Yakutat and Valdez were serviced and one re-installed at Whittier. The ship went to Redfox Bay, Afognak Island, to install a gage. A bubbler gage was installed on Nachakni Island, Kupreanof Strait and at Dolphin Point, Raspberry Strait. A portable automatic gage was installed at Port O'Brien on the west coast of Kodiak. A bubbler gage was installed at Saltery Cove on the east side of Kodiak Island.

The ship PATHFINDER had a launch hydrographic unit operating off Kenai and electrotape traverse observations were made on Augustine Island. A party was placed ashore to make triangulation observations and planetable surveys before departing for Kamishak Bay. Three launch units did hydrography in the Kamishak Bay area. Efforts were then concentrated on Orca Inlet. All reestablishment of the main triangulation scheme was completed and topography and hydrography were continued. En route to Seattle, the PATHFINDER investigated reported magnetic disturbances off Vancouver, B. C. No inconsistent anomally was found. A deep-sea track line was run en route from Seattle to Honolulu. The working grounds in Hawaii were on the south side of Maui Island and vicinity of Lanai Island. A semi-automatic data logger was installed and used on all shoran-controlled ship hydrography. A seamount was found 15 miles south of Oahu, west of Penguin Bank. Favorable weather contributed to a period of good progress in the vicinity of Molokai and Lanai Islands. When the ship departed Hawaii for Seattle running another deep-sea track line; on this crossing the magnetometer fish functioned satisfactorily. The PATHFINDER ran a deep-sea track line from Dixon Entrance to Seaward, Alaska. Developments were made on two seamounts; one being the Surveyor Seamount. The fishing vessel TRADEWIND, adrift in Tonki Bay, was taken in tow and turned over to the Navy Tug 539 at the entrance to Womans Bay, Kodiak Island. A bubbler tide gage was established at Snug Harbor, Tuxedni Channel, on the west side of Cook Inlet, and another gage established on Shaw, southern part of Kamishak Bay.

The ship PIONEER, on the Indian Ocean Expedition, was en route to Palau from Djarkata on July 1, 1964. She completed the Lombok Strait investigation, ran a track line across Java Sea, through Makassan Strait, and continued across the Celebes Sea. A 16 ½-foot core was obtained in the Mindanao Trench, a bottom photographic station was observed, and a Geological Echo Profiling (GEP) profile of 183 nautical miles was run. The track line continued to Palau where a GEP profile of 144 nautical miles was made along the northern and eastern sides and across the Palau Trench with dredges made on the western and eastern slopes. The ship was at the Port of Palau, Malakal Harbor, from July 9-11. The ship continued the track line eastward, with a 13-foot core being obtained in the Marianna Trench. Bottom dredging and grab sampling were taken along the western side of Guam, also 51 nautical miles of GEP profile

was run in the same area. The ship was in Apra Harbor, Guam, July 17-19. Two scientists from the Geological Survey were aboard on the Palau to Guam leg and were satisfied with the results obtained along this section of the track line. The line from Guam to Honolulu was completed, making the usual underway observations, hydrography, gravity, magnetics, weather, biological and hydrographic phenomena sightings, surface temperatures and salinities. Nine uncharted seamounts were crossed, with the closest to the surface being 660 fathoms in general depths of 3,000 fathoms about 200 miles south of Wake Island. The ship arrived at Honolulu entrance July 30, 1964, and the field work of the International Indian Ocean Expedition was ended. The PIONEER sailed from Honolulu for California on August 4. Hydrography, gravity, and magnetics were observed continuously while BT and weather observations were made on a 2-hour schedule. One line was run across the gravity test range prior to entering San Francisco Bay. A tagline survey around the Golden Gate Bridge piers was made. Deep-sea track lines were run between California and Hawaii; oceanographic stations were completed en route. A reported seamount was developed and a least depth of 975 fathoms found. The ship continued ocean surveys west of Honolulu to 165°W, from 20°30'N to 35°30'N. The ship conducted a calibration loop to determine the accuracy of the Navy Satellite Navigation System. Preliminary results of comparison obtained at Kodiak, Adak, Attu, Midway, Johnston, and Honolulu, while en route, indicate that the system will be valuable to ocean surveys.

The ship SURVEYOR investigated the probable earthquake fault area between Kodiak and Cape Hinchinbrook, and in Prince William Sound. Circumnavigation of Prince William Sound was completed and included magnetometer profiles, gravity observations, and geological echo profiler coverage inshore of the 1,000-fathom curve. The fault zone southwest of Cape Cleare, Montague Island, was developed with bottom sampling and coring. The continental shelf and slope, seaward of a line between Cape Hinchinbrook and Chirikof Island, was surveyed to beyond 2,000 fathoms. The ship resumed operations on the Aleutia Trench project. North-south lines were run between 165°48'W to 180°, operations included bathymetry, magnetometer, and gravity observations. In addition, oceanograph ic station observations commenced with station 1 and continued through station 36. Oceanographic stations observations included sea-bottom surface material for the U. S. Geological Survey, special light transmissivity lowerings, corings, Nansen casts, and Geomagnetic Electrokinetograph (GEK) patterns. The ship ran a north-south line of bathymetry, magnetics, and gravity east of Molokai for the University of Hawaii. The ship completed dredging operations northeast of the east end of molokai Island, off Maui Island, northeast of Hilo, and south of Ka Lae for the U. S. Geological Survey. A track line was run en route to Seattle, ending at Cape Flattery where a gravity

calibration line was traversed to Dungeness Point. After transiting the Juan de Fuca and Cape Flattery gravity lines, she commenced a track line to the Gravity Calibration Range off Point Reyes, Calif. On one of the ship's deep sea track line between Honolulu and California, while making the usual oceanographic observations en route which included bathymetry, gravity, magnetics, and current measurements by GEK, the ship stopped for deep sea corings, multisampler lowerings for calibration purposes, and swallow pinger tests and evaluations were completed. Beginning south of the Hawaiian archipelago, in 260 fathoms at 169°50'W, north and south lines of bathymetry, gravity, and magnetics were run at 10-mile spacing, eastward to 157°W, the northern limit was at 35°30'N. latitude. An uncharted submarine mountain was crossed, the least depth found was 820 fathoms in surrounding ocean bottom depths of 2,400 fathoms; a second submarine mountain was crossed with a least depth of 499 fathoms; and a third seamount was found about 20 miles east of the previous two, with a least depth of 392 fathoms. A deep-sea core was taken at lat. 29°02'N., long. 147°20'W., for the University of Washington. During the annual modifications and repairs, the installation of a helicopter deck was completed. The West Coast Upper Mantle operations included bathymetry, magnetics, and gravity while on the track line from Cape Flattery to Cape Mendocino; ocean bottom sonar scanning operations were started 13 miles northwest of Cape Mendocino on the 100-fathom curve; and intermittent towing and repairs to the Ocean Bottom Sonar Scanning system continued along the 100-fathom curve, southward from Cape Mendocino.

STATISTICAL SUMMARY

Location	HYDROGRAPHY				TOPOGRAPHY		
	Nautical Miles of Sounding Lines	Square Miles	Nautical Miles of Wire Drag	Square Miles	Miles of shoreline	Miles of Inspection of Shoreline	Control Stations Identified
Maine to Cape Henry	2327	74					
Chesapeake Bay							
Cape Henry to Florida	21031	3122	5	4			
Puerto Rico	2256	46	31	9			
Gulf Coast	8149	1160	99	63			
West Coast	1642	2					
Lake Mead	529	12					
Northeast Pacific	45894	398019					
Alaska	6089	1786			243	222	166
TOTAL	87917	404221	135	76	243	222	166

Deep Sea Sounding Lines, to and from project areas;

HYDROGRAPHER	175
EXPLORER	3001
PATHFINDER	5502
PIONEER	17942
SURVEYOR	8510
Total Nautical Miles	35130

STATISTICAL SUMMARY

	Triangulation			Oceanography							
	Triangulation and traverse sta. recovery	Triangulation Stations Established	Traverse, Electronic	Towed Magnetometer	Sea Gravity Meter	Bathyther'g'ph Lowerings	Oceanographic Station	Drift Bottles Released	Biological Tows	Water Samples Analyzed	
										Salinity	Dissolved Oxygen
	No	No	Miles	Naut. Miles	Naut. Miles	No	No	No	Each	No	No
Maine to Cape Henry					1870		21				
Chesapeake Bay										145	99
Cape Henry to Florida	19	4	1			20		280		32	240
Gulf Coast	12										
Puerto Rico and Atlantic	60			600						116	
West Coast	10	4		412	1847						
Lake Mead						2					
Northeast Pacific	15		2	55571	40632	880	45		19	1358	676
Alaska	328	25	239	3162	3229	46	10			67	5
	444	33	242	59745	47578	948	76	280	19	1718	1020
Deep Sea Sounding Line to and from Project Area.											
EXPLORER				2397		205	14	738		435	326
PATHFINDER				3497		77					
PIONEER				5349	3680	163	5			213	101
SURVEYOR				8364	7955	208	4			211	
				19607	11635	653	23	738		859	427

MARINE DATA DIVISION

The Office of the Chief of the Division discharged supervisory and administrative duties and continued information and consultation functions with the public. These functions, both as correspondence and conferences, consisted of advice to private and public engineers on the influence of tidal phenomena on coastal engineering, tidal currents, data exchange with research institutions and government agencies, international exchange of data and programs for analyses, and advanced dissemination of tide and current predictions.

Coast Pilot Branch

Activities were directed, primarily, toward publication of new editions and supplements for the eight United States Coast Pilots. The seventh edition (March 21, 1964) of U. S. Coast Pilot 4, Atlantic Coast, Cape Henry to Key West, in press at beginning of fiscal year, was delivered and approved for issue on September 17, 1964. The seventh edition (October 3, 1964) of U. S. Coast Pilot 9, Pacific and Arctic Coasts, Cape Spencer to Beaufort Sea, went to press on October 1, 1964, and was delivered on April 27, 1965. The seven January 1, 1965 Supplements went to press on January 2, 1965, and all were delivered by March 9, 1965. The seventh edition (April 3, 1965) of U. S. Coast Pilot 1, Atlantic Coast, Eastport to Cape Cod, was in press at the end of the fiscal year.

Marine Information Specialists of Coast Pilot Branch totalled 10.0 man-months of field inspection in the New England States (2.2), Middle Atlantic States (2.4), Gulf of Mexico States (3.0), West Indies (1.4), and Alaska (1.0).

Tides and Currents Branch

Tide and tidal current tables for the year 1966 were processed by electronic computer for the first time, with satisfactory results in printed copy by the Government Printing Office. The new process greatly facilitates matters relative to tide and current tables published by the Coast and Geodetic Survey for many years. It eliminates much time used formerly by the operation of the tide predicting machine which is now used only for special work. Daily tide and tidal current predictions for all standard reference stations were processed for the years 1967 to 1970 inclusive.

Special tide predictions were prepared for McMurdo Sound, Antarctica; Magueyes Island, Swansea, Wales; and tidal current predictions in Rosario Strait, Wash.

The tidal current survey in Chesapeake Bay was completed; 90 stations were occupied throughout the upper half of the bay. In addition, 14 current stations were occupied in the Rappahannock River and 3 in the James River in a cooperative program with the Virginia Institute of Marine Science at Gloucester.

The tidal current survey in the San Juan Islands, Wash., is about 85 percent complete. Several stations in the entrance to Strait of Juan de Fuca and a few repeat stations remain to be completed. One result of this survey is the addition to the Tidal Current Tables, Pacific Coast, of two new primary current stations, one in Rosario Strait and the other in San Juan Channel. The station in Rosario Strait was re-occupied using new Geodyne current meters with excellent results.

A comprehensive tidal current survey of Long Island Sound and Block Island Sound, the first in these waters since 1929, has been started by the ship MARMER.

A revision of the standard harmonic analysis method for obtaining amplitude and epoch of the tidal current constituents for predicting tidal currents has been approved for use. The traditional stencil summing which essentially labels the observations for each solar hour according to the nearest component hour, will be eliminated from all future 29-day series. Instead, a program has been written for completing the traditional Fourier analysis by computer.

The use of Geodyne current meters as a possible replacement for the Roberts meter has been under consideration by the Bureau. The data from a station occupied in Rosario Strait using these meters at two depths was excellent. These were reduced by computer methods.

Statistical summary of work completed

Tide records processed (station months)	1,606
Leveling records processed (stations)	375
Bench marks recovered	1,540
Bench marks established	128
Bench marks destroyed	19
Tide notes prepared (locations)	671
Tide notes prepared (hydrographic sheets)	58
Planes of reference verified (volumnes of sounding records)	645
Descriptions and elevations of bench marks (stations)	123
Tidal currents processed (meter days)	1,994
Harmonic analyses computed (stations)	12
Special tide predictions (stations)	13
Tidal data for Small-Craft Charts (charts)	11
Datum planes and tidal ranges determined (stations)	58

Predicted tides compared with observed revealed certain discrepancies in the relationship of the plane of reference mean lower low water (LLW) and mean sea level for predicted heights at Anchorage, Alaska. Short-period analyses of the new tidal series at Anchorage were computed, and predicted heights for 1966 were corrected.

Tide stations in Prince William Sound, Cook Inlet, and Kodiak Island, installed after the Alaska Earthquake in March 1964 were reoccupied during the 1965 field season to further check tidal datum planes referred to land elevations after the earthquake.

Changes in land elevations referred to tidal planes, resulting from the effect of the earthquake, were published. The report on seismic sea waves caused by the Alaska earthquake was published, with statistics from 69 tide gage records included.

Original marigrams (pressure gage) for McMurdo Sound, Antarctica, were processed for the Naval Oceanographic Office. A 29-day analysis was computed for December in the summer season and another in July during the winter season. From harmonic constants, diurnal range of 1.8 ft. and tropic range of 2.6 ft. were computed. Tide records indicate a very rough surface probably due to changing ice conditions during the "spring and autumn" seasons. Predicted tides for the summer season appear to check observations during warmer weather November-February.

Tide records for several locations in the Tongue of the Ocean, Andros Island, Bahamas, were processed for the Naval Oceanographic Office.

Tide records for several months duration from a gage in the Entrance to Noyo River, Calif., were processed at the request of the U. S. Army, Corps of Engineers, San Francisco, Calif.

A year's series of tide records for 3 stations operated by the Engineers in the vicinity of New Orleans were processed and results furnished the New Orleans Field Office to predict tides at these locations.

Fourteen tide gages (9 ADR-punch tape) were installed on the west coast of Florida from Naples to lower Charlotte Harbor and Caloosahatchee River in March-April 1965. Records are to be used for the establishment of tidal datum for boundary problems in this area. The gages will remain in operation for a period of 1 to 2 years, pending conformity of results for the several locations.

Preliminary discussions were initiated by the Fish and Wildlife Service, Department of the Interior, and the Coast Survey for the establishment of tidal planes in Laguna Madre, Tex.

Oceanographic Analysis Branch

Personnel of the Oceanographic Analysis Branch continued to sustain the acquisition, processing, analysis, and interpretation of physical and geological oceanographic, and marine geophysical data. In July the Branch moved to the Navy Yard Annex, and in November the Branch was subdivided into an Oceanographic Section, a Marine Geology Section, and a Marine Geophysics Section.

Oceanography.--Following is a listing of oceanographic transactions completed during the fiscal year:

Oceanographic Stations sent to National Oceanographic Data Center (NODC)	117
Bathythermograph Observations sent to NODC	1,814
Drift Bottle Cards received	73
Temperature-Salinity requests answered	35
Temperature-Density Stations established	6
Reversing Thermometers sent to ships	35
Reversing Thermometers calibrated at Naval Oceanographic Instrumentation Center (NOIC)	72

A public release paper, "Coast and Geodetic Survey Drift Bottle Program," was written and printed for distribution and a cooperative project was initiated with the NODC for logging drift bottle releases and returns on a coding form so that these data can be stored and retrieved by computer.

Twenty-nine oceanographic stations were taken in the Atlantic, five in the Pacific and two in the Celebes Sea. Twenty-three bathythermograph and sixteen oceanographic station sections were prepared for the PIONEER International Indian Ocean Expedition report.

Marine Geology.--Geological Echo Profiles (GEP) were run over the Philippine and Palau Trenches, and near the Island of Guam in cooperation with representatives of the U. S. Geological Survey.

GEP profiles, depth recorder fathograms, underwater photographs, and cores were taken over the faulted and uplifted sea bottom southwest of Montague Island, Alaska, and GEP profiles were run within Prince William Sound, west, south, and east of Kodiak Island, Alaska, and over the continental shelf to the Aleutian Trench.

Marine Geophysics.--Special data preparation and handling directions were prepared for inclusion in Dr.

Orlin's manual, "General Instructions for Gravity Observation at Sea". The draft copy of this manual and one on magnetic observations at sea were reviewed and suggestions submitted.

Four cross-sections from the Bay of Bengal showing depths in fathoms, free-air gravity anomalies in milligals, and total magnetic field intensity in gammas were prepared and submitted with appropriate text for inclusion in the International Indian Ocean Expedition report.

The marine geophysical contribution to the Alaskan earthquake investigation comprised 14 profiles including bathymetry, gravity, and magnetic measurements. Two zones of special interest, southwest of Montague Island, were further developed by preparation of contoured gravity anomalies, total magnetic intensity, and residual magnetic intensity overlays. The result of this was presented as part of a paper at the Seattle American Geophysical Union (AGU) meeting.

Mr. Arthur Raff of Scripps Institution of Oceanography was supplied with magnetic data in the vicinity of 41°N, 170°W. A sample tabulation of 750 reduced gravity and magnetic observation points, produced by the Marine Data Reduction program, was prepared for Dr. Stewart to accompany the ocean surveys report.

One hundred and seventy-three underwater gravity meter sites were observed on the east coast between 35°N and 39°N from the shore to 20 fathoms depth. These were made in support of the Upper Mantle Project. They also provided a calibration range on the east coast.

FACILITIES DIVISION

The most significant event was the consolidation of the New Ship Staff with the Facilities Division. This improved the administrative and engineering support of the Bureau's new ship construction and the existing fleet, and resulted in the more efficient use of technical files and administrative and technical personnel assigned to the Division.

At the end of fiscal year 1965, ten ships were authorized under the Bureau's replacement and new ship construction program, with contracts awarded and construction underway for nine ships, and one Class 1A Ocean Survey Ship in the final design stage. To summarize;

	Completion scheduled for
The country's newest and largest Class I Oceanographic Survey Ships,	OCEANOGRAPHER--January 1966
	DISCOVERER--April 1966

OCEANOGRAPHER and DISCOVERER are both in the outfitting stage of construction.	
Construction contract awarded in August 1964 for the MT. MITCHELL a class II Hydrographic Survey Ship.	December 1966
Construction delays on two earlier ships in Class II, the FAIRWEATHER and the RAINER, have been resolved. New contracts for construction have been awarded.	April 1967 June 1967
Class III Hydrographic Survey Ships, awarded in December 1964, for the MC ARTHUR and the DAVIDSON	August 1966 November 1966
Contract awarded in February 1965 for construction of two Class IV Wire Drag Vessels, the RUDE and the HECK.	July 1966 October 1966
Preliminary design for the Class 1A Ocean Survey Ship, funded in fiscal year 1965, has been completed. Plans and specifications preparation are in progress, with the construction contract to be awarded in fiscal year 1966.	Tentative - July 1968

The Division monitored all aspects of the construction program, including the acquisition of Government-furnished instruments, equipment and supplies, and preparation for outfitting of these ships, for commissioning them into active service. It maintained close liaison with the Office of Ship Construction of the Maritime Administration, which has the responsibility of contracting for the construction of these ships.

The USC&GS ship SCOTT was decommissioned and transferred to General Services Administration as being in excess of our needs. It was sold as surplus.

Alterations to increase the capabilities of the ship SURVEYOR were effected by the installation of a helicopter platform for use in our oceanographic survey work as well as in supporting shore parties.

The final phase of the Norfolk Ship Base construction project was completed with the construction of the new office and warehouse building and dredging the channel around the ship base.

NATIONAL COOPERATION

Tide and current data were furnished the following organizations:

Corps of Engineers, U.S.A. - various districts; U. S. Naval Stations at Key West and Annapolis; U. S. Dept. of Justice at Seattle, Wash., and San Francisco, Calif.; Bonneville Power Administration, Seattle, Wash.; U. S. Navy Oceanographic Office, Washington, D. C.; U. S. Public Health Service, Charleston, S. C., and Portland, Oreg.; Sanitary Eng. Dept., City of Charleston, S. C.; and Virginia Institute of Marine Science.

For the State of Florida, Trustees of the Internal Improvement Fund, Mean High Water Committee, to conduct a 2-year tidal survey in a 25-mile section of the west coast of Florida in the Charlotte Harbor area. Tidal datum will be determined to solve existing tidal boundary problems.

For Dr. Thomas W. Donnelly, Associate Professor of Geology, Rice University, a towed magnetometer and track line survey in the vicinity of Virgin Passage.

For the Alaska Barite Company, a hydrographic survey in Duncan Canal, vicinity of Big Castle Island, south east Alaska, for the purpose of obtaining a channel adequate for deep draft ore vessels.

For the Lamont Geological Observatory, Dr. Takashi Ichiye, dye diffusion experiments approximately 5 miles off shore from Niantic Bay, Conn.; for the Virginia Institute of Marine Science, a series of current observations in Burwell Bay, James River, Va.; for the University of Alaska, surface samples were obtained between Yakutat and Juneau, Alaska; for the University of Washington, bottom cores were obtained in a track line between California and Hawaii; for the Navy Department and Coast Guard, a revision hydrographic survey was made in Ensenada Honda, P. R.; for the University of Hawaii, bathymetry, gravity and magnetics in a proposed moho area northeast of Maui Island; and for Scripps Institute of Oceanography, magnetic data from the vicinity of 41°N, 170°W.; for the U. S. Geological Survey Hawaii Volcano Observatory, deep-sea dredging was accomplished on rift zone ridges extending seaward from Maui and Hawaii Islands; and for the U. S. Geological Survey, Washington, D. C., sea-bottom surface material along 160°W., between Hawaii and the Aleutian Islands and GEP Profiles in the vicinity of Philippine and Palau Trenches and Island of Guam.

OFFICE OF PHYSICAL SCIENCES

OPERATIONAL ACTIVITIES

Geodesy Division

During fiscal year 1965 the following functions were performed by the Geodesy Division: Planning and the preparation of instructions for, and the supervision of the establishment of horizontal and vertical surveys, astronomic and gravity observations, and the observations for polar motion; supervision of the office computations of these surveys and observations, and the compilation, publishing, and distribution of geodetic control data for the use of other Federal agencies and the public; cooperation with other Federal agencies as well as state, county, and local agencies on matters related to control surveys; establishment of special precise geodetic observations over various missile test ranges; supervision of the field operations of the three-dimensional satellite triangulation project which, during the year, included coverage of the northwest portion of the forty-eight states and western Canada.

Horizontal Control

Horizontal control surveys for mapping, charting, and as a basis for other surveying and engineering purposes, were accomplished by triangulation, electronic distance traverses, and combinations of these.

Special surveys were accomplished for control and study of horizontal movement at earthquake faults along the routes of proposed California aqueducts, in cooperation with the California Department of Water Resources; in cooperation with the Canadian Geodetic Survey to determine the position and elevation of Mt. Kennedy; and for the detection of earth movement in the area of the proposed linear accelerator near Pleasanton, Calif.

The high accuracy Geodimeter traverse was continued from northwestern Florida westward to Lumberton, Miss., thence northward to Greenville, thence westward to Camden, Ark. Another traverse along the east coast connected to the earlier traverse at Savannah, Ga., and progressed northeasterly to Charleston, S. C.

Resurveys in Alaska for the study of horizontal movement resulting from the 1964 earthquake, and possible future earthquakes, were made in the Seward-Anchorage-Glennallen-Prince William Sound area. A special high accuracy net was established at Anchorage for this purpose.

One of our parties continued surveys for Virginia arterial highways throughout the year. Under cooperative agreements with the highway departments of Kentucky, Louisiana, Minnesota, Mississippi, Oregon, and Tennessee, inspection was provided for surveys accomplished under standard specifications furnished by this Bureau. Results of these surveys are to be published as part of the National survey net.

Special first-order horizontal coverage was provided for Rockland County, and begun for Suffolk County, New York.

Three parties operated throughout the year establishing the precise control for positioning, testing, and research for satellites, missiles, and related operations for the Atlantic Missile Range, the Pacific Missile Range, and the White Sands Proving Grounds.

Four parties averaging 21 men each were on regular operations; six parties ranging in size from 12 to 43 men were on special purpose surveys; a party averaging 26 men was on the precise Geodimeter traverse; and an average of 14 men were on mark maintenance and preservation work.

During this fiscal year, a total of 60 horizontal control survey projects were processed and the final adjusted data were listed for the files. These projects accounted for 4,051 points being added to the files.

In addition to the final adjusted data prepared for the files, preliminary adjustments were made for several surveys in areas where the field work had not been completed. These preliminary adjusted data were requested by the U. S. Geological Survey and by other organizations. The major projects in this category were in the following areas: Harrisburg-Metropolis area, Ill.; Lake Charles to Kinder area, La.; Oklahoma City area, Okla.; and El Campo area, Tex. These projects involved approximately 300 points.

Preliminary adjustments were also made of the 1964 resurveys in the vicinity of Anchorage and Prince William Sound, Alaska. These data were used to determine the extent of horizontal earth movement following the severe earthquake of March 1964. These adjustments were for resurveys in the following areas: Anchorage to Palmer; Palmer to Glennallen; Anchorage to Whittier; Turnagain Arm to Seward; Valdez to Thompson Pass; Montague and Latouche Islands; and Unakwik Inlet, Prince William Sound.

Second-order surveys accomplished by the Highway Departments of Kentucky, Minnesota, Mississippi, Oregon, and Tennessee were submitted to the office for processing. These surveys were executed primarily for control in the construction and maintenance of new highways in the states.

The data for these projects were reviewed, adjustments were made, and the final results were added to our files.

Adjustments for special surveys made for the Department of Defense were as follows: Vicinity of Cape Kennedy, Fla.; Point Mugu, Calif.; Bermuda Island; Grand Turk Island, British West Indies; Wake Island; and various surveys in the vicinity of the Hawaiian and Marshall Islands. Final data for most of these surveys were in a special category and therefore the data were not added to our regular files.

The adjustment of a first-order class I survey in Rockland County, N. Y., was completed. Requirements for this survey were to obtain relative accuracies between stations on the order of one part in 100,000. Precise length control in this area net was furnished by six Geodimeter bases. The final adjusted data indicated the results were well within the specified requirements.

An adjustment was completed for a first-order class I area network in the vicinity of Phoenix, Ariz. The requirements of this survey, done at the request of the Arizona Highway Department, were to obtain relative accuracies approaching one part in 100,000. Geodimeter measurements also furnished precise length control for this area. The final data for this survey indicated the results were within the specifications.

Adjustments were completed for resurveys in certain areas of California where triangulation nets had been established for the study of horizontal earth movement. These adjustments were in the following areas: Vicinity of Hayward; Camp Parks, Pleasanton area; San Fernando to Bakersfield; and four sites where a proposed aqueduct will cross known fault lines. Reports of these adjustments were furnished to the California Department of Water Resources.

A simultaneous adjustment of the 1963 and 1964 observations of a small network of points in the vicinity of Salt Lake City, Utah, was completed. This network of points straddling the Wasatch fault was established for the study of earth movement in this area. The net, with lines of 450 and 900 meters in length, will be reobserved at intervals of approximately one year.

Near the end of the fiscal year the high-precision traverse surveys, extending from the vicinity of Jacksonville, Fla., to Greenville, Miss., were completed. The Geodimeter measurements and observed directions are being checked as soon as the field data are received in the office. An adjustment of this section will be made after astronomic observations for position have been completed. The final data from this high-precision traverse survey will furnish control for the satellite triangulation project.

Vertical Control

Three main multiple-unit leveling parties have been in the field throughout the year with a fourth leveling party working in Alaska during the summer extending the basic control net and releveling old lines. The four parties had an average strength of 18 men.

Releveling of old first-order lines were undertaken in California, North Dakota and Louisiana. First-order levels were run in Delaware, Florida, New Jersey, New York, and Pennsylvania as part of the program of releveling the basic net. Second-order levels were run in Virginia in connection with the state highway system.

During the year 5,289 miles of first-order and 838 miles of second-order levels were completed. Elevations were determined for 10,140 bench marks, of which 4,965 were new marks.

As of June 30, 1965, the total amount of leveling done was 197,513 miles of first-order and 291,985 miles of second-order, along which 449,644 bench marks have been leveled over.

Geodetic Astronomy

In continuation of the program to extend regional coverage of deflections of the vertical, astronomic positions were observed at 17 stations in New England and 68 stations in Arizona and New Mexico. Astronomic positions were observed at 13 stations for control of the geodetimeter traverse between Jacksonville, Fla., and Greenville, Miss. Astronomic azimuths were observed at 37 stations along the geodimeter traverse between Florida and Arkansas. In California, 23 azimuths were observed at repeat stations in connection with the study of crustal movements in earthquake fault zones. Astronomic positions and azimuths were also observed to control triangulation, provide tracking and geoid information for the Atlantic Missile Range, and for various special requirements relating to the direction of the earth's gravity field.

Astronomic Computations

Processing of astronomic data was maintained current with field work during the year. A total of 130 positions and 93 azimuths were computed. Zenith telescope observations were processed monthly in connection with the determination of micrometer screw character-

istics and level vial constants at the Ukiah and Gaithersburg latitude observatories.

Gravity Observations

Gravity traverse measurements were accomplished at 321 stations on primary level lines in the northeastern U. S. during the period July - November 1964. A traverse around the perimeter of Florida was completed in early March 1965. Operations then continued on traverse projects from Memphis, Tenn., to Columbus, Ga., and from Knoxville, Tenn., to northern Ohio. A total of 820 new stations were established along 3,360 miles of primary level lines during the year.

As part of the Alaskan earthquake damage surveys following the March 1964 earthquake, land gravity measurements were performed in July and August of 1964 in southeast Alaska near Juneau, in Prince William Sound over the epicenter area, and along new level lines in the Kenai peninsula west of Prince William Sound. A program of repeat observations in Alaska was begun in May 1965 to detect possible changes in crustal structure during the postearthquake period.

Marine gravity operations included work by the PIONEER on the Indian Ocean Expedition until August 1964. Gravity observations on the SURVEYOR at oceanographic stations in the Aleutian Islands area were accomplished in the latter part of 1964 following her special assignment to Alaskan waters in connection with earthquake damage surveys. Early in 1965 the PIONEER and SURVEYOR resumed operations over north-south oceanographic tracks in the area between Hawaii and the Aleutian Islands.

In cooperation with the U. S. Naval Oceanographic Office in May 1965 a sea gravity meter test range was established off the east coast between the Chesapeake Bay entrance and Wallops Island, Va.

Gravity intensity was observed at a number of physical laboratories in connection with the calibration of inertial devices and dead-weight balance systems.

Gravity Reductions and Geoid Studies

Positions, elevations, and anomaly data were compiled for gravity traverses over primary level lines extending from Rochelle, Ill., to Atlantic City, N. J., and from Memphis, Tenn., to Huntsville, Ala. Gravity data were processed for the 1964 earthquake damage surveys in Alaska over the Kenai Peninsula, in Prince William

Sound, and in the vicinity of Icy Strait in southeast Alaska. Special gravity anomaly contour maps were compiled for recent surveys over the rocket launch facilities on Merritt Island, Fla., and the gravity equipment evaluation range off the east coast of the U. S. between the Chesapeake Bay entrance and Wallops Island, Va. Numerous gravity values were determined by interpolation for meteorological sites, physical laboratories, and various test facilities as requested during the year.

An extensive system of geoid profiles was developed in the central U. S. between the Gulf of Mexico and southern Minnesota. The profiles were determined from existing astrogeodetic deflections, supported by the integration of surface gravity data. The total distance of the profiles was 925 miles, with an average station interval of 13 miles. Of special interest was the 10-foot rise and fall of the geoid over a distance of 90 miles in the flat country of north-central Iowa. This is a geodetic effect of the midcontinent ridge of gravity highs extending from northeast Kansas to Lake Superior.

A network of geoid heights was determined in conjunction with tracking station requirements of the Atlantic Missile Range in the vicinity of the Bahama Islands.

Variation of Latitude

The variation-of-latitude observatories at Ukiah, Calif., and Gaithersburg, Md., continued in operation throughout the year. At Ukiah, 4,232 star pairs were observed on 264 nights, complete sets being observed on 184 nights. At Gaithersburg, 3,519 star pairs were observed on 267 nights with complete sets on 99 nights. Latitude observing records were transmitted weekly to the Central Bureau of the International Polar Motion Service in Misuzawa, Japan. At both observatories a continuous program was maintained for determination of micrometer screw characteristics and Talcott level values.

SATELLITE TRIANGULATION

Activities in satellite triangulation continued to expand during the past year. At the beginning of the fiscal year, satellite observations using the Echo I and II satellites were underway to complete the Maryland-Florida-Bermuda triangle. Early in the first quarter of the fiscal year, a fourth camera system was placed in operation in Antigua, British West Indies, and observations coordinated with the three operational camera systems.

During the second quarter a cooperative agreement with Canada was concluded to allow for the extension of satellite triangulation from the U. S. through Canada to central Alaska and the Aleutian Islands. During this quarter, the camera systems were transferred to occupy stations in Canada at Lynn Lake, Manitoba, Whitehorse, Yukon Territory, and Cambridge Bay, Northwest Territories.

In the third quarter, the Cambridge Bay station was transferred to Moses Lake, Wash., and a fifth camera station activated at Chandler, Minn., in order to complete the network in western Canada.

In the fourth quarter, a cooperative agreement was reached between the Departments of Defense and Commerce to assist in the funding of C&GS satellite triangulation operations in activating up to eight camera systems, to extend the satellite triangulation network from the U. S. through Canada, Greenland, and Iceland to northeastern Europe, and to measure Geodimeter baselines in the U. S. to scale the satellite triangulation network. During this quarter, Canadian stations were transferred to Greenville, Miss., and Albuquerque, N. Mex., completing the network across the U. S., except for stations at Brownsville, Tex., and Wrightwood, Calif., which will be occupied later.

At the end of the fiscal year, preparations were nearly completed for increasing the number of camera systems to eight, and for extending the satellite triangulation northward through central and eastern Canada.

Recovery and Maintenance Program

An average of 14 men were utilized in the recovery and maintenance of geodetic marks in many conterminous States and Hawaii. The program was directed by the respective regional offices, and the men were based at the regional and field offices and other points convenient to the areas of activity. According to monthly reports, 26 bench marks and 24 triangulation or traverse station marks were repaired; 478 bench marks and 192 triangulation or traverse station marks were recovered.

Publication of Data

The publication of new data and the reproduction of old data have been continued in 30-minute quadrangle units. The drafting and publication of the 1:250,000-scale horizontal and vertical control diagrams, in cooperation with the U. S. Geological Survey, have been continued. Forty-five new diagrams were printed, bringing the total in this series to 203.

About 16,580 mailings of geodetic control data were made to organizations and individuals on our automatic mailing list. In addition, about 5,228 mailings were made in response to individual requests for information. Sales to users totaled $12,320, and material valued at $65,819 was distributed to those authorized free distribution.

Special Projects

Utilization of electro-optical distance measuring instruments in connection with triangulation has furnished a technique especially valuable in small closely spaced nets. Full use of readily available measured lengths have made practical the achievement of relative accuracy of about one part in 100,000. The net at Anchorage, Alaska, and a special survey of Rockland County, N. Y., have fully demonstrated the effectiveness of this field procedure.

The total number of aqueduct-earthquake fault crossings in connection with the Feather River project in California was brought to 22 during the year. Most of these are not connected to the net, being designed primarily for the detection of local movement. All but the four most northerly, in the San Francisco Bay region, were reobserved within the year as part of a continuing program of monitoring.

Releveling was undertaken in Alaska to study results of the recent earthquake; at Camp Parks, Calif., to study seismic activities; in the vicinity of Fort Myers, Fla., to help solve tidal boundary problems; and in the San Joaquin Valley of California where a study of changes in elevation was being undertaken in cooperation with the California Department of Water Resources.

Precise Geodimeter Traverse

Locality	Reconnaissance (miles)	Observed (miles)
Arkansas.....	60	89
Florida.....	-	299
Georgia.....	-	20
Mississippi.....	5	197
South Carolina.....	-	83
Total	65	688

Tabulation of Field Activities

Triangulation Reconnaissance

State	Area Square Miles
Alaska	5,799*
Arkansas	1,870**
California	7,880
Illinois	1,100
Indiana	1,560
Kansas	2,400
Louisiana	*
Michigan	4,500
Mississippi	465**
Montana	6,400
Nevada	2,750
New York	810
Tennesse	360*
Texas	2,500
Virginia	1.935*
Total	40,329

** See table of Precise Geodimeter Traverse
* Electronic Traverse planned

Geodimeter Baseline Measurements

Locality	Length in miles
Mt. Lassic - Horse Ridge, Calif.	16.21
Arcadia - Farlington, Kansas	11.93
Wilson - Triplett, Kansas	9.16
Ark Post - Campbell RM 3, Ark.	5.50
Wheatley RM 1 - Eden 2, Ark.	8.55
Bald - Cragmere, N. Y.	4.11
Cragmere - Perk, N. Y.	6.19
Tallman - Gessner, N. Y.	4.63
Sterling - Tiorati, N. Y.	7.70
Tiorati - Bear Mt., N. Y.	5.18
Piermont 2 - Hook Mt. 2, N. Y.	4.98
Total	84.14

Gravity Determinations
(Including Reoccupations)

	Base net stations	Level line stations
Alabama	8	42
Alaska	97	1,014
California	10	--
Connecticut	--	32
Florida	6	176
Georgia	--	64
Kentucky	--	66
Louisiana	--	3
Maine	--	28
Massachusetts	--	28
Mississippi	--	13
New Hampshire	--	16
New Jersey	--	36
New York	--	122
Ohio	--	54
Pennsylvania	6	33
Rhode Island	--	13
Tennessee	--	77
Texas	6	--
Virginia	--	29
Vermont	--	30
Total	133	1,876

Leveling

State	1st order (miles)	2nd order (miles)
Alaska	1,245	29
Arizona	0	6
California	1,714	280
Delaware	32	0
Florida	657	0
Hawaii	0	3
Indiana	31	0
Kentucky	4	1
Louisiana	931	15
Michigan	19	129
Minnesota	7	19
Montana	88	3
New Jersey	293	0
New York	28	0
North Dakota	89	87
Ohio	93	4
Pennsylvania	40	0
Virginia	17	263
Total	5,288	839

Triangulation, 1st-, 2nd, and 3rd-Order

State	Number of Stations	Area
	Marked and Intersection	Square Miles
Alaska	113	506
Arizona	4	45
Arkansas	218	3,658
California	254	5,913
Florida	81	**
Georgia	1	**
Hawaii	6	6
Idaho	10	1,390
Kansas	108	2,375
Kentucky	46	30*
Louisiana	47	2
Michigan	23	600
Minnesota	281	4,569*
Mississippi	60	481
Montana	107	3,330
New York	71	986
North Carolina	113	1*
Oregon	10	8*
South Carolina	15	**
Tennessee	108	668*
Texas	30	1,515
Virginia	131	1,364*
Washington	33	1,362
Puerto Rico	13	26
Total	1,883	28,835

** See table of Precise Geodimeter Traverse
* Electronic Traverse also measured

Earthquake Surveys

	Number of Stations		Area
	Old	New	Square Miles
Vicinity of Anchorage, Alaska	274	110	2,310
Taylor Winery, California	4	-	-
Total	278	110	2,310

Highway Horizontal Control Surveys

State	Marked Stations	Miles of Road
Kentucky	46	127
Louisiana	47	36
Minnesota	94	187
Mississippi	2	0*
Oregon	10	9
Tennessee	101	168
Virginia	102	287
Total	204	814

*Triangulation only

Astronomic Determinations (Including Reoccupations)

Locality	Latitude	Longitude	Azimuth
Alabama	1	1	4
Arizona	26	29	-
Arkansas	-	-	7
California	2	2	31
Florida	10	12	20
Illinois	-	-	1
Maryland	1	-	-
Massachusetts	2	2	-
Mississippi	13	13	20
New Hampshire	9	9	-
New Mexico	53	61	-
Texas	1	-	1
Vermont	10	10	-
Washington	-	-	1
Foreign	6	6	6
Total	134	145	91

Summary of Geodetic Field Operations

	Fiscal Year 1965	Total to June 30, 1965
1st-, 2nd-, and 3rd- order triangulation stations.....	1,883	175,614
1st-and 2nd-order leveling (miles).....	6,127	489,498
1st-order base lines (taped)..	0	453
Geodimeter base lines.....	11	253
Precise Geodimeter traverse (miles).....	688	1,624
2nd-order base lines (taped)..	0	59
Latitude Stations.....	117	2,122
Longitude Stations.....	115	1,924
Azimuth Stations.....	68	1,862
Gravity Stations.....	1,685	19,818

Electronic Computing Division

The Electronic Computing Division continued to furnish a comprehensive electronic computing service to all Offices of the Survey. The increase of more than seven times in computational processing for Bureau programs was due primarily to the greatly expanded workload in the geomagnetism, seismology, and satellite triangulation programs, and was made possible by the use of offsite computers in a sharing concept. In addition, administrative reporting became more automated, with new requirements and many revisions being necessary on existing data processing routines.

Ocean Studies.--The principal computer usage for the Oceanographic Program was for the IBM 7094 computer predictions of tides; and for operation of a series of subroutines designed for time series analysis, called BOMM after its authors. Additional programming was accomplished to compute hyperbolic lattices on a base mapping sheet for an electronic navigational positioning system. The Marine Data Reduction System, which provides processing for gravity, magnetic, and sounding data obtained during oceanographic surveys was made operational.

Hydrography.--The Hydrographic Program is not an extensive user of existing computer facilities. Its work included volume key-punching of tidal data and IBM 1620 computer program applications. This consisted of conversion of Loran C coordinates and other grid intersections to geographic positions, and the use of established computer programs for State plane coordinate computations.

Cartography.--During the past year, special analysis and programing were accomplished by the Division to furnish input for the Naval Oceanographic Office Concord Plotter for the automation of Radio Facility charts. Additional computations included those for airline distances between cities in the United States, geodetic inverses for azimuths and distances, geographic position conversion to State plane coordinates, and traverse calculations. Production control programs for summarization of daily cartographic reports on a biweekly and monthly basis, which reflect labor and materials used were continued. Documentation was updated and reprogramming accomplished for the Charts Inventory series of programs.

Geodesy.--Computer usage in the Geodetic Program involved the adjustment and data processing for geodetic triangulation adjustments using its library of IBM 1620 programs. Approximately 200 of these jobs were performed during the past year. Of special significance in the total electronic computer effort during the year has been in research and development, geodesy, or the Satellite Triangulation Program. The current version of this reduction system includes more than thirty programs. More recent computer programs have involved the use of star catalogs, a new orientation program, a world net-adjustment program, additional efforts in graphic displays, matrix inversion and determinant evaluation. The current workload is approximately 20 star plates per month. A new service initiated for the Geodesy Division was to machine produce listings of adjusted horizontal control data for publication. Using this concept, an attempt is being made to aid the Geodetic Data Distribution Section in their format conversion problem.

Geomagnetism.--During this year, much divisional programer and data processing effort was allocated to World Magnetic charts. Computer programs and processing were completed for reducing the airborne geomagnetic data to sea level, for the reduction of the three geomagnetic components, declination, horizontal and vertical intensity to epoch 1965.0 and subsequent meaning by one degree quadrilaterals. For the U. S. chart series, 30-minute quadrilateral means were obtained. The Dipole Program which adjusts the location and amplitude of a number of magnetic dipoles within the earth to the observed field on the surface of the earth, has undergone numerous tests, resulting in several modifications.

Data processing also included keypunching of scalings for the magnetic observatories throughout the world. A large portion of Geomagnetism's IBM 1401 use concerned reformating tapes of geomagnetic data being sent to National Aeronautics and Space Administration. The master magnetic tape file of geomagnetic data now includes approximately 400,000 data records.

Seismology.--In the past year the computations for approximately 25,000 earthquake locations were processed. There has been modification of the Fortran version of the earthquake hypocenter program that resulted from improved computational techniques. New methods were devised to update the file tape containing the various tables and constants used by this program. Other computer usage involved the production of the Seismological Bulletin, the sorting, reproducing and listing of Schuster values, and keypunching of scalings.

Administration.--The electronic computer service for the Office of Administration used about one-third of the personnel resources of the Electronic Computing Division; accounted for 44 percent of the 1401 time, approximately one-half of the keypunch effort, and maintained a file of 125 magnetic tapes. During this time almost complete reprograming in major computer programs was required for insertion of premium pay rates of the Wage Marine Plan into the payroll system, the installation of a new project structure, etc. New system design and programing were required for the commissioned officer payroll, military unit cost report, personnel grade and salary report, and others. Summaries of computer usage and corresponding costs for the Bureau administrative functions were compiled for the Departmental ADP Study Group representatives.

Photogrammetry.--The work for the Photogrammetry Division was divided into two distinct areas: analytic aerotriangulation and the operational responsibility for the satellite triangulation reduction system. For the past year, approximately six strips of analytic bridges averaging 10 to 12 photos per strip per month, and about 25 stereoplanigraph strip bridges per month were processed on the IBM 1620 and IBM 7030 computer. The reduction of the glass-plate satellite photographs averaged 20 per month. Photogrammetry used its own personnel to form a "divisional clearing house" for all of its computer requirements. This unit controlled its own data preparation, checked for completeness and orderly receipt of the results from the computer, accomplished preliminary quality checks, and performed the proper distribution of the many different results.

The move of the Electronic Computing Division of the Coast and Geodetic Survey from the Department of Commerce Building, Washington, D. C., to the Washington Science Center was completed on a weekend late in September of 1964. Downtime for the 1401 computer was one day (Saturday) and that for the 1620 computer was one and a half days (Saturday and Sunday). The move was completed without disrupting any routine work.

Feasibility Studies.--There was extensive participation by the Division in the Coast and Geodetic Survey Feasibility Study for automatic data processing (ADP). The final report stated the basic requirements for the

present and developing electronic computer needs of the Bureau. It was recommended that an action committee be appointed to accomplish the required system design work that was indicated by the report. Previous to this study, this Division participated in a working group appointed to conduct a preliminary analysis of ADP applications of the Bureau. Members of the Division also cooperated with committee members of the Departmental ADP Study for Administrative Functions.

OPCON.--The OPCON system, a copyrighted product of Datatrol Corporation was purchased. The system provides a library of frequently used routines for the IBM 1401. It makes possible a more rapid response to urgent requests using existing files of information.

Security Storage Tapes.--More than two hundred electronic computer programs of all descriptions were loaded onto a security storage magnetic tape file. This two-tape file contains the current version of all worthy and strategic computer programs, and was submitted for storage with the Bureau Security Officer.

Calcomp Plotter.--The use of the Calcomp Plotter, that is on-line with the IBM 1620, was greatly increased during the year for graphic displays. These applications were for seismology, oceanography, geomagnetism, and satellite triangulation. The plotting included histograms, residuals from least squares adjustments, radial vector plots, magnetic dip in latitude bands, atmospheric refraction constants, and a preliminary version of portions of an Obstruction chart.

Stretch Conversion.--The Weather Bureau IBM 7030 (Stretch) was phased out in March 1965. Its use at that time by the Electronic Computing Division had become required and necessary for two expanding Bureau Programs. This workload was transferred to the Stretch facility at the Naval Weapons Laboratory, Dahlgren, Va. This transfer included the system tape operation which uses the in-house IBM 1401 to prepare magnetic tape input data and to process the magnetic tape output material from the Stretch.

Training.--The Division sponsored a two-day course concerning ADP management standards in June 1965. This training was presented to 34 Bureau personnel by Mr. Dick H. Brandon of Brandon Applied Systems, Inc. The course was attended by Bureau computer programers, system analysts, and electronic computer operators. A Fortran home study programing course was administered by the Division for new employees of the Division and other Bureau personnel as required. In Fiscal 1965 twenty persons received this individual instruction course.

Aptitude Testing:--To evaluate prospective employee's and potential open-shop programers from other Divisions,

the Division has a standard programer's aptitude test. The one hour examination was supplied to the Division by the IBM Corporation. During this year, 152 individuals were tested. A large portion of this was accomplished at the request of the Nautical and Aeronautical Chart Divisions as an aid in the selection of their personnel who would participate in a special phase of their training program.

The usage of all electronic computers by Bureau Program is as follows: -

	Hours			Minutes	
	650	1401*	1620	7030	7094
Oceanography.....	-	50	117	68	629
Geodesy.....	116	33	583	63	-
Satellite Triang..	-	140	1339	1322	341
Geomagnetism.....	39	700	334	2398	152
Seismology.....	-	292	734	3448	44
Photogrammetry....	156	3	378	43	-
Charts Inventory..	-	238	-	-	-
Administration....	108	1172	-	-	-
Others.....	102	14	46	-	-
Total fiscal 1965	521	2642	3531	7342	1166
Total fiscal 1964	1715	1452	4206	887	-

*metered time

Numbers of electronic computer programs:

IBM 1401	190	IBM 7030	26
IBM 1620	135	IBM 7094	16

Not including routine scheduled operational reporting such as charts inventory, reproduction control, cost accounting, and payroll; the average service in the Operating Branch has been:

34 daily requests for EAM* usage
22 daily requests for 1620 usage
19 daily requests for 1401 usage

*electric accounting machine

Photogrammetry Division

The Photogrammetry Division execute the surveying and mapping by photogrammetric methods of land areas required for the control of hydrographic surveys, for the construc-

tion and up-to-date maintenance of aeronautical and nautical charts, for the location of landmarks and aids to air and marine navigation, and for other Bureau purposes. The Division operated aircraft for aerial photography and performed the photogrammetric field surveys and office mapping activities required for the preparation, processing and production of its principal products--basic maps, chart topography, shoreline maps, supplemental control, aerial photographs, and other related photogrammetric data and services. The latest developments and applications in photogrammetric techniques and instrumentation were used by the Division to provide for increased output, precision, and economy in its surveying and mapping operations. It collaborated with other offices of the Bureau in the application of aerial photography and photogrammetry on various Bureau programs which involved the operation of deep-sea cameras, the measurement of tidal currents, special studies and surveys related to the potential exploitation of the continental shelf areas and on the detection of earth crustal movements, and the planning and operation of the satellite triangulation program for the establishment of a worldwide geodetic reference net. The Division provided photogrammetric consultant services to federal, state, and local agencies, and to private engineering firms; and it performed special photogrammetric surveys for federal agencies and states. Also, it furnished aerial photographs, survey data, copies of maps, and related services to federal, state, and local agencies, and to the general public.

Photogrammetric surveying and mapping activities were in progress throughout the United States, Puerto Rico, and the Virgin Islands of St. John and St. Thomas for hydrographic and nautical charting purposes, on the airport charting and air facilities location program for the Federal Aviation Agency, and for other Bureau and national cooperative programs. A significant part of the Division's total effort was devoted to the Alaska Earthquake area; a detailed, illustrated report on the Division's role in this effort was furnished for inclusion in the Bureau's published report on the 1964 Alaska Earthquake.

The Baltimore and Tampa Photogrammetric Offices were closed, and their functions consolidated and transferred to the Norfolk Regional Office. The Division completed its move from the Commerce Building, including the transfer of the Aerotriangulation Section and its heavy plotting instruments to the new building at Washington Science Center.

The Chief of Division and the Photogrammetric Branch Chief attended the 10th International Congress on Photogrammetry in Lisbon, Portugal. In London, England, the Chief of Division presented a paper before Representatives of the British Survey and Mapping community; the Branch Chief was a participant at the Aerotriangulation Symposium convened in Delft, Netherlands. Visits to and conferences on photogrammetric developments were held with officials

of the Wild Heerbrugg Instrument Company, Zeiss Aerotopograph, and Agfa, Inc., in Switzerland and Germany; the Institute Geographic National in Paris; and the British Ordnance Society in London. The Assistant Chief of the Division attended the meeting of Pan American Institute of Geography and History Consultation on Cartography at Guatemala City, Guatemala. A trip was made by the Operations Branch Chief to inspect Photogrammetry's field units and the Air Photo Mission in the Alaska earthquake area, and to assist in coordinating their photogrammetric and photographic operations.

At the annual joint-convention held by the American Society of Photogrammetry and the American Congress on Surveying and Mapping, two interesting, technical papers on photogrammetric subjects were presented. Photogrammetry Division's Equipment Specialist received the Talbert Abrams and the Autometric award at the Convention's presentation of awards ceremony; these awards were made in recognition of and to encourage the authorship and recording of current, historical, engineering, and scientific developments in photogrammetry.

Over one hundred participants were welcomed by the Director of the Coast and Geodetic Survey at a seminar on Analytic Aerotriangulation held at the Washington Science Center in order to provide interested members of the scientific community an opportunity to share in our experience on the development and applications of a system of analytic aerotriangulation in surveying, mapping, satellite geodesy, and engineering. The participants represented private firms, government agencies, universities, and colleges.

The photographic missions of the Coast Survey permitted continuing reconnaissance of the coastline for changes and rapid correction of shore and land information on nautical charts by the application of new photography directly to the chart drawings; in addition, this repeat photography provides a historical record of the changes along the coast.

The compilation from color photography of a topographic base for a new, large-scale, harbor chart of Seattle, Wash., was completed. The preparation of this topographic base was unusual and significant for the reason that both the aerotriangulation and stereoscopic compilation of planimetry on our plotting instruments were accomplished solely from color diapositive plates. The first glass plates with color emulsion were produced experimentally by Eastman Kodak Company at our request in the fall of 1963; these plates are now in production. The exclusive use of color through the complete sequence for mapping a project represents a landmark in the development of photogrammetry. Also, color photography has greatly improved the Bureau's ability to locate aids to navigation and landmarks by the direct application of new photography to map and chart drawings

without field investigation; numerous aids to navigation and landmarks were positioned in this manner.

The application of color aerial photography to tidal current surveys for separating types of targets through color coding was accomplished successfully on a survey in Long Island Sound. This means that on future photogrammetric tidal current surveys, the color coding technique will provide a means of associating and identifying targets connected to submerged drogues at various coded depths, that is, each depth coded to the color of the surface target. Where, previously, our photogrammetric methods applied only to the current's surface direction and velocity, it will now be possible to make measurements photogrammetrically of current direction and velocity by cross sections.

Two new Wild B-8 topographic stereoplotters were installed and calibrated at the Norfolk Regional Office in order to provide it with the capability of utilizing color aerial photography in its photogrammetric mapping. The B-8 stereoplotter with its superb viewing system is ideal for stereoscopic compilation with color photography for the "model" is viewed in full color without any loss of the fine resolution of the original film. In view of the superiority of color over black and white photography, these new stereoplotters will enhance the efficiency of our photogrammetric mapping operations.

On the return trip of the ship PIONEER to San Francisco from its Indian Ocean cruise, deep-sea camera lowerings were made to obtain stereoscopic photography of the ocean floor. A second deep-sea camera system aboard the ship SURVEYOR in the Gulf of Alaska was used to photograph an earthquake faultline on the ocean floor after the fault was located with sonic depth measuring equipment.

The specialized training program--approved by the Civil Service Commission--for professional cartographers was continued in the Division. Six employees from Seismology Division were trained in basic photogrammetric interpretation techniques, and a total of seventeen Bureau junior officers received intensive training in photogrammetric procedures--with emphasis on control identification--at the Norfolk and Seattle Ship Bases. A training course for aerial photographers, which included our pilots and copilots, was held in the Air Photographic Laboratory; each participant received about 20 hours of classroom work and operational instructions on aerial cameras and films that are currently applicable to our operations. At the request of the U. S. Corps of Engineers, a pilot and photographer from Walla Walla District, Wash., were given training in all phases of our air photographic operations. In addition to the technical training in photogrammetry received by the Foreign National Trainees assigned to our Division, a new course was prepared to acquaint them with the administra-

tive and operational aspects of implementing and executing photogrammetric operations within a government agency.

The first block adjustment of a relatively large multi-strip aerotriangulation problem was completed. The developed Block Adjustment program consists of the simultaneous solution of a large number of normal equations required for the absolute orientation of an entire block of aerial photographs. Studies are continuing on weighting control and on optimizing production procedures, e.g., reduction in data handling, regularizing a work flow system, etc.

The calibration procedure used for the precision satellite tracking cameras was adapted to our aerial cameras. The distortion of the camera lenses and optical filters is determined now with much greater precision through photographs of the stars taken at the Beltsville Laboratory where a stellar calibration pier and a camera housing were constructed. This new method uses several hundred uniformly spaced stars as optical collimators of known angular position as contrasted to the previous laboratory method limited to the use of 25 or fewer man-made collimators arranged to produce photo images only along the principal diagonals of the photograph area.

In connection with the Bureau's satellite triangulation program, this division made voluminous and highly accurate plate measurements required for the calibration of the precision satellite tracking cameras and for the calibration of the Mann comparators to obtain final directions on the order of accuracy of 2 microns on the photographic plate; computed look-in angles for satellite camera tracking operations; and assisted the Electronic Computing Division in the development of programs and procedures for the reduction of photogrammetric data on the currently operational satellite program. Using passive satellites Echo I and II, the observations and the photogrammetric reduction of the star plate measurements for four triangles were completed with a positional accuracy of better than 1:500,000 over lines approximately 1,610 kilometers between stations. A new Mann comparator was acquired, with another comparator scheduled for delivery in the next fiscal year, for use on the Geodetic Satellite program in the joint effort by Departments of Defense and Commerce for the establishment of a worldwide geodetic reference net.

Linear Miles of Aerial Photography

Program	Mission 375	Mission 376	Total
Nautical Charting	11,067		11,067
Aeronautical Charting		8,150	8,150
Miscellaneous Projects	2,573		2,573
Total	13,640	8,150	21,790

Film Exposed

Type of Film	No. Rolls
Panchromatic	51
Infrared	4
Color	53
Total	108

Laboratory Processing and Printing

Aerial negatives developed	20,613
Nine-lens prints	7
Single-lens prints (black and white)	49,500
Single-lens prints (color)	5,600
Photographic plates (black and white)	2,203
Photographic plates (color)	1,100

Aerial and Laboratory Photography

Two photographic missions were active during the year to obtain panchromatic, infrared, and color photography at various scales for nautical and aeronautical charting, for special surveys done for other agencies, and for research and development studies in photogrammetry. These missions were active on photographic assignments in Alaska, Puerto Rico, the Virgin Islands, and in the conterminous United States. An attached table summarizes the aerial photography and related laboratory processing accomplished.

Air Photographic Mission 375 was assigned mainly to acquire panchromatic, infrared, and color photography at various scales for coastal mapping and chart maintenance work with much of its effort devoted to mapping, revision, and special purpose photography of the Alaska earthquake area. On October 15, 1964, this Mission ended its cooperative arrangement with the Coast Guard as a joint U. S. Coast Guard-Coast and Geodetic Survey Mission - thus terminating an historic and successful cooperative arrangement that had existed since 1941. This arrangement was discontinued due to changes in techniques and in the requirements of the two agencies. The Mission, comprised of a pilot, copilot, and two civilian aerial photographers, now operates a new Grand Commander Aircraft, leased and operated by the Coast and Geodetic Survey.

Air Photographic Mission 376 was assigned to aerial photography on the aeronautical obstruction charting program for the Federal Aviation Agency. Operating a leased twin-engine aircraft, the Mission--with its complement of pilot, copilot, and a civilian aerial photographer--was active on photographic assignments for panchromatic and color aerial photography of the various airports and air navigational facilities for use by field parties on airport surveys and facilities location, and in the photogrammetric offices for the compilation of airport obstruction charts and the construction of airport mosaics for noise abatement studies.

Test photography was flown to evaluate new color plates and films; also, tests were made on a new universal camera designed for panchromatic, infrared, and color photography with the same lens.

Two commissioned officers were assigned to fixed-wing flight training and another completed advanced fixed-wing training at Fort Rucker, Ala.

Field Surveys

Photogrammetric field survey units operated along the Atlantic, Gulf, and Pacific coasts of the conterminous

Summary of Coastal Mapping for
Hydrographic Support and Nautical Charting

Locality	Field Surveys (Including hydrographic support)		Map Compilation		Maps Registered
	Shoreline (Linear miles)	Area (Square miles)	Shoreline (Linear miles)	Area (Square miles)	Number
Atlantic Coast					
Maine to Cape Henry	150	175	120	60	32
Cape Henry to Key West	290	290	165	63	9
Puerto Rico and Virgin Islands	50	90	39	17	-
Gulf Coast	220	280	100	980	63
Pacific Coast					
California	150	200	48	16	-
Oregon and Washington	55	75	42	25	-
Alaska					
Earthquake Area	275	200	368	198	-
Gulf of Alaska	150	150	110	60	-
Western and northern areas	-	-	-	-	-
Hawaii	75	75	25	25	13
Total	1,415	1,535	1,017	1,444	117

United States, in Alaska, Hawaii, and Puerto Rico to provide hydrographic control and support for 8 ships and 1 shore-based hydrographic party, to identify aids to navigation, to make surveys of maritime facilities for the preparation of small-craft charts and of folded editions of intracoastal waterway charts, to field-edit chart drawings, and to provide field inspection and control for photogrammetric mapping. Aeronautic field survey units continued airport surveys and surveys for the location of aids to air navigation in all the states, Puerto Rico, and the Virgin Islands for the Federal Aviation Agency. Other field units were engaged in cooperative work for various federal and state agencies.

A long needed tidal current survey for Block Island and Long Island Sounds was started by the ship MARMER, using standard equipment and conventional methods, which was supplemented with a synoptic photogrammetric tidal current survey; about one-half of the work was completed, and field operations will be resumed again in the fall of 1965 for its completion. The large expanse of water made this a very difficult survey and required the placement of plywood targets (anchored offshore) for their identification on aerial photography in order to provide vertical datum and positional control.

Special field surveys were completed for the study, development, and application of photo-geodetic control. It is a test of aerial triangulation by modern photogrammetric methods in conjunction with a test to compare tower triangulation and geodimeter traverse methods conducted by Geodesy Division in a 40-by 50-mile area in southeastern Kansas.

Photogrammetric employees were assigned to the Alaska earthquake area for field duty to provide photo-hydro support to the vessels engaged in hydrographic operations, to install and level in tide staffs for tide-controlled infrared photography, to premark control prior to photography to facilitate and improve control identification work, to recover control, and to furnish the field inspection required for shoreline and special mapping.

Office Activities

Photogrammetric office activities included the planning, direction, and review of the diverse field and office operations in the areas of surveying, mapping, aerial photography, satellite geodesy, research and development, and on other special photogrammetric tasks; furnishing detailed map information (foreshore, shoreline, offshore, and inland features of interest to the mariner) for the construction and up-to-date maintenance of the Bureau's nautical charts; special shoreline surveys and supplemental control in support of hydrography; the

location of navigational aids and landmarks; reduction of tidal current measurements; star plate measurements, incidental programing and electronic computer processing of data on the satellite triangulation project; development and application of photogrammetric techniques for existing and new Bureau programs and needs; special photogrammetric work and technical assistance to federal, state and local agencies, to private firms and individuals; active participation in national and international technical groups and societies; and the continuation of the aeronautical charting activity for the Federal Aviation Agency as reported under the section titled "National and International Cooperation".

Over 200 specially prepared shoreline maps with aerial photographs for the field location of hydrographic control by photogrammetric methods were furnished to the Bureau's ships. In addition to these data, about 1,240 linear statute miles of intricate shoreline was compiled photogrammetrically and transferred to the hydrographic smooth sheets.

Using the latest advances in analytic aerotriangulation, a block adjustment was completed, and an evaluation made to the photogrammetric control vis-a-vis the geodetic control on the second series of tests for the detection of earth crustal movement along the fault at Salt Lake City; there was no detectable movement, and the accuracy achieved on the two series of measurements made so far was of first-order magnitude. The geodetic control data will become part of a continuing record of surveys in this unique study. The photogrammetric counterpart or effort in these surveys will involve a final adjustment to a single set of geodetic control data in order to validate the repeatibility of the derived data and its dependability for use in the detection of crustal movements.

The work was completed on the Bureau's commitment to the American Society of Photogrammetry Committee on color photography of the Bennettsville area for the Society's National Color Tests Study. This work involved the joint efforts of the Air Force, Army, Coast and Geodetic Survey, and the Eastman Kodak and Ansco Companies. Photogrammetry Division will continue to provide technical assistance to the various agency members that participated in the National Color Test Study - a study designed to enable the agencies to evaluate, by means of programmed tests, the application of color aerial photography to their particular area of interest. The increasing number of requests from federal and state, from institutions of higher learning, and industry for advice and assistance in the processing and application of color aerial photography is indicative of a new and vigorous national interest in this important contribution by the Coast and Geodetic Survey to the state-of-the-art in photogrammetry.

A detailed, topographic map at the scale of 1:2400, covering the site of the new Castle Rock Varian Magnetic Observatory in California, was prepared for Seismology Division.

Using stereomodels of photographs taken before and after the earthquake on the Wild B-8 stereoplotter, a vertical shift of 33 feet was determined photogrammetrically for a new fault located at Macleod Harbor on Montague Island, Alaska.

Infrared aerial photography, obtained at the mean high water (MHW) stage of the tide, was used on several mapping projects to preclude the requirement of identifying the MHW line on the photography prior to mapping or charting. Infrared photography, which provides a definitive line between land and water, permitted the delineation of the shoreline at MHW directly from the photographs to our maps and charts.

Geomagnetism Division

The earth's magnetic field is a dynamic phenomenon which, for reasons as yet not fully understood, is continually shifting and changing in ways that frequently have no discernible regularity. A primary responsibility of the Geomagnetism Division is to record, catalog, publish, and disseminate detailed information on this natural phenomenon. During the year, this formidable task was pursued through a variety of activities embracing the efforts of the headquarters staff located in Washington and those of field installations and parties from Puerto Rico to Guam and from Point Barrow, Alaska, to the South Pole.

Throughout the year, the Division operated magnetic observatories and laboratories, planned and carried out field observations at many locations, processed and disseminated the various categories of data resulting from this work, calibrated magnetic instruments, developed and tested instruments of improved design, assembled and archived geomagnetic data from sources outside the Bureau, supplied geomagnetic data to the scientific community and the general public, compiled the world and the United States magnetic charts for epoch 1965.0, pursued a number of scientific investigations involving geomagnetic phenomena, and cooperated and collaborated with other agencies on projects of mutual interest.

Variations in the earth's magnetic field were monitored by continuous recording equipment at 11 Bureau-owned observatories located at Fredericksburg, Va.; San Juan, P.R.; Dallas, Tex. (operated jointly with the Graduate Research Center of the Southwest); Boulder, Colo. (operated jointly with the National Bureau of Standards); Tucson, Ariz.;

Castle Rock, Calif. (operated jointly with the Varian Foundation and the University of California); Sitka, Alaska; College, Alaska; Point Barrow, Alaska; Honolulu, Hawaii; and Guam. The San Juan observatory was relocated to a new site at Cayey, P. R., because of encroachment resulting from civil expansion in the area of the old site. The new observatory was dedicated December 10, 1964, and named the San Juan Geophysical Observatory. This observatory employs modern instrumentation, including a Proton Vector Magnetometer (PVM) for absolute magnetic measurements and control of both the horizontal and vertical intensity baselines.

Though not in routine operation at the end of the year, the Castle Rock Magnetic Observatory was completed and the instruments, consisting mainly of the Automatic Standard Magnetic Observatory-Remote (ASMOR), were installed. The output is transmitted over telephone lines and recorded at the University of California. Construction of the new observatory at Newport, Wash., was well advanced at the end of June. A trisensor rubidium magnetometer system, employing both analog and digital readout, was designed for use at this observatory. Contracts for the major portion of the instrumentation were let. Certain parts were being fabricated at the Fredericksburg Magnetic Observatory.

Additional recordings of variations in the earth's magnetic field were made throughout the year at four temporary recording stations on Pacific islands under a program supported by the National Science Foundation (NSF) as part of the U. S. special effort during the International Years of the Quiet Sun (IQSY). These recording stations were located on Majuro, Koror, Midway, and Adak.

Under a continuing arrangement with the Office of Antarctic Programs, National Science Foundation, operation of the magnetic observatories at Byrd, South Pole, and Eights Stations in Antarctica was continued. Plans were formulated for the establishment of a magnetic observatory at the proposed Polar Plateau Station which is scheduled for activation in 1966. These plans provided for the closing of Eights Station prior to activation of the new station. Antarctic activities also included participation in the over-snow traverse from South Pole Station to the Pole of Inaccessibility (a point at approximately 79.5°S.Lat. and 40°E.Long.) on which measurements of the magnetic vector were made at intervals of a few miles.

Regional data on secular changes in the strength and direction of the earth's magnetic field were augmented by observations at 28 magnetic repeat stations in the conterminous United States, at 1 station on Okinawa, and at 3 stations in Alaska. Observations at the latter 3 stations were made near the end of the

year and represented the beginning of a concerted effort to be undertaken during the 1965 field season in the State of Alaska. Use of an improved version of the 3-component saturable core inductor (fluxgate) recording instrument, to record transient changes in the earth's magnetic field while absolute observations are in progress at repeat stations, was begun in Alaska. Improvements were made to this instrument by the design and incorporation of an automatic level-maintaining feature. This feature is highly desirable for work on unstable tundra. It will also be employed in a similar instrument which was being fabricated for use at the new Antarctic Polar Plateau Station.

Improved Z variometers (modified Ruska with la Cour magnet) were designed and installed at Guam and San Juan Observatories. The quality of the Guam Observatory data was further upgraded through the design, fabrication, and subsequent use of a special coil device employed in conjunction with the portable proton magnetometer (ELSEC) for direct measurement in absolute terms of the horizontal component of the earth's field. Through the routine use of observatory-type proton vector magnetometers (PVM's) at four magnetic observatories (Fredericksburg, Tucson, College, and San Juan) and portable-type proton magnetometers for total intensity measurements at all others, the Division continued to exercise its established leadership in maintaining the world standard of magnetic measurements.

The complete series of magnetic charts of the world was compiled for the first time by analytic methods, involving a combination of local presmoothing and overall spherical harmonic analysis. These charts were compiled by the Coast and Geodetic Survey in consultation with the Royal Greenwich Observatory of Great Britain and in collaboration with the U. S. Naval Oceanographic Office, which publishes them. In addition, a parallel series of magnetic charts of the United States, showing slightly greater detail than the world charts, was being compiled by other analytic methods.

A master file of 220,000 worldwide magnetic observations was used extensively for compilation of both the world and the U. S. magnetic charts. Copies of the tapes from the master file were furnished to interested groups, including the National Aeronautics and Space Administration (NASA), which used the data for a number of research and special investigative studies. Computer programs were being developed for screening and evaluating the old and new data in the files. A separate tape file of over 4,000 observatory-years of annual mean values was edited and refined. Copies of this tape were made available to NASA and to the Royal Greenwich Observatory.

A Bureau-developed semiautomatic scanning device for scaling and digitizing magnetograms, from Bureau-operated

observatories as well as from observatories throughout the world, was nearing completion. This device will be employed in a joint NASA-C&GS-NSF project involving the digitization of magnetograms from worldwide sources for correlation with magnetometer data from artificial satellites.

Seismology Division

The Seismological Research Group continued the study of the Prince William Sound Aftershock sequence resulting from the March 28, 1964 earthquake. Over 7,500 shocks were recorded by the temporary seismic net in Alaska during the first month of operation. This investigation included hypocenter locations using local station data, determination of depth of foci using the pP-P technique of Berlage, fault plane solutions of the larger events using both P and S wave data and the graphical analysis of the energy distribution sequence.

The analysis and interpretation of all the seismic data related to the event are currently being completed. The Group contributed 270 manuscript pages and 25 illustrations to Volume I of the Bureau report on the earthquake which is currently in press. Volume I comprises the operational activities of the Survey following the quake. About 70 percent of the Group's contribution to Volume II of the report is complete which is made of technical and research papers. Nine papers are being prepared covering the location of the March 28, 1964 earthquake and the location of approximately 2,000 aftershocks; a description of a digital computer program specially written for computing the location of these earthquakes; a study of the focal depths; epicenter and origin times of the Prince William Sound earthquake and aftershocks; the nature of faulting in the earthquake and aftershocks; strain release in Alaska earthquakes; strain release in the Prince William Sound earthquake and aftershocks; magnitude of the Prince William Sound earthquake and aftershocks; travel time, velocities and crustal structure in Prince William Sound and the Gulf of Alaska.

On April 29, 1965, at 15:28:43.6 G.M.T. the Puget Sound, Wash., region was shaken by the second largest earthquake known to have occurred in the area since 1833, which had a magnitude of 6½. Coast Survey geophysicists were sent to Seattle immediately following the earthquake to survey damage, service strong motion instruments, and install four temporary seismographs in the epicentral area to record aftershocks.

The temporary seismograph stations were operated for a period of 2 weeks, during which 28 aftershocks were recorded. Strong motion seismographs were in operation at Seattle, Olympia, Tacoma, and Ross Dam during the earthquake. Excellent seismograms were obtained from

all the strong motion instruments. Seismological data from the temporary stations and from the Worldwide Network of Standard Seismograph Stations were analyzed by the Seismological Research Group. A report was prepared by the Group which is available at the Government Printing Office.

On May 3, 1965, at 10:01:34 G.M.T. an earthquake of magnitude 6-6¼ occurred in El Salvador which killed 125 people and caused considerable property damage. At the request of the United Nations Educational, Scientific, and Cultural Organization (UNESCO), Paris, France, the Coast and Geodetic Survey was requested to send a seismic team to measure the aftershocks of the earthquake. One geophysicist was dispatched to the area with one strong motion and one teleseismic set of instruments. He teamed with Dr. Lomnitz of Berkeley, Professor Rosenbleuth of Mexico City, and Dr. Fiedler of Caracas. The Bureau operated two stations of strong motion instruments, instruments that give detailed data for lateral force considerations in building codes, and assisted in operating the existing stations that are operative in the country. Survey representatives returned to San Francisco on May 29 at which time a report was sent to UNESCO.

Of the proposed 120 Standard Seismograph Stations of the Worldwide Network, 111 have been installed and are equipped with standard, identical sets of ultrasentitive seismographs and related instruments. Stations at Hallett, Antarctica, and Camp Century, Greenland, were discontinued, the instruments of the former being sent to Rarotonga, Cook Islands, and those of the latter being returned to the Seismological Center at Albuquerque. Regarding the vaults for the 9 remaining systems, 3 are complete, 3 are under construction, and 3 have not been started.

Stations installed during the year included: Akureyri, Iceland; Davao, Philippine Islands; San Juan, P. R.; Sombrero, Chile; Lembang, Indonesia; Sa da Bandeira, Angola; Tabriz, Iran; Natal, Brazil; Junction, Tex.; Rarotonga, Cook Islands; Tokyo and Matsushiro, Japan; and Poona and Kodaikanal, India. In addition, maintenance teams visited 65 stations where they made complete tests and readjustments and instructed new personnel as necessary. Time lost in total station operation during the year was less than 4 percent.

The World Data Center for Seismology was gradually brought to peak operation during the year, so that by the end of the report period a full staff was operating the facility on two shifts. In addition to making permanent file copies of the 220,000 seismograms produced by the network, over 1,900,000 copies of seismograms were reproduced to fill requests from seismologists throughout the world.

A card file of all hypocentral data was begun for all seismic events instrumentally located. The hypocentral data contained in the Bulletin Mensuel of Bureau Central International de Seismologie for the years 1950-1961 and from the International Seismological Summary for the years 1950-1957 have been put on punched cards. When this catalog is complete it will be possible to list immediately all events having any combination of the following parameters: time, location, depth, magnitude, authority, or intensity, together with references to the source of data and of further studies. Also, a procedure was developed to automatically select and list a sample of current earthquake locations well distributed geographically for use in the Earth Sciences Curriculum project.

The expansion of computer facilities achieved by the Seismological Investigations Branch and the development of more efficient techniques allowed for the processing of 250,000 earthquake messages and the location of 5,000 earthquakes.

The hypocenter program for the IBM 7030 (Stretch) computer was modified to give more control to the geophysicist analyzing the output and to allow for efficient treatment of special cases. These modifications make it possible for the geophysicist to insist on the inclusion or exclusion of any number of specified observations, and to specify for the computer the relocation of epicenters in certain geographic areas having a minimum number of observations. The complete derived data of distance, azimuth, time, and magnitude residuals and the epicenter parameters of latitude, longitude, origin time, depth, and magnitude can be stored on a single card with the input observation. This option will allow the association of these data from all study earthquakes for any set of parameters. For example, time residuals may be ordered as a function of any or all of distance, depth, magnitude, and region for traveltime studies or all observations of a single station grouped as a function of time residual, magnitude residual, magnitude, and distance, etc.

An important subroutine was added to the main program which selects a geographic name from a file of 729 seismic region names for the world as each epicenter is computed. This subroutine allowed the complete automation of the Preliminary Determination of Epicenters cards, the publication of the results of the hypocenter program for worldwide distribution. Also, as a result of this routine, the Antarctic Letter and the list of epicenters in the Seismological Bulletin were completely automated.

The input-output programs were modified so the hypocenter rejected on one pass would be used as the first approximation on the next pass through the computer. Programs were written to convert magnetic tapes of data in the Vela format to our internal format, and to produce

cards and magnetic tapes from our format to that of the International Seismological Centre.

A record 5,600 earthquakes were located routinely during the fiscal year. This included a major series of events beginning on February 4, 1965, in the Rat Islands, Aleutian Islands. About 1,300 aftershocks were located in a nearly rectangular area 650 km. long and 200 km. wide following a main shock of magnitude 7 3/4. This distribution suggests block faulting for Island Arc structures. Temporary stations were installed on Amchitka and Shemya to aid in locating these events.

A special study was carried out for the Department of Defense. Task I: U. S. seismicity in 1963; all earthquakes located by the Coast Survey were listed and the seismicity maps prepared. A detailed compilation of the local activity in the Western United States was completed and an epicenter program was written which will locate local earthquakes using readings from as few as three stations. Task III: Network Capability; preliminary noise studies were made in an effort to assign ambient background factors for standard stations.

The origin time of the disturbance was 14:51:08 e.s.t. Preliminary estimates indicate a seismic magnitude of 4 3/4, roughly one order of magnitude larger than the expected magnitude of an equivalent underground event.

The Atomic Energy Commission's Plowshare Program for the peaceful application of nuclear energy included a large scale excavation as a major project. Project Dugout was a simultaneous chemical explosive detonation of a row of five 20-ton charges exploded in basalt. Interpretation of the seismic data by the Special Projects Branch revealed that at distances greater than 250 meters the seismic energy was propagated in a symmetrical manner. This indicates that the seismic source was essentially a point source at ranges several times greater than the maximum dimensions of the disturbed zone.

The 340-ton Dannyboy nuclear cratering experiment in basalt provided additional data on the mechanics of earth excavation with explosives. Cratering experiments were conducted with TNT equivalent explosions ranging in size from a few pounds to over 2 million pounds. The seismic monitoring projects indicate that the percentage of total available energy which is converted to seismic energy decreases with an increase in the size of the detonation. For the Dugout and Dannyboy experiments, approximately 0.3 percent of the total source energy was expended as seismic energy.

Project Shoal was a 12,500-ton nuclear detonation in granite conducted to compare the seismic signals between detonations and earthquakes of comparable sizes. It was found that earth particle displacements were larger by a

factor of 2 at recording stations on alluvial deposits as compared to granite while the accelerations were about the same for both media. Earth particle velocities attenuated much faster with distance for stations on granite than those on allubium. Asymmetrical wave propagation was noted where the path was through fault blocks with more efficient propagation parallel to fault zones or through competent rock.

The 5,000-ton Salmon nuclear detonation in a Mississippi salt dome yielded valuable information in a stable tectonic region. It was found that high explosive detonations in the unconsolidated surface sediments converted a larger percentage of available source energy to seismic than the nuclear detonation in the salt dome. For distances out to 12 km., the increase in the period of maximum earth particle accelerations was not as pronounced as the displacements. Asymmetrical seismic propagation was observed with larger relative amplitudes recorded to the north and south of the detonation point.

The requirements of the space program demands that rockets place into orbit payloads of increasing sizes. The increased payload means a more powerful rocket which in turn requires greater amounts of propellants. The present policy of considering a 100 percent TNT equivalence makes large-scale launches impossible based upon safety requirements because of the proximity of populated areas near the launch sites. The Special Projects Branch participated in an experiment with National Aeronautics and Space Administration and the Department of Defense to determine the energy release when 82,000 pounds of solid rocket propellant is intentionally destructed.

As a consequence of the Vela Uniform program, it has been possible to contour P_n and P-wave maximum amplitude patterns over the United States from a number of well recorded seismic events in the unified magnitude range of four and five occurring both within and without North America. The seismological affects reported by Pasechnik for Eurasia appear to be present within the United States, for there are marked and persistent deviations from the conventional curves showing attenuation of signal amplitude with distance. In general, the United States west of a line from Glacier National Park to El Paso produces lower seismic amplitudes for teleseismic events of a given magnitude than would be expected. Two other areas of comparatively low signal strength are tentatively located in the Wichita--Oauchita Mountain belt and the eastern portion of the Appalachian Mountains. Higher than usual signal amplitudes were found in the Dakotas, southeast Texas, and the northern Lake Michigan region.

Large explosions in four localities in the United States have provided energy sources for seismic waves that were recorded on a continentwide basis. The Gnome and Salmon shots provide a sort of closed profile with

the Nevada Test Site shots, and with each other. A wide scatter of first arrivals on a time distance plot indicating P-wave speeds of 7.7 to 8.4 km./sec. in the upper mantle is well known. Less well known is an apparency of an 8.8 km./sec. speed which appears as first arrivals about 14° from the source. This may represent ray paths through an 8.5 km./sec. medium at depths of about 150 km. under the plains and 200 km. under the cordillera. This medium may possibly begin at the base of a supposed low speed layer.

In the distance range from 11° to 24°, energetic P-waves are associated with apparent surface wave speeds of 10.25 km./sec., which appear as first arrivals about 19° and point to a discontinuity at a depth of about 400 km., beneath which the P-wave speed is about 9.6 km./sec.

This is believed to be the true teleseismic P, called P_t here to distinguish it from P_n. The P_n appears first until about 19° when it merges with P_t then disappears because of its relative weakness. At 15° to 19°, the P_t to P_n amplitude ratio may be as high as 7 to 1, and recognition of P_n is often a matter of signal to noise ratio. This points out the fallacy of rigid dependence on first arrivals in attempts to locate epicenters from regional data.

The cooperative agreement between the Coast and Geodetic Survey and the Department of Water Resources of the State of California continues. Field work called for by this agreement is 96 percent complete. With additions made during the period, the strong motion network installations totalled 114 seismographs and 207 seismoscopes. During the latter part of September, the operation of the two seismic trailers at Buena Vista and Mt. Abel was concluded, and preparations were made for a move to a new location near Livermore, Calif.

Building response observations included field vibration testing of the Mt. McKinley Building in Anchorage, Alaska, and repeat building measurements in Seattle, Wash. During the period, 31 earthquake questionnaire card canvasses were made; 133 earthquakes were reported felt, and 24 strong motion records were obtained. Three records from the April 29, 1965, Puget Sound earthquake were of major engineering importance.

The Bureau of Reclamation Seismograph Stations at Glen Canyon Dam, Page, Ariz., and Flaming Gorge Dam, Dutch John, Utah, were modernized with new seismograph instrumentation having calibration capability and an additional low gain vertical component for recording very strong local earthquakes. A four component seismic telemetry system was purchased for the Bureau of Reclamation and will be installed at the San Luis Dam and Reservoir at Los Banos, Calif.

A visible recording seismograph was installed in the foyer of the Geology Building, University of New Mexico, for public interest. The seismic signal is transmitted by hardwire telemetry from the underground vaults of the Albuquerque Seismological Center in the Monzano Mountains. The display created considerable public interest. Another visible recording seismograph was constructed for installation at the Forest Service Earthquake Visitors Center on the Madison Slide created by the Hebgen, Mont., earthquake. Also, the Museum of Science and Industry, Portland, Oreg., was furnished a visible recording seismograph for public display.

Improvements, modifications, and tests of the MK-II strong motion seismograph were completed. Primary changes include: (1) reduction of start time from 250 msec. to 70 msec.,; (2) development of a transistorized time-mark generator; and (3) miscellaneous improvements to the electronic and optical systems. All changes were incorporated into the five units.

An entire seismograph network, consisting of three outpost stations and a central recording complex, was developed and assembled at the Center prior to installation on Oahu by Center personnel. The network provides a means of rapid azimuthal determination of seismic events to aid in the location of tsunami generating earthquakes. Data are transmitted from the outpost stations using frequency modulation telemetry.

The Special Projects Party operated several seismic channels in support of various activities of the Atomic Energy Commission, Nevada Operations Office safety program and was 90.4 percent successful. Two-night periods were spent gathering microtremor data using four 3-component stations of NBS-21 seismometers. Thirty-six earthquakes were recorded on the instrumentation. The Los Alamos Scientific Laboratory reflection-refraction program to delineate subsurface geological structures continues under the modified plan. The Department of Defense has also requested some reflection studies in the area which are of interest in the program.

Seismic Sea Wave Warning System

During the year, the Seismic Sea Wave Warning System continued its expansion adding British Columbia, Canada, to the areas receiving warnings.

The "Annotated Bibliography on Tsunamis" was completed and forwarded to the International Union of Geodesy and Geophysics for reproduction and distribution. Work on the first supplement to the bibliography, covering articles published in 1963 and 1964 and articles missed or not abstracted in the original publication, was begun. Nine

Changes to the "Communication Plan for Seismic Sea Wave Warning System" were issued to keep the plan up-to-date.

Much work was done on public educational material during the year. A color film "Tsunami" was prepared, also a 46-page color brochure entitled "Tsunami! The Story of the Seismic Sea Wave Warning System." Two small pamphlets entitled, "Notes on the Seismic Sea Wave Warning System," and "Tsunami Notes," were prepared for public use. Extensive distribution began on all the above mentioned educational material with the exception of the film.

A conference on the International Aspects of the Tsunami Warning System in the Pacific was held at Honolulu under the sponsorship of the Coast and Geodetic Survey on behalf of the Intergovernmental Oceanographic Commission. In addition to those from the U. S., representatives from Canada, Chile, China, French Polynesia, Japan, Mexico, New Zealand, Peru, Republic of the Philippines, the U.S.S.R., and Western Samoa were in attendance. Means of furthering cooperation between national warning systems and the Seismic Sea Wave Warning System were explored.

NATIONAL AND INTERNATIONAL COOPERATION

International Agencies

The Coast and Geodetic Survey, in collaboration with the National Academy of Sciences and the National Science Foundation, continued to operate one of the subcenters of World Data Center A for the collection, exchange, and dissemination on a worldwide basis of data in geomagnetism, seismology, gravity, and tsunami. This activity, begun as a part of the International Geophysical Year and funded to a great extent by the National Science Foundation until this year, has continued to play a very active part in the archiving of geophysical data, particularly geomagnetic data.

Magnetic activity reports from all the Bureau's magnetic observatories were prepared and furnished to the the international permanent center in the Netherlands. This work was part of the Bureau's cooperation with the Association of Geomagnetism and Aeronomy, International Union of Geodesy and Geophysics.

Compilation of the world magnetic charts and the final adoption of the positions of the north and the south magnetic poles were done through close collaboration with British and Canadian representatives. Likewise, compilation of the U.S. magnetic chart, particularly the work near the United States-Canadian boundaries, was done in close collaboration with representatives from Canada.

Observations for intercomparison and standardization of magnetic instruments were a continuing activity, especially at the Fredericksburg Observatory. The determination of instrument constants and index corrections for a magnetometer-inductor set, property of the Government of Colombia, was undertaken.

Information about seismograph and earthquake motions was supplied to seismologists in the following countries: Argentina, Australia, Bolivia, Burma, Chile, England, Iceland, India, Iran, Israel, Italy, Mexico, New Guinea, Norway, U.S.S.R., and Yugoslavia.

National Agencies

The Aeronautical Obstruction Charting Program was continued for the Federal Aviation Agency (FAA). This program provides for the preparation of special airport obstruction charts, the location of air facilities, and the construction of mosaics for noise abatement studies at airports. Airport obstruction charts are special purpose charts used by the FAA and the airlines to administer and comply with safety regulations pertaining to permissible gross take-off and landing loads. They provide complete data on airport dimensions and approaches, runway lengths and gradients, location and height of obstructions, and other pertinent information. The air facilities phase of the program provides for the location or position of newly established aeronautical aids and for the relocation of those that are moved.

Aerial photography for this program was taken by Air Photo Mission 376. Eleven to fourteen 2- and 3-man survey parties were assigned to field surveys in all states, including Puerto Rico and the Virgin Islands of St. John and St. Thomas. At the end of the year, a total of 511 Airport Obstruction Charts and 251 Turbine Data Sheets were on issue. Accomplishments for the year were as follows:

Summary of Accomplishments
Aeronautical Obstruction Charting Program

	Number	Number of Charts and Data Sheets Published	
		New	Revised
Airport & Air Facilities Photographed	131		
Airports Surveyed	128		
Noise Abatement Mosaics Constructed	22		
Air Facilities Located	44		
Airport Obstruction Charts		37	100
Turbine Data Sheets		20	35

A special harbor-line survey along the Williamette and Columbia Rivers in the port city of Portland, Oreg., was completed for the Corps of Engineers. This survey furnishes second-order coordinate positions for about 60 harbor-line reference stations, aerial photography, and special planimetric maps depicting the mean high-water line, alongshore structures such as piers and wharves, and the pierhead lines.

The combined geodetic-photogrammetric survey of the Colorado River was completed for the States of Arizona and California. Each state was furnished with copies of 25 planimetric maps, scale 1:18,000, depicting the Colorado River from the common corner of the States of Arizona, California, and Nevada to the Mexican border. The maps show the river shoreline, main drainage, the road network within about one mile of the river, all boundary and ground control within the compilation limits, and the state boundary line interconnected between the established boundary points.

Data reduction of the satellite observations on triangles Maryland-Florida-Bermuda and Florida-Bermuda-Antigua for the preliminary positioning of the Bermuda and Antigua stations was completed for the Patrick Air Force Base.

The data reduction for six star plates was performed for the National Aeronautics and Space Administration at their request for the Bureau's support in calibrating a Radar System at Wallops Island, Va.

The Photogrammetry Division provided and will be providing data reduction support on the accelerated Geometric Satellite Program now being conducted jointly by the Army Map Service and the Coast and Geodetic Survey.

Tide-controlled infrared photography was used to prepare shoreline maps of the Cape Kennedy area for the Air Force Eastern Test Range and the National Aeronautics and Space Administration. The mapping will be repeated at intervals as part of a long-range study of coastal changes in this area that may require action for protective measures.

Color and panchromatic aerial photography for the Army Engineer District in Walla Walla, Wash., was obtained in Juneau, Alaska, and of various dams and reservoirs in the States of Washington and Oregon.

The Electronic Computing Division has given advice, assistance and programming instruction to universities, state, and other Federal agencies concerning its operational computer programs. In addition, a number of such requests from private industry have been handled in the past year. Generally, this service has concerned the geodetic surveying aspects of the work performed by the Division.

The Naval Ordnance Laboratory, Washington, D. C., was furnished information on the Seattle earthquake of April 29, 1965. The Naval Oceanographic Office was furnished information on the seaquake of December 26, 1964, at 08:16 G.m.t., off the coast of Mexico.

The Office of Civil Engineers, Department of the Air Force, Washington, D. C., was furnished information on the seismic probability on world basis. Air Force Technical Applications Center was furnished information on the processing of Array Observatory data for the International Seismological Research Center.

The Geological Survey, Department of the Interior, was furnished information on data relative to U.S.S.R. seismicity; information on the possible seismic cause for displacement in Utah; and information concerning possible measurements of accelerations of earthquakes in the vicinity of Idaho Falls, Idaho. The Bureau of Reclamation was furnished information on possible earthquake activity near Wenatchee, Wash., during July 1965.

The National Aeronautics and Space Administration at Huntsville, Ala., was furnished information on recent disturbances recorded on tiltmeters.

The Atomic Energy Commission was furnished epicenter and magnitude information on the December 22, 1964, San Diego earthquake.

Continued extensive use was made of the laboratory facilities at the Fredericksburg Magnet Observatory by other agencies, particularly by the National Aeronautics and Space Administration (NASA). Use of the large coil facility for the development and testing of instrumentation, components, and accessories for use in artificial satellites and space probes contributed substantially to progress in the Nation's space effort.

Magnetic surveys to test the suitability of compass swing areas for compass calibration were made at 19 air fields in the United States and at one on Okinawa. Most of these surveys were made at U. S. Air Force bases. Included, however, were the Navy and two commercial firms.

Pointing up the intimate relations between geomagnetism and the space program, the Bureau, in cooperation with NASA and the National Science Foundation (NSF), conducted an extensive program of digitizing data from its own and from other observatories (about 50) throughout the world for use by NASA to correlate with data recorded by magnetometers aboard satellites and other space vehicles. Pending development by the Bureau of its own scaling and digitizing device, the magnetograms were being scaled and digitized by commercial firms under contract.

Through a continuing agreement, the world magnetic charts were compiled by the Bureau in collaboration with the U. S. Naval Oceanographic Office, which published them. Similarly, a magnetic chart of Central America was compiled in collaboration with the Inter-American Geodetic Survey.

At the College Observatory, research on various geomagnetic phenomena continued in collaboration with the Geophysical Institute of Alaska. Also at the College Observatory, collaboration with the National Bureau of Standards in the recording of rapid magnetic fluctuations for special studies was carried on throughout the year. At the Tucson Observatory, collaboration with the University of Arizona in lightning studies by providing space and facilities and by otherwise aiding in the recording of special events was effected during the summer months.

Through a continuing agreement with the Carnegie Institution of Washington, space and assistance were provided at Fredericksburg Observatory for the continuous operation of cosmic ray sensors and recorders.

Daily reports of magnetic conditions were sent from several Bureau observatories to various field stations of the Central Radio Propagation Laboratory of the National Bureau of Standards for use in forecasting ionospheric conditions. Similarly, daily reports of magnetic conditions and special reports of abnormal magnetic conditions were furnished to numerous institutions, commercial firms, individuals, and groups.

Special studies were undertaken for the U. S. Air Force in an effort to delineate known magnetic anomalies of specified magnitudes in declination.

OFFICE OF CARTOGRAPHY

OPERATIONAL ACTIVITIES

Nautical Chart Division

Under the direction of the Chief, Nautical Chart Division, a long-range Nautical Charting Plan was compiled and presented for approval during the year for the orderly construction of new charts and the up-dating of existing coverage to implement the Hydrography Program. This plan is designed to meet increasing commercial and recreational needs of the Nation's expanding economy, its industrial development, requirements for increased foreign trade, changes in social and natural conditions, and advances in marine technology.

The Hydrography Program provides justification for making decisions in the allocation of Bureau resources and furnishes a basis for the assignment of tasks in support of the Nautical Charting Plan. This program will continue to be up-dated to provide justification for specified action.

The Nautical Charting Plan will coordinate Bureau activities and establish efficient management practices for the execution of the Hydrography Program. It is patterned to meet the diverse needs of National Defense, economic growth, and public welfare of the Nation by a series of planned activities in surveys and resultant chart production.

For special study and planning, the Country was divided into separate regions. Each region was treated separately according to new charting requirements, chart maintenance, justification, number of new charts, reconstructions and maintenance printings required to 1975, and other pertinent data.

Also included is a priority list of planned new nautical charts for each year extending from 1965 to 1975 with chart diagrams showing proposed chart limits, numbers, scale, and scheduled date of printing.

The output products of the Hydrography Program perform vital public service essential to the safety and advancement of marine commerce, science, engineering, industry, and the economic development of the Nation's natural resources.

At the end of the year, 172 current editions of charts on public issue were dated before July 1, 1955. Forty-seven of these are now scheduled for issue in 1966, with 24 already in work. This compares with editions of 245 charts which were more than 10 years old at the beginning of the year.

One year ago the latest printings of 71 charts were at least 10 years old. At present the latest printings of 67 of the 172 charts are at least 10 years old. Nine of these are in the 1966 program. Of the remaining 58, the Distribution Division has been notified to place 12 in the 1966 program and we will continue to place the others in program as our capability permits.

To produce and maintain an adequate supply of the 812 nautical charts issued by the Bureau, 470 drawings were forwarded to the Reproduction Division as follows: 20 new charts, 2 reconstructions, 314 new editions, 86 new prints, 13 reprints, and 36 overprints. Six charts were cancelled by improved coverage. A total of 1,107 articles relative to navigational dangers originating with surveys and reports of the Bureau, the Corps of Engineers, and others were compiled for inclusion in the Weekly Notice to Mariners. Four thousand seven hundred-fifty items (surveys, letters, etc.) were received and all critical information shown thereon was immediately furnished the mariner. Nine special-purpose charts constructed and maintained in this Bureau for the Department of the Navy are designated "FOR OFFICIAL USE ONLY". Thirty-two charts constructed and maintained in this Bureau are classified "CONFIDENTIAL (MODIFIED HANDLING AUTHORIZED)". They are not issued to the general public, but are stocked and distributed by the Naval Oceanographic Office.

The conversion of Introcoastal Waterway Charts to the Small-craft Route Chart format is continuing. Compilation of three of the Gulf Intracoastal Waterway charts is progressing according to schedule. The waterway is now completely covered by the route charts from the New Jersey coast to Miami and across Florida to Tampa Bay. Fourteen new Small-craft Charts (three of which were due to format changes) were issued during the year bringing the total to forty-two on issue.

The Nautical Chart Catalog is being converted from the present stapled binding to the signature fold format. This new format will display the entire nautical chart coverage in three separate single page volumes printed front and back instead of the present 44 sheet catalog. Increased legibility and usability will result from the continuity of coverage and scale, and from the judicious application of color. Fourteen new prints and thirty-six reprints of pages from the Nautical Chart Catalog were revised where necessary, and reprinted.

During the year, twenty-five charts were forwarded to Reproduction for overprinting. This method of applying excessive hand corrections eliminated the need of either destroying 136,435 copies of the charts or the addition of 856,264 hand corrections to them by the Distribution Division.

Fifty-eight correction chartlets were compiled and forwarded to the Naval Oceanographic Office for printing and insertion in the Notice to Mariners. This number includes one correction chartlet, second provisional edition of Chart 8525. This completes the crash Earthquake Damage Program. Alaskan charts are now being maintained under normal maintenance procedures.

In accordance with an agreement formulated at the 8th International Hydrographic Conference, Monaco, May 1962, most maritime nations are participating to produce bathymetric plotting sheets of the world's oceans. These plotting sheets are forwarded to the International Hydrographic Bureau headquarters in Monaco for compilation of General Bathymetric Charts of the Oceans (GEBCO). The United States commitment, being fulfilled by the Coast and Geodetic Survey and Naval Oceanographic Office includes the North Pacific, Arctic, and west half of the Atlantic Oceans. As of June 30, eight new hydrographic survey indexes have been compiled by the Nautical Chart Division, covering the Gulf of Alaska. Consisting of thirty-two pages, they include all hydrographic surveys from 1867 to 1964. These indexes were prepared for use with the studies and reports of the Prince William Sound, Alaska Earthquake of 1964.

Six plotting sheets containing bathymetric data for GEBCO were completed. Eleven projection negatives were sent to Canada covering Lat. 29° to Lat. 74° for GEBCO program. Through liaison, Canada completed three plotting sheets in the Hudson Bay which were in the Coast Survey area of commitment to the IHB program.

Various chart drawings were prepared for the Scientific and Technical Publications on Alaska Report.

Four Ocean Survey Sheet(OSS) plotting sheets containing nautical chart information were prepared for Duke University.

Receipt, Verification, and Review of Original Surveys

Hydro. Survey	On Hand July 1, 1964	Completed During the Year	Balance June 30, 1965
Unassigned	298		282
Verification and review unfinished	345		349
Registered		46	
Verified		56 (a) (b)	
Available for review	21		42
Reviewed		40	
With preliminary verification and review	53	13	40

(a) Includes 15 surveys verified by reviews.
(b) Includes 9 surveys verified in Seattle Regional Office.

The number of surveys verified in the Hydrographic Verification Section was 32. An additional 15 were verified by reviewers and 9 were verified in the Seattle Regional Office. A total of 6 surveys were machine plotted during the year; 3 of these have been reviewed; 2 are in need of completion of junctions before verification is considered complete. The total backlog of surveys on hand which have not been verified and reviewed is 349, of which 282 have not been assigned. This is an increase of 7 in uncompleted surveys over that at the end of last year.

The number of surveys registered during the year was 46 compared to 54 registered during the previous year. The number of surveys in the Processing Offices or aboard ships which are in various states of processing, smooth plotting or verification is about 90 and does not include about 60 ocean surveys on which the field work is still incomplete. Review addendums were completed for 13 surveys which had previously been given only a preliminary verification and review. After additional verification and inking, 40 surveys will still require review addendums.

Surveys verified or reviewed during the past year were made during the period 1954-1964. A number of problems were encountered during the verification and review of these surveys. Several surveys were made with fathometers having phasing heads. Adjustments based on the best available information were applied during verification in order to resolve discrepancies arising from this condition. On 8 surveys numerous intermediate soundings on deeps and peaks were added to more accurately delineate the bottom. On several surveys an average of bar check corrections had been used. Discrepancies on these surveys were resolved by applying specific bar check corrections determined for the days involved. Weak fixes resulting from small angles and the use of distant signals were encountered on some surveys off the coast of Maine. On portions of two surveys an initial correction had been incorrectly applied or had been omitted. On one survey the position numbers on a section of line had been incorrectly altered in the volumes which resulted in large discrepancies with the general delineation of the bottom.

Other problems include adjustments to shoran corrections in order to move sounding lines off the land area, corrections for erratic speed of the fathometer, and difficulty in interpreting strays and grass or kelp on the fathograms. On several surveys made during a period of more than one season where changes in the bottom had occurred during the survey period, a judicious study and selection of soundings was required in order to show adequate representation of depths.

Surveys inked and partially verified in the Seattle and Norfolk Regional Offices have generally required additional work by the Washington Office verifiers in checking the shoreline, applying junctions and revising depth

curves. Two surveys requiring extensive revisions were returned to the Seattle Office.

The machine plot of automated surveys has generally been found to be accurate and with few errors. Deficiencies in the first few surveys originated largely in the cartographic completion of the survey such as in the failure to add the junctions, the improper symbolization of features located by triangulation, the failure to provide recorded information for certain plotted features, and the inadequate drawing of depth curves. It is considered that more complete experience in verification will eliminate these deficiencies.

Requests were filled for about 2,800 copies of our original hydrographic and topographic surveys and prior editions of charts. Payment of about $8,370 was received for 1,141 copies for which charges were made. Included among these were 238 copies furnished through 30 reimbursable agreements with Federal agencies for a total of about $2,230. The requests originate principally with engineers and geologists, the Corps of Engineers, universities and oceanographic institutions, oil companies, the Naval Oceanographic Office, the public, lawyers and District Attorneys, and the Geological Survey. About 123 certifications of charts and surveys to be used in litigation were furnished to the Justice Department, law firms, attorneys and private individuals.

The verification and review of 7 field examinations were completed. Four of these were assigned to new trainees. Presurvey reviews of 5 new areas and the up-dating of presurvey reviews in 8 additional areas were completed for inclusion in Project Instructions for hydrographic surveys.

Evaluation of several reports of shoal soundings were submitted to the Nautical Data Branch and the Naval Oceanographic Office for use in Notices to Mariners.

Requirements are being formulated for the second generation plotter to be purchased for the Norfolk Regional Office. These cover survey plotting, chart compilation requirements, and requirements of the Aeronautical Chart Division and the Division of Photogrammetry. ADP equipment related to the collection, digitizing and display of nautical chart data was inspected at various demonstrations. A study was made of the problems related to the digital conversion and machine plotting of hydrographic data originally recorded and plotted by manual methods. Survey H-8667 was adequately replotted by machine methods and the accuracy of the machine proved.

Liaison was maintained with the Director's Feasibility Task Force. Assistance was furnished the Nautical Chart Division's R and D group and the Assistant Director's Office on survey processing and cartographic requirements.

The processes of compiling charts using automatic data processing have undergone continuing development and improvement with the advent of greater increases in the design, and quality of digital and analog graphic plotters. Considerable progress was made during the year in the development of new and improved equipment for use in data collection related to hydrographic surveying. As a result, the field work accomplished during this year has already been fully applied to the nautical chart compilations. The use of similar equipment is under study to aid the cartographer to likewise enter graphic data into the automated systems. Translation of this collected data to the compilation processes have also undergone extensive analysis and development. As a result, this year saw successful machine construction of graphic negatives for electronic navigational lattice to be applied to the nautical chart; the successful plotting of a chart base projection, including the plane coordinate intersections, and the fixed position data. As such the design of a system has become feasible and preliminary concepts are being formulated for testing.

The Division's eight-phase training program details all trainees to productive work throughout the two-year training period, and includes a field detail in hydrographic surveying for male trainees. Of the sixteen employees participating in fiscal year 1965, three completed training, one is on military leave, one resigned for health reasons, one with hydrographic verification training transferred to another agency, and the remaining ten are in various stages of training. Seven Engineer Student-Trainees were assigned for periods of training lasting from one to six months. Training in Automatic Data Processing was accelerated, eighteen employees taking a two-day course, five taking a one week course, two taking a one week Management Standards Seminar, and five taking advanced courses in the evenings at the Department of Agriculture Graduate School. Three employees led a one-day Bureau-wide seminar on Automation of Nautical Data. A training program has been adopted that will provide an ADP-Cartographer nucleus to begin the changeover from manual to automated cartography. Three to five years of after hours training at local universities or the Department of Agriculture Graduate School is required to train Operators, Programmers, and System Analysists. Eleven employees took after hours training courses in Cartography and related subjects totaling 31 credit hours. One employee had a one week course in Administrative Operations, and two employees took the Patent Office course in Effective English Usage.

SUMMARY OF ALL CHART CONSTRUCTION ITEMS RECEIVED

Items Received	1965	1964	1963	1962
Shoreline Surveys	78	90	64	78
Planimetric Maps	36	40	75	37
Topographic Surveys (photogram.)	3	0	9	7
Quadrangles	110	16	49	58
Hydrographic Surveys	86	54	82	72
Surveys, other organizations	2,255	1,800	1,547	1,292
Letters with charting data .	1,761	1,595	1,468	1,271
Foreign charts for inspection	421	761	826	2,115
TOTALS:	4,750	4,356	4,120	4,930

SUMMARY OF ALL CHART CONSTRUCTION WORK COMPLETED

Work Completed	1965	1964	1963	1962
New Charts	24	21	18	4
Reconstructions	2	1	5	3
New Editions (Other than above)	316	212	176	82
New Prints	101	151	232	316
Reprints	15	37	23	31
Overprints	25	20	18	24
Corrections indicated from Notice to Mariners	23,782	20,888	15,440	16,029
Articles written for Notice to Mariners	1,107	1,148	1,120	1,159
Charts on which all aids were checked	19	41	63	37
Proofs of charts verified	472	391	425	537
TOTALS:	25,863	22,910	17,520	18,224

NEW SMALL-CRAFT NAUTICAL CHARTS PUBLISHED IN FISCAL YEAR 1965

NO.	TITLE	SCALE 1:
114-SC	South Coast of Cape Cod and Buzzards Bay, Massachusetts	20 & 40,000
152-SC	Galveston Bay to Freeport, Texas	40 & 80,000
185-SC	Admiralty Inlet to Olympia--Including Hood Canal, Washington	10, 20, 25 40 & 80,000
310-SC	Penobscot Bay, Maine	20 & 40,000
311-SC	Penobscot River, Maine	40,000
549-SC	Approaches to Baltimore Harbor, Maryland	40,000
572-SC	Head of Chesapeake Bay, Maryland	40,000
605-SC	Rappahannock River--Carrotoman River to Fredericksburg, Virginia	20 & 40,000
636-SC	St. John's River--Atlantic Ocean to Jacksonville, Florida	20,000
837-SC	Casino Creek to Beaufort River, South Carolina	40,000
839-SC	Beaufort River to St. Simons Sound, South Carolina and Georgia	40,000
5072-SC	Gulf of the Farallones, California	20 & 100,000
5142-SC	San Pedro Channel, California	18 & 80,000
5147-SC	Los Angeles and Long Beach Harbors, California	12,000

NEW CONVENTIONAL NAUTICAL CHARTS PUBLISHED IN FISCAL YEAR 1965

NO.	TITLE	SCALE 1:
518	Galveston Bay Entrance--Galveston and Texas City Harbors, Texas	25,000
563	Chesapeake Bay--Cape Charles to Wolf Trap, Virginia	40,000
564	Chesapeake Bay--Wolf Trap to Pungoteaque Creek, Virginia	40,000
4125	Approaches to Lahaina, Maui, Hawaii	15,000
5060	Approaches to San Diego Bay, California	100,000
5072	Gulf of the Farallones, California	20 & 100,000
6441	Everett Harbor, Washington	10,000
6442	Seattle Harbor, Elliott Bay and Duwamish Waterway, Washington	10,000
8668	(Preliminary Chart) Wide Bay to Cape Kumlik, Alaska peninsula	106,667

NAUTICAL CHARTS CANCELED DURING FISCAL YEAR 1965

NO.	TITLE	CANCELED BY CHART
535/536	Towles Point to Fredericksburg, Virginia	605-SC
577	Nassau Sound to Jacksonville, Florida	636-SC
837/838	McClellanville to Port Royal Sound, South Carolina	837-SC
839/840	Port Royal Sound to Brunswick River, South Carolina and Georgia	839-SC
5598	Farallon Islands, California	5072
6449	Seattle Harbor and Lake Washington, Washington	690-SC and 6442

Aeronautical Chart Division

To meet the demands of civil and joint civil and military aviation, the Aeronautical Chart Division produced a total of 2,186 charts in several series, during fiscal year 1965. This represents a net increase of 124 charts over the previous year. The following new charts were produced: A VFR/IFR Planning Chart, reported in test and evaluation last year, now available for general distribution; 216 Instrument Approach Procedure Charts. Three prototype products were also produced; a Standard Instrument Departure Booklet, a Visual Navigation Chart Scale 1:500,000; and an Enroute Chart in Alaska, to combine high and low airway structures.

Upon receipt in the third quarter of the fiscal year of a manuscript copy for the new isogonic chart of the United States for epoch 1965, action was started to transfer the new isogonic lines to all charts for the next printing; determine the magnetic variations at every radio navigation facility, and list all changes in variation for transmittal to the Federal Aviation Agency (FAA); revise all charted magnetic bearings to or from each facility whose variation is changed, including bearings of radials, reporting point references, instrument approach procedures

and transitions, and final approaches from facility to airport; and list all changes in these, except airway bearings, for transmittal to the Federal Aviation Agency; and replot the isogriv lines throughout the Jet Navigation Chart and Aircraft Position Chart series.

Charts Maintained During 1965 include: 185 Visual Navigation Charts with 322 issues, 96 Radio Navigation Charts with 1,226 issues, 1,881 Instrument Approach Procedure Charts with 4,345 issues, 6 Aircraft Position Charts with 12 issues, and 18 Auxiliary Charts with 5 issues. Four existing local charts, Chicago, Los Angeles, San Francisco and Washington, were converted to the new format, reported last year, which can be folded to 5 by 10 inches.

Aeronautical Planning Chart AP-9, scale 1:5,000,000, discontinued in February 1965, was replaced by the VFR/IFR Planning Chart, scale 1:2,333,232. The airspace structure over the conterminous United States was altered by Airspace Docket No. 63-WA-74, from a trilevel to a bilevel system effective September 17, 1964. The low altitude system ceiling was raised up to but not including 18,000 ft. MSL, and the floor of the high altitude system was lowered to 18,000 ft. MSL. The Low Altitude area charts, and High Altitude charts were altered to include these data. The eight Intermediate Altitude charts were discontinued as of the effective date of the new system.

The new high altitude airway route structure over Alaska was effective March 4, 1965. The design of a combined portrayal, in a separate color, was approved by the Federal Aviation Agency. Until further notice from FAA a double set of charts, one showing the combined high and low altitude route structures, the second showing only the low altitude structure, will be issued with a questionnaire to assess user requirements.

The Division is cooperating with the Federal Aviation Agency in the development and production of a prototype Standard Instrument Departure Procedure (SID) booklet for evaluation by the FAA and user organizations. The primary feature of the booklet, consisting of approximately 150 pages 5 by 10 inches in size, will be individual graphic portrayals of about 128 civil Standard Instrument Departures (SID's) at airports. The booklet is designed to provide uniform, convenient portrayal of all SID's and to satisfy both civil and military requirements for civil SID information. If adopted, it would allow the elimination of the present Area Departure and SID charts. Reproduction copy was furnished to the Federal Aviation Agency for 128 Oil Burner charts for publication in the Airman's Information Manual (AIM) and 156 pages of FAA Ceiling and Visibility Minimums for 116 airports of the 20 new Low Altitude Controller charts produced for FAA, 17 were at the scale 1:250,000, the remaining 3 at the scale 1:1,000,000.For use by FAA air traffic controllers,

construction was completed on a new series of 8 High Altitude Controller charts covering the conterminous United States at the scale 1:500,000 to supplement the existing series of Low Altitude Controller charts at the same scale; the new charts will have the same 28-day revision schedule as the other controller and enroute charts.

A prototype of a visual navigation chart of the U. S. at 1:500,000 scale has been prepared for FAA, embodying new concepts in this type of aeronautical chart. Two adjoining, sectional type, charts were printed back-to-back with a common bleeding edge on their line of junction with legends and other supplementary data in side panels. The prototype chart covers part of the eastern U. S. from Washington, D. C.,to near Albany, N. Y., and includes inset charts of the major terminal areas (Washington, Baltimore, Philadelphia, and New York) at 1:260,000 scale.

The methods in chart construction procedures, in chart scheduling, and modernization of equipment put in effect during the year resulted in more efficient operation and utilization of manpower. Examples of these changes are: the initial development for a simultaneous central compilation of airspace changes for all visual and instrument navigation charts. Previously the FAA dockets revising airspace were used by the individual compilers, of the several series of charts, and the information was applied to the chart standard directly from the dockets. Under that system there has been duplication of effort in reading dockets and plotting the airspace changes, as well as the possibility of variation in portrayal from different interpretations of the narrative descriptions in the dockets. To develop a method of simultaneous central compilation of airspace changes for all charts, prototype graphics were prepared from airspace descriptions and copies were prepared photographically at various chart scales and tested in the several compilation sections. Similar graphics, modified as indicated from the prototype testing, are now being prepared from a few selected actual scheduled dockets, fully reviewed, reduced or enlarged to the scales of each of the charts concerned, and used as copy in actual chart production. The graphics are still being evaluated in this stage for optimum portrayals.

Subscriptions to the Instrument Approach Procedure Charts of the conterminous United States have heretofore been available only to all 48 states or for those east or west of the Mississippi River. Beginning January 1, 1965, subscriptions were made available on a regional basis. The 48 states have been divided into 6 regions, and subscriptions may be ordered for the charts covering any single region or any combination of regions. This provides greater flexibility for users in ordering charts as well as a saving in cost for those users whose interest lies in only one or two regional areas. Appropriate

price adjustments were effective at the same time. Tabbed index cards identified by state names are issued with the charts to facilitate filing in binders and replacement of obsoleted charts.

Relief has been portrayed on the visual aeronautical charts for many years by contours and gradient tints. This portrayal provides continuous information on terrain elevation, but the detail of land forms for visual reference in flight is incomplete. Relief shading, on the other hand, would show land form in detail but would provide no elevation information. Both types of information are desirable, but they have never been successfully combined on aeronautical charts. This Division, in cooperation with the Reproduction Division, is conducting experiments to combine shaded relief and gradient tints on visual charts so as to provide the advantages of both portrayals without obscuring other charted data. Experimental printings from available shaded relief negatives have been made on the Huntington Sectional chart and on the prototype Anchorage, Alaska, Visual Navigation chart. This work will continue with other experimental printings.

The 6-month revision schedule of the sectional aeronautical charts has presented a continuing problem in obsolescence of parts of the aeronautical information before a new edition is published. As most sales of these charts are at retail, there has been no practicable channel for communicating changes to holders of the charts. The Airman's Information Manual, published December 10, 1964, by the Federal Aviation Agency, included a Visual Navigation Chart Bulletin section. This consisted of a listing of all sectional charts with the numbers and dates of the current editions and those information changes affecting safety which have occurred on each chart since the date of the current edition. The Division compiled this information for publication in the initial issue of the Manual and continues to furnish revision material for subsequent issues every 28 days. Subscribers to the Manual are able to update their sectional charts every 4 weeks.

The World Aeronautical Charts of the United States have for a number of years become increasingly congested and difficult to read as the aeronautical information which has been required increased in quantity and density. Various proposals to reconstruct these charts to relieve the situation have had to be postponed because of higher priorities of other programs. A number of changes for the improvement of these charts are now to be made as each comes up for regularly scheduled revisions, beginning with the July 1965 printings. The types of change which have been selected are those which will improve legibility of the charts. These include elimination of the overlying blue airspace tint; changes in base colors to improve contrast and conform to other visual chart series; portrayal of airway center lines in a screened tint instead of solid lines; and removal of selected minor features and names.

SUMMARY OF AERONAUTICAL CHARTS PRODUCED

Chart Series	No. in Series 7-1-64	New Charts	New editions	Reprints	Prototype	No. in Series 6-30-65*	
Visual Navigation:							
WAC U.S. & Alaska	62	-	67	3	-	62	(62)
Sectional	88	-	170	18	-	88	(88)
Local	28	-	53	-	-	28	(28)
Jet Navigation	4	-	4	4	-	4	(4)
Planning	1	1	-	-	-	1	(1)
Alaska Visual (Prototype)	-	-	-	-	2	2	(1)
Aircraft Position:	6	-	12	-	-	6	(6)
Radio Facility:							
Enroute Low Altitude	28	-	364	-	-	28	(14)
Low Alt. Area Arrival and Departure	34	-	442	-	-	34	(34)
Low Alt. Area & Multiple Departure (SID)	20	-	239	-	-	18	(4)
Enroute Intermediate Altitude	8	-	16	-	-	-	(-)
Enroute High Altitude	4	-	52	-	-	4	(2)
Enroute Alaska	4	-	52	-	-	4	(2)
RF 191 Enr. Hawaiian Cht. (Honolulu Area)	1	-	13	1	-	1	(1)
Caribbean	3	-	39	-	-	3	(1)
Alaska (Prototype) Low/High	-	-	-	-	4	4	(2)
Instrument Approach Procedures:	1,753	216	3,344	785	-	1,881	(1211)
Auxiliary:							
Outline Maps	9	-	-	2	-	9	(9)
Geomagnetic	1	-	1	1	-	1	(1)
Azimuthal	1	-	-	-	-	1	(1)
Projections	4	-	-	1	-	4	(4)
Miscellaneous	3	-	-	-	-	3	(3)
Total	2,062	217	4,868	815	6	2,186	(*1479)

*Numbers in parentheses indicate conversion to chart count on a unit-of-issue or piece-of-paper basis.

Distribution Division

At the beginning of the year we were represented by 527 authorized nautical chart agents. During the year 72 new agents were appointed and 15 cancelled. At the end of the year there were 580 nautical agents. During the year 251 or 48 percent of these nautical agents were inspected of which 209 or 83 percent were found to be performing their services adequately. 17 percent were found to be unsatisfactory and were reminded that unless conditions improved, their contracts would be cancelled.

At the beginning of the year we were represented by 671 aeronautical agents. During the fiscal year 91 were appointed and 45 cancelled for a total of 717 aeronautical agents at the end of the year. 316 or 47 percent were inspected and 262 or 83 percent were found to be performing their duties adequately. 54 agents or 17 percent were found to be unsatisfactory and were reminded of their unsatisfactory conditions. These statistics indicate the need for additional inspections. Efforts are being made to inspect agents once every two years to properly instruct them in the manner in which their agencies are to be conducted.

The written instructions for the inspection of authorized nautical chart agents and for authorized aeronautical chart agents were completely revised during the year. The new instructions now serve for both the inspection and the inspection report for both type of agents, whereas the previous instructions and reports were separate for each type of agent.

Over-the-counter sales amounted to $30,310.58 or an average of $2,525.88 per month. The money received for over-the-counter sales indicates only in small part the services rendered by personnel in the Sales Room. It should be noted that small purchases almost without exception require much more personal service than the large sales. Most large purchasers list their requirements and know what they want, whereas the small purchaser spends a great deal of time in examining our many products frequently without any purchase. Public subscribers to Instrument Navigation Charts increased from 12,435 to 15,783, and FAA subscribers increased from 3,316 to 5,500.

CHARTS AND RELATED PUBLICATIONS ISSUED

FISCAL YEAR 1965

Type of Chart or publication	1963	1964	1965
Nautical Charts	1,712,172	1,706,896	2,085,288
Aeronautical Visual Flight Charts	5,710,168	5,845,952	6,501,484
Aeronautical Instrument Flight Charts	20,873,322	23,023,069	23,010,700
Miscellaneous Maps and Charts	68,726	118,225#	113,397#
Coast Pilots	15,528	11,171	16,490
Tide and Current Tables	74,802	63,951	52,437
Tidal Current Charts	*	6,288	5,837

* included with Nautical Charts

includes Chart No. 1 carried as Nautical chart before 1964
Distance tables carried as Coast Pilots before 1964,
and Nautical catalogs.

During the year we have been plagued by inadequate mail service from the Washington Science Center. In many cases orders which should have received priority service did not get this much needed service because of delays in receiving the orders. In several cases orders were not received until after the deadline for delivery.

During the year 279,865 more conventional nautical charts were issued than in the previous fiscal year and 98,256 additional small-craft charts were issued during this period. It will be noted that in the statistical portion of this report, in every category except radio facility related data, there was a substantial increase. In the IAP related data category, a 200 percent increase was made. During the year, approximately 240,000 additional hand corrections were made in the three offices over the previous year. Due to our curtailment in personnel, this increase was not sufficient to forestall issuing uncorrected charts which had been so stamped. This is definitely a lack of service which in many cases cannot be obtained from the Notice to Mariners by the user because of the long period of time for which the charts are printed. The Alaska and Pacific Airman's Guide was issued on a free basis to subscribers and paid

for by the Federal Aviation Agency. At the end of the year subscribers receiving these publications were placed on a paid subscription basis. Several accomplishments were made in forms and information pamphlets distributed on a free basis, such as the list of authorized aeronautical and nautical chart agents and other information pamphlets. Through study, these pamphlets were reduced in price to a point where they could be issued free. The result was an ever-increasing knowledge of our products by the public which was reflected in increased sales of both nautical and aeronautical charts.

Throughout the year there was a large increase in turnover of personnel. The hiring grade of clerk-typists was reduced to GS-2 which reflected in the caliber of personnel employed. Even the grade of chart correctors employed was reduced to Grade 2 which was contrary to all recommendations made by the Chief of the Division. This is very important and vital work which must be performed efficiently and accurately by low grade employees.

The division has a total of 36 clerical employees excluding supervisory personnel. During the year, 20 clerical employees left the division by transfer or resignation. These separations were for the purpose of obtaining promotions in other jobs, for returning to college, for getting married, and for retirement.

It is obvious that the division is critically handicapped by the continuous requirement for training new personnel who are not experienced in our work. There are two basic reasons for the rapid turnover in personnel.

1. The low salaries and slow promotion process which are given to the clerical positions.

2. New personnel are primarily girls who have just graduated from high school and who have never worked before. It is obvious that most of these young girls are transient because they are not settled to the point to which our particular type of work is to be their permanent career. Other activities, including college and marriage, take a constant toll of these employees. Mature women have become our most stable working group.

In cooperation with the Electronic Computing Division, a system was inaugurated whereby the price of nautical and aeronautical charts would be set up on the computer for both agents and the public. The system was tested and proved to be very efficient. In addition, at the request of the General Accounting Office, the Electronic Computing Division also incorporated into our statistical report the condemnation of charts by agents which presents a much better picture of actual accomplishments.

In the Finishing Branch there was a decided increase in all types of work. Overtime was held to a minimum in

DISTRIBUTION OF NAUTICAL AND AERONAUTICAL CHARTS - FISCAL YEAR 1965

	NAUTICAL CHARTS				AERONAUTICAL CHARTS			
	Conventional		Small Craft		Visual Flight		Instrument Flight	
Free Issue:	Copies	%	Copies	%	Copies	%	Copies	%
Coast & Geodetic Survey	24,297	1.3	8,798	4.0	14,692	.2	146,913	.6
Coast Guard	10,428	.5	2,117	1.0	4,651	.1	-	-
Federal Aviation Agency	26	-	8	-	289,163	4.5	4,099,594	17.8
Congressional	3,600	.2	1,031	.5	441	.01	15	-
State & Local Governments	3,342	.2	375	.2	3,765	.06	-	-
Foreign Governments	15,399	.8	692	.3	978	.01	418	-
Other Government Agencies	23,915	1.3	2,511	1.1	40,778	.63	395,218	1.7
Miscellaneous	7,616	.4	1,101	.5	18,669	.29	12,615	.1
Mobilization Reserve	33,425	1.8	-	-	-	-	-	-
Total Free Issue	122,048	6.5	16,633	7.6	373,137	5.8	4,654,773	20.2
Reimbursable:								
Department of Air Force	-	-	-	-	2,934,735	45.1	124,250	.6
Department of Navy	1,041,554	55.8	12,845	5.9	732,460	11.4	-	-
FAA (special printings)	-	-	-	-	64,000	1.0	101,580	.4
G.P.O. (special printings)	-	-	-	-	72,600	1.1	-	-
Other Special printings	-	-	-	-	24,200	.4	-	-
Total Reimbursable	1,041,554	55.8	12,845	5.9	3,837,995	59.0	225,830	1.0
Total Sales to Public	563,346	30.2	125,246	57.4	1,775,035	27.3	14,525,578	63.1
TOTAL ISSUED	1,726,948	92.5	154,724	70.9	5,986,167	92.1	19,406,181	84.3
Condemned	139,990	7.5	63,626	29.1	515,317	7.9	3,604,519	15.7
Total Issued and Condemned	1,866,938	100.0	218,350	100.0	6,501,484	100.0	23,010,700	100.0
Total Air Force Charts Issued - 1,286,041								

the Finishing Branch and very little overiime was used in the Stock Room to meet the 28-day deadline for Radio Facility Charts. During the year two surveys were made of activities of the Distribution Division, one by the Department of Commerce and one by a private concern. In every case a deficiency was indicated in the maintenance of chart agencies but which we were unable to correct because of budget and personnel deficiencies.

Reproduction Division

In fiscal year 1965, the upward trend in all production activities continued. The total number of charts and maps printed increased in all categories, rising by 6 percent over the preceeding year. Aeronautical charts printed increased by 89, registering a significant, but modest gain. In proportion to the aeronautical program, the increase in nautical charts was dramatic. 397 nautical charts were printed in fiscal year 1964 and 457 printed in fiscal year 1965 for an increase of 60 charts. In rounding out the total nautical printing program, 56 chartlets, representing in excess of 1 million copies, when included, raise the total number of nautical charts printed to 513.

Miscellaneous production, which includes volume printing of scientific publications, data, graphs, and maps for our Bureau and other Federal agencies was up from 373 jobs in fiscal year 1964 to 566 jobs printed in this year ended June 30. A crash project conducted to assist the Army Map Service in meeting an emergency requirement accounted for 169 jobs of the 193-job increase over the last fiscal year.

Table 1 summarizes and compares chart production (printed) over a 3-year period:

TABLE 1.--COMPARISON OF CHARTS PRINTED BY FISCAL YEARS

	1963	1964	1965
Nautical :	408	397	457
Aeronautical :	3,910	4,615	4,704
Miscellaneous:	329	373	566
Totals :	4,647	5,385	5,727

Omitted from the above table are chartlets and the number of charts backprinted. Back printing, however, represents a separate pass through the presses and requires essentially the same effort as front or face printing. In the nautical chart program alone, 65 charts were backprinted during the fiscal year. This was an increase of 14

charts over that of the previous year. While backprinted charts are not counted individually for distribution purposes, they are indicative of the total workload in all operating branches.

Coincidental with the increase in total number of charts printed was a corresponding rise in the number of copies delivered to the ordering office. Copies delivered rose by 19 percent when compared to the previous year. Table 2 compares the number of copies delivered to previous year deliveries.

TABLE 2.-CHART PRODUCTION(COPIES DELIVERED)BY FISCAL YEARS

	1963	1964	1965
Nautical :	1,680,000	2,084,000	2,402,000
Aeronautical :	29,143,000	33,833,000	36,013,000
Miscellaneous:	1,014,000	1,653,000	6,158,000
Totals :	31,837,000	37,570,000	44,573,000

Multilith production, a relatively minor part of our primary mission, made a noteworthy contribution to the Bureau's specialized activities. A total of 2,562 jobs, totaling 8 million delivered copies, were completed by the Special Services Offset Section during the fiscal year.

Paper.--Chart paper, with its annual consumption of about one half million dollars, is, by far, the largest material cost item necessary to carto-reproduction. More substantial establishment of improved issuance and spoilage control procedures, begun in the prior year, coupled with near-total availability of more economical stock sizes, realignment of which was also initiated last year, provided a major cost reduction for the year.

Chemical wood (aeronautical chart) paper use totaled 1,941,249 pounds or 282,120 pounds less than fiscal 1964 consumption. At the prevailing rate of 17¢ per pound, a saving of $47,900 accrued.

An improvement of this magnitude could not be readily applied to all paper stocks nor to all chart series, but total-program effect can be noted in this comparison (Table 3):

TABLE 3.--TOTAL PAPER CONSUMPTION

	Fiscal Year 1964	Fiscal Year 1965
1st Quarter	$ 110,785	$ 118,335
2nd Quarter	143,269	139,715
3rd Quarter	146,306	123,929
4th Quarter	143,505	130,975
Total	$ 543,855	$ 512,954

Full significance of this nearly $31,000 reduction becomes more notably apparent when chart production totals for the two years are appropriately related. (Figure 1)

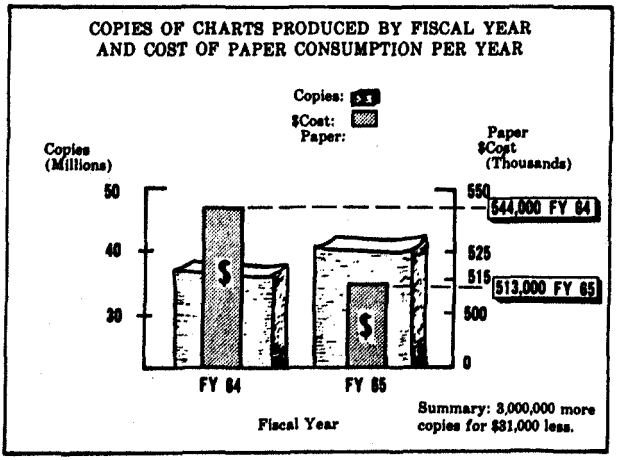

FIGURE 1

Printing Plates.--Printing plates purchased "ready to use," fully tested and evaluated through gradually extended use in actual production, were determined advantageous for 100 percent use in lieu of in-house grained plates. Final phase-out of graining operations, begun about mid-year, was substantially completed at year's end; and formal request to abolish the activity and dispose of equipment was submitted.

Elimination of the graining activity in the Photomechanical Branch will result in these economies: (1) Abolishment of three positions - $18,000 and (2) Annual plate cost reduction - $23,500, or approximately $2.50 per plate. (Includes graining material cost)

Conversion to Plastic Media.--The changeover from wet-plate glass negatives to plastic-base photographic and

engraving (scribing) materials made slow but measurable progress during the year. Conversion has been approached cautiously because of material variables which are problematic. Thus, uncertainties in correction techniques have tended to impede our progress in this regard. An ability to make correction on existing negatives is vital to timely completion of nautical and aeronautical charts on a scheduled revision cycle.

Experience gained thus far provides a sound basis for additional experimentation and possible acceleration of the changeover; however, the funds available in fiscal year 1966 will allow only a moderate program.

To date, plastic media have been fully adapted to:

28 Conventional Nautical Charts

29 (All) Small Craft Folio and Route Charts

13 (All) Small Craft Area Chart Overprints

5 Sectional Aeronautical Charts

9 Local Aeronautical Charts

2 Planning Charts

6 Aircraft Position Charts

1 Jet Navigation Chart

Once conversion is complete, reduced production costs and improved color and chart-component registration accruing therefrom would offset the additional expenditure required for initial conversion.

Sounding Engraver.--A portable sounding engraving device was obtained from the Canadian Department of Mines and Technical Surveys and adapted for use in the Negative Engraving Branch. Fifteen individual units were completed and made available to engravers for use on nautical chart constructions and revisions. A suitable master template and the acquisition of equipment for duplicating it makes it possible to provide additional units, as required, easily and inexpensively. After a period of instruction and familiarization, the engraving of soundings on plastic scribe sheets will become standard procedure and a significant factor in the stepped-up conversion from glass to plastic as media for chart maintenance and reproduction.

A work measurement study of Negative Engraving Branch operations was conducted by a Bureau Management Team. Time standards or, in numerous instances, the use of job (technical) estimates, were established for engraving work by chart category and job type.

These new standards are not replacements for those long established for relating individual employee performance to individual job requirements, but are intended for development of a monthly and cumulative "Index of Effectiveness" for total engraving activity. (Figure 2)

MONTHLY EFFECTIVENESS INDEX-NEGATIVE ENGRAVING BRANCH
(Study Standards)

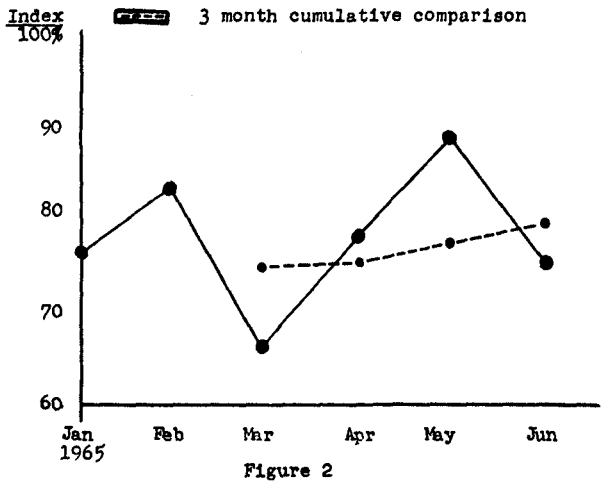

Figure 2

PAR Standards provided by the Printing Industry of America have for some years been effectively applied to most Division operations. Because of changing procedures and techniques, new or modified equipment and the introduction of improved materials, these standards require periodic review and updating. Division management accomplished this for presswork and, also, developed an additional set of standards which provide an accurate, comprehensive index of individual operator performance. Significantly, their introduction and application brought about a measurable increase in production rates during the year. Similar revisions were initiated in other operating branches.

Organization.--One major reorganization took place within the Division during the report year. A Photomechanical Branch was organized in May concurrent with a consolidation of the Photographic Branch, Transfer-Process Branch, and Layout Section into a single operating unit. This consolidation was made in consonance with industry-wide technological progress, and in the interest of en-

hancing production efficiency through operational streamlining. A 3-E project was proposed to that effect in June 1964.

Although appreciable savings are expected to result from this consolidation, the full impact of the reorganization cannot be accurately assessed because approval came late in the fiscal year. An immediate evaluation, however, discloses recognizable improvements in operating efficiency, and suggests that substantial dollar savings will accrue, principally from positions abolished as surplus under the reorganization.

Education and Training.--Attendance at the 7th International Graphic Arts Technical Seminar at Paris, France, during June by the Division Chief was a fitting climax to another year of significant and valuable employee training. Almost 10 percent of our personnel participated in some form of self-improvement.

Courses attended included both managerial and technical subjects, ranging from Systems Analysis to Introduction to the Graphic Arts. Interestingly, two-thirds of all courses attended took place on the employees' time. A breakdown by course follows:

Course or Seminar	Number of employees
International Graphic Arts Seminar	1
Systems Analysis Seminar	1
Manpower Utilization Seminar	2
Source Data Automation (GSA Institute)	4
Cartographic-Reproduction Techniques	1
Cartography	1
Principles of Electricity	1
Reading Improvement	1
Introduction to the Graphic Arts	7
Offset Pressman (Advanced)	2
Offset Pressman (Basic)	1
Photography (Advanced)	2

In addition to the training listed above, this Division conducts a comprehensive in-house training program for selected personnel and indoctrination tours for new employees. The heart of both the in-house program and indoctrination tour is planned rotation through the administrative offices and various operating (production) areas. This increases an employee's technical knowledge as well as his understanding of the many different processes inherent to our complex operation. At the same time, a telling blow is struck for the furtherance of teamwork.

Staff Meetings.--Recognizing communication as an unending requirement for efficient management, Division administration scheduled regular meetings of key personnel. These daily meetings provide a forum where timely exchanges of information concerning production and administration

take place. Day-to-day problems are now more promptly solved, a better informed staff is developing and the "management team" concept is more firmly established. Beneficial results have also shown in greater interest and enthusiam in work, closer coordination of activities and a higher level of morale.

Management Assistance.--The Management Assistance Committee established during last year to periodically review and analyze processes, practices, and procedures was continued. Recommendations resulting from studies of designated managerial problems undertaken by this committee have been of material benefit in conducting the affairs of this Division.

A pilot project was conducted to determine the feasibility of establishing a silver recovery program from solutions and film used in the Photographic Branch. This study was a cooperative project with the Veterans Administration and the General Services Administration. The VA has an elaborate organization for handling the reclamation of silver from its hospitals and photographic labs throughout the country. The GSA was interested in evaluating "Save Silver" possibilities in Government operations.

The project proved that preliminary estimates or speculations to be extremely conservative and resulted in a continuing program being planned for implementation early in fiscal year 1966. In addition to the recovery of a metal in critically short supply, it is estimated that approximately $10,000 will be returned to the Treasury annually. Additionally, preliminary tests indicate an extension of from 50 percent to 100 percent in the useful life of chemical solutions used in our photographic work.

OFFICE OF RESEARCH AND DEVELOPMENT

A review of our research and development effort was made and it was determined that, in many instances, better research could be conducted if laboratories and research groups were established in locations more conducive to research activities. Cooperative efforts could be established in these areas with universities or other scientific organizations. During the year we have been fortunate in establishing four basic research efforts:

1. Land and Sea Interaction Laboratory.--This oceanographic research group was established at Norfolk, Va., in April 1965. Cooperative relationship was made with the Virginia Institute of Marine Sciences. The major success has been achieved in establishing good research projects. Laboratory and field experiments have been good, and notable results are already being realized.

2. Advanced Seismic Experiments Group.--This group was established in January 1965 at San Francisco, Calif. Its purpose is to conduct basic research in the field of seismology. Its location was chosen so that it would be near an active fault. During this short time, the group has conducted some major seismological experiments under the sponsorship of some other government agencies in addition to those sponsored in-house.

3. Joint Oceanographic Research Group.--This oceanographic research group located in Seattle, Wash., was established near the close of the fiscal year. Its major achievement has been the establishment of a formal cooperative agreement between the Coast and Geodetic Survey and the University of Washington.

4. Joint Tsunami Research Effort.--This effort, located in Honolulu, Hawaii, was established toward the close of the fiscal year. Here again the major achievement for this effort has been the formal cooperative relationship established between the Coast and Geodetic Survey and the University of Hawaii. As the name implies, much research will be conducted on tsunamis. This is of vital interest to the Survey, as well as to both the University and State of Hawaii.

Ocean Studies Program--As indicated above, much was done in the area of oceanography in setting up research groups that would create an environment and be more advantageous to oceanographic research. The establishment of the Land and Sea Interaction Laboratory, Joint Tsunami Research Effort, and Joint Oceanographic Research Group is just one aspect of the achievements in the Ocean Studies program for this fiscal year. Research activities continued to be basic and applied in nature. Development of various types of instrumentation continued.

Under the Estuarine Studies Project the University of Southern California submitted the sedimentological data of the Choptank estuary, Md. These data augment an earlier study on the magnitude of erosion and sedimentation of this estuary. These data and a previous report have been put into manuscript form preparatory to publication. In addition, analysis of sedimentological data from Charleston Harbor, was completed.

During the year, efforts on developing a Nearshore Buoy System were devoted to establishing the objective of the system, determining instrumentation parameters within the present state-of-the-art, and developing specifications for hardware procurement. To provide information useful for both commercial and scientific purposes, it was decided that the general circulation in an estuary should be described in terms of salinity, temperature, and current speed and direction. To develop a profile, the depth is required at which each reading is taken. The equipment must operate from a buoy as the system needs to have the ability to both record in the buoy and to telemeter the data to a recording station. Information should be in a form suitable for automatic data processing. Near the end of the year, a contract for a prototype system was let. Delivery will be within a year.

Work on the Continental Shelf Physiography Project resulted in three papers published in professional journals from the work on the Florida Platform, Aleutian Islands, and the Alaskan Peninsula. One of these named a previously known but undescribed submarine feature, the Miami Terrace. The other two dealt with two features on the Aleutian arc, Adak Canyon and Amlia Depression.

The contract with Florida State University was completed during the year and a final report was received. An earlier report indicated that the study area (northwestern Florida continental shelf) may have a significant bearing on interpreting the changes in sea level along the northeast coast of the Gulf of Mexico from the Pleistocene to the present time.

In the Tide Research Project, a computer program for editing and reducing data from a digital tide gage was completed and became operational.

Studies on land emergence in southeast Alaska and secular changes in sea level along the coasts of the United States were completed.

In continued cooperation with the tide research program of the Institute of Geophysics and Planetary Physics, University of California at San Diego, 62 years of hourly heights at Baltimore were furnished to the institute. In addition, the Coast and Geodetic Survey financially supported the tidal research computing effort of the institute.

A comparative study of traditional and least squares tide analysis techniques was completed sufficiently for the results to be presented at an international tidal symposium in Paris. A computer program for Fourier analysis of sequential tide and tidal current data was developed and is now operational. Studies for developing an operational least squares analysis computer program for series shorter than a year are underway.

Under the Deep Sea-Floor Research Project, most of the year was devoted to basic theoretical studies, These studies were involved with the following:

Ocean Basin Origin.--Assuming isostatic equilibrium and sea level continents, wide variation of the earth's sial to water volume ratio results in a narrow range of continent to ocean thickness ratios. Quite likely, the surface areas and thicknesses of continents and oceans are fundamentally related and would not have varied greatly from their present distribution even if sial or water had been generated at rates markedly different from those now evidenced. Ocean depth is suggested as the basic mechanism controlling this relationship.

Continental Drift.--Stereographic projections of Australia and Antarctica about a common point yield a second-order cartographic fit along the 2,000-meter isobath further suggesting the reality of continental drift. A similar analysis suggests that the Bay of Biscay has been opened by rotation of Spain away from the coast of France.

Crustal Impact and Shock Structures.--Shatter cones were discovered in two residual boulders in the central uplift eye of the Middlesboro structure. This finding gives additional support to the interpretation that Middlesboro is probably an astrobleme; i.e., an ancient meteorite impact scar.

Veined and brecciated chrondrites commonly display striated fractures which have been interpreted as slickensides (fault dislocations). Observations on several such fractures in various collections suggest that they are not true slickensides but, instead, are probably shock fractures related to shatter coning.

Other Deep-Sea Research.--Wedge-shaped prisms of shallow water marine strata now cap many continental margins. These terrace wedges are believed equatable with wedge-shaped miogeosynclines of the geologic past. Modern terrace wedges thicken toward the ocean basin and terminate at the top of the continental slope; presumably ancient ones did also. The term miogeosynclines is contracted to "miocline" since these wedges presumably never were truly synclinal in form. The folded Appalachian Mountains and the Millard belt of the western United States may be examples of ancient mioclines.

Under the Environment and Structure of the North Pacific Project, the laboratory at the Marine Science Center was equipped to handle routine sediment analyses. Specialized equipment (e.g. core curring box, core racks in the freezer, microsplitter) was designed and fabricated, the proper forms for recording data were prepared, a computer program for calculating sediment size statistics was checked out, and a procedure manual for sediment analysis was written.

Three cores taken during the International Indian Ocean Expedition (IIOE) were subject to analyses at the laboratory. They were opened, logged both macroscopically and microscopically, and sampled. A size analysis was made on the samples.

The clay fraction from representative samples have been submitted to the University of Washington for X-ray diffraction identification of clay minerals.

Additional samples from the three IIOE cores were sent to D. P. Kharkar, Tata Institute of Fundamental Research, Bombay, for Ionium-Protactinium (Io-Pa) age determination and to J.D.M. Wiseman of the British Museum who is examining Ethnodiscus in the sediments. Plant material from one core was identified by the University of Washington. Carbon 14 dating of this material will be arranged in the future. Micropaleontological studies of radiolaria and foraminifera observed in the cores have been started.

A series of six cores from the northeast Pacific were opened for sampling and photographing by marine geologists from the University of Washington. Logs of these cores have been prepared.

The Marine Geophysics Project was productive during the year. Studies were completed on the 1961 PIONEER survey area. This involved the preparation of isoline charts of the magnetic and gravity fields and the bathymetry for an area between longitudes 155°W., and 159°W., and latitudes 55°N., and 45°N., and the interpretation of these anomaly charts.

Studies were also completed on the geological and geophysical structure of the Andaman Sea.

Several accomplishments can be noted under the Physical Oceanography and Sedimentation Project. Construction of the oceanographic data acquisition system for the Class I and II vessels is nearing completion. Equipment for the Class I is well advanced in the construction phase - recorders, plotters, and indicators have been selected and ordered. Inspections of the system have been made periodically. Demonstration of the program for solution of the Loran C position was given. The total program package for the Class I and II systems is in the final stages of preparation and testing of the individual parts in simu-

lation with artificial data. Planning for the Class IA system was initiated.

In studies in cooperation with the Weather Bureau, it was found that computer analysis of variables in a beach-ocean-atmosphere system indicates that predicator equations standup in tests on an independent data set.

Studies on large amplitude internal waves in the Indian Ocean were completed and a paper on the subject was published.

A plan to test the hypothesis that the western boundary of the Gulf Stream follows the bathymetry along the coast of Florida was proposed. A temperature recording system was assembled and delivered to the HYDROGRAPHER for data collection during this season's scheduled crossings of the Gulf Stream edge off Florida.

Plans were prepared for a field test program for the Sea-Air Interaction Laboratory (SAIL) to investigate the environmental factors in remote measurement of absolute sea-surface temperature by infrared radiometry. Field experiments were performed at Miami, Fla., by Coast and Geodetic Survey and Weather Bureau personnel. Comparative sea-surface temperature measurements were made by radiometers, which were mounted in a DC-6 airplane of the Weather Bureau Research Flight Facility and on a Coast Guard vessel. In addition to investigating the effect of atmospheric moisture with the boat and airplane, a preliminary reconnaissance flight resulted in data to determine (1) the location of the western boundary of the Gulf Stream between Fort Pierce and Miami, Fla., (2) the effect of high altitude to 7,000 feet on the measurement of sea-surface temperature, (3) the relationship between the color line of the Gulf Stream boundary by color photography and the thermal gradient by thermometry, and (4) comparison of the relative merits of types of color film in recording the color line of the Gulf Stream edge.

The editing logger for the Seattle Processing Center was completed. Two more Hydrographic Universal Loggers have been completed and are now in operation on the ships PEIRCE and PATHFINDER. A computer system to work in concern with the Hi-Fix system and the Datex logger has been installed on the ship PEIRCE so as to assist in the ship's operation of hyperbolic Hi-Fix surveys. Specifications have been written and invitations have been issued for a computer-plotter system to be used on the ship WHITING. A study committee has prepared specifications for a complex plotting system to be installed at Norfolk for processing hydrographic and oceanographic survey data.

Under the Land and Sea Interaction Studies Project, emphasis was placed on establishing a laboratory at Norfolk, Va., and for which the ordering of basic laboratory equipment was completed. Many discussions were held with rep-

resentatives of the scientific community for the purpose of establishing possible cooperative research efforts.

Geomagnetism Program.--The research and development efforts of the Coast and Geodetic Survey's geomagnetism program are to extend knowledge of the earth's magnetic field and to develop instrumentations, systems, and techniques for the improvement and extension of research on, and related surveys.

Under the Magnetic Field and Its Variations Project, the text of a paper was revised to reflect various improvements and refinements that had been introduced in the computing program to enhance the rigor and accuracy of the results, and the illustrations were finished. The completed manuscript was submitted for consideration and publication.

Some preliminary results were obtained from the relative amplitude of midday Z and H rays during disturbed periods at Koror. Days of large and of weak Sq have been noted.

A total of 60 hours of selected recordings have been submitted to the University of California for processing and analysis under the cooperative study contract. One investigator on the Fredericksburg staff spent 2 months at the University of California participating in data reduction and analysis and receiving specialized training in magnetotelluric data analysis.

An extensive report on a study of Puerto Rico was completed and submitted for review. A seminar on the subject was conducted at the Washington Science Center by two members of the Fredericksburg staff. A network of temporary stations was established on an east-west line through Fredericksburg Magnetic Observatory (FMO) to determine the extent to which the FMO recordings are influenced by the "coast effect."

Work continued on the Development of Cooperative Magnetic Observatories Project. Varian Associates installed the new Automatic Standard Magnetic Observatory-Remote (ASMOR) detecting unit at the Castle Rock Observatory and the recording unit at the University of California at Berkeley. These units are interconnected by telephone lines.

The Ames Research Center, Moffett Field, Calif., is purchasing an ASMOR recording unit and will be supplied magnetic signals directly from Castle Rock. Bureau personnel stationed at the Castle Rock Observatory are cooperating with scientists from Stanford University and University of California at Berkeley on research projects related to micropulsations and earthquake predictions.

The Instruments and Methods Development Project was very active during the year. A contract was signed for the emplacement of the Underwater Stable Platform in 12,000 feet of water approximately 1,000 miles south of

Los Angeles, Calif. Most of the instrumentation and equipment including a three-component magnetometer, a tide gage, a current meter, and a wave recorder, were completed for the tests. Calibration and reliability tests and a small amount of construction in the shop remained to be done.

The automatic standard magnetic observatory (ASMO) sensor at Fredericksburg was refurbished by the manufacturer and modified to diminish its temperature sensitivity. It has continued to function reliably since that time, however, it is being moved into a new temperature controlled building. Comparison with the proton vector magnetometer (PVM) has indicated a continuing ASMO pier tilt which will necessitate a periodic check on the axis of orientation with a theodolite.

An ASMO is being installed at the Dallas Magnetic Observatory.

Seismology Program.--The Bureau placed strong emphasis on establishing a research atmosphere. The goals as outlined in fiscal year 1964 were to be implemented. A major step was taken with the establishment of the Advanced Seismic Experiments Group located in San Francisco, Calif. The group conducts advanced and exploratory research in seismology and related earth sciences. It also conducts applied research and development activities, including field operations and data analysis on specific projects. In addition to the establishment of the group, much research was accomplished under the Seismology Program for the year.

Under the Studies of Seismic Waves and Earth Structure Project, computations which were made for the Salmon event show that the use of the existing Pn grid for the United States in the POLO program decreases the location error of the epicenters by an order of magnitude compared with those obtained without the Pn corrections. It has been decided not to revise the grid at this time because it appears to give valid corrections for the eastern United States. A table of Pn grid values at 1/2° intervals for the region of Japan and the Soviet Far East, covering 31° to 16°N, and 132° to 168°E., was prepared for the CDC-1604 computer.

An interative technique is being used to improve P traveltime tables, determine average station corrections, and estimate the variance of the stations for distances between 20° and 105°. First determinations of residuals from 167 earthquakes showed that corrections of as much as 0.8 second were needed in the existing traveltimes. Improved traveltimes from the first determination were used to locate hypocenters of 184 earthquakes during the second determination. Traveltime corrections did not exceed 0.2 second on the second determination. These corrections were applied and a third determination of the hypocenters will be made using the improved traveltimes from the second pass.

A program for plotting earthquake epicenters on the CDC-165 plotter was written. The program can plot either constant-scale or Mercator projections. It will be used in seismicity studies. Options for other map projections will be developed as needed.

A computer program was written for the determination of relative locations of the epicenters of seismic events. The program is based upon the principle that the time and distance residuals of the "unknown event" are approximately distributed as a sine function of the azimuth of the recording stations from the reference event. The program was written to utilize data from the Vela Uniform Aleutian Islands Experiment, but will be useful for the determination of the epicenters of foreshocks and aftershocks with respect to the epicenter of the associated main event.

Under the Improved Seismic Systems Project, a 20,000-pound explosion detonated in Lake Superior on October 10, 1964, by the U. S. Geological Survey was recorded at the 48-geophone array at Hanna, Alberta, Canada. The magnetic tapes of this event, the Salmon event at Hattiesburg, Miss., on October 22, 1964, and of a sample of pre-Salmon noise were played back and digitized at intervals of 0.01 second by the contractor, Seismograph Service Corp. of Tulsa, Okla.

The data were subjected to power spectrum analysis in two frequency ranges. This analysis, especially of the logarithmic spectra, demonstrated significant spectral similarities between geophone elements of the array. Quality of recording, reproduction, filtering, and digitization was checked by examination of statistical parameters, such as the standard deviation, skewness, and kurtosis as computed from the second, third, and fourth moments about the mean. The ordinate distribution was symmetrical, unimodal, and approximately normal.

A program was written for the electronic computer, causing orthogonal polynomials to be fitted to the normalized ground particle velocities of the compressional waves simultaneously recorded by all 48 of the array geophones at a single point in time. These two-dimensional polynomial solutions were computed for the Lake Superior shot records thus generating three-dimensional trends and a function of time as the fourth variable.

The ratio between first degree polynomial coefficients in the north-south and east-west directions is used to obtain the arc tangent of the azimuthal angle through the source. The error was less than 0.2 degree of azimuth for the Lake Superior explosion.

Improvements in efficiency over previous methods are: First, this method of source identification eliminates misuse of compressional wave arrivals from other sources

in an epicentral location program, even though such arrivals lie within the allowable time range. Second, the above method markedly improves the accuracy of determination of the time of arrival of Pn, a compressional wave phase to within 0.1 second, even in the presence of noise energy greater than that of the signal throughout the signal band width. Third, the use of the statistical F ratio permits identification of weak signals from buried nuclear explosions on an objective, rather than on a subjective basis. Fourth, the determination of both azimuth and apparent velocity of a buried signal as a function of time allows recognition of phases such as p^P and s^P which are highly useful in the determination of focal depth. Fifth, the three dimensional first degree trends reach their maximum degree of statistical significance at a point in time when the average of the normalized particle velocities is so near zero as to be nonsignificant. Thus, the effective signal-to-noise ratio used in azimuth and apparent velocity determination is far greater than that indicated by the average (zeroth degree polynomial) at the appropriate point in time.

An attempt was made to find the most accurate and efficient method of contouring vertical ground motion of the seismic waves within the area occupied by the seismic array at successive instants of time to show the progression of signal-and noise-wave patterns through the array. Search of the pertinent literature indicated that two-dimensional trignonometric interpolation of the information in the area of the array by use of sin x/x would give the best contour locations, except for the poor convergence of the infinite tails of the function.

As a result of this study, a computer program was written, allowing the evaluation of coefficients for trigonometric interpolation of any discrete function of N equally spaced values. For $3 \leq N \leq 12$, these coefficients have been computed on Stretch and are being differenced and checked for tabulation and duplication in a special Bureau publication.

The improvement in efficiency, using these tables is indicated by the reduction in time required to sum n multiplications compared with that required for complete harmonic analysis and resynthesis to equal precision. Time reduction is given by the ratio $\frac{2N}{1.5N^2+N}$, which is about 94.4 percent for N = 12.

Under the Seismic Instrument Development Project, testing and modification of the strong-motion seismograph, Mark II, have continued. Solid state, 24-v. d. c. time mark generators were designed and built by Grafix Inc., Albuquerque, N. Mex. Frequency stability is better than $\pm$0.3 percent for normal temperature fluctuations. All optics holders have been modified to eliminate creep and facilitate in adjustment. Metal idler rollers in the recorder film magazine were replaced by rubber-covered

rollers for obtaining additional film pressure on the drive roller. Three instruments were installed in the Pioneer Building, Los Angeles, Calif., on March 12 for displacement and acceleration measurements during a building vibration project. Four instruments were turned over to the Seismological Field Survey on March 19.

Work continued on teleseismic instrumentation. Design, fabrication, and testing of the slipping assembly for transmitting power to the film-advance motor and programer were completed. Primary and secondary light source housings were designed and fabricated. Design, fabrication, and testing of the drum-step assembly, galvanometer pedestal and base assembly, drum drive assembly, external film-advance programer, and control panel assembly have been completed. Design, fabrication, and testing of the trace translating mechanism have progressed to 75 percent completion. Design and fabrication of the optics holders have been 50 percent completed. Geotechnical Corp. of Garland, Tex., fabricated and delivered the optical pieces. Drafting of engineering drawings is in progress.

In January 1965, preliminary results of the 1964 Vela Uniform Experiment Project in the Aleutian Islands were presented to the Committee on Seismology of the National Academy of Sciences-National Research Council (NAS-NRC) at Pasadena, Calif., together with preliminary plans for the followon in 1965.

Upon receiving authorization from the Advanced Research Projects Agency No. 3 to ARPA Order 533, engineering and technical personnel initiated procurement procedures to modify and improve the data acquisition portion of Dacan in accordance with previously engineered plans. Amendment No. 4 subsequently allowed initiation of procurement procedures for additional modifications and additions to Dacan.

Throughout the report period, personnel assigned to the Theoretical Studies and Analysis Sections of ASEG continued work on analysis and interpretation of data pertinent to the 1964 Aleutian Experiment.

Ocean-bottom seismographs intended for use in seismic experiments in a deep oceanic trench island arc region in the summer of 1965 were scheduled for completion on or about May 31. A meeting was held in Dallas on May 11 (at the plant of the instrument manufacturer) of government representatives; although the manufacturer felt then that he could deliver on or nearly on schedule, it was apparent that no full-scale testing of the instrumentation as an assembled system would be possible prior to May 31. Plans for Bureau participation in operational tests (in shallow and deep water) of the ocean bottom systems and for a 2-month geophysical experiment in the Kuriles region in the summer of 1965 were prepared and

were officially transmitted to ARPA by the Director on June 4, 1965. By this time, unexpected difficulties were encountered by the manufacturer in the course of laboratory tests; these necessitated postponement of the shallow- and deep-water tests approximately 2 months.

Hydrography Program.--The research and development effort under this program was directed toward the improvement of current charts and services and toward the reduction of unit costs of supplying these products and services. An attempt was made to apply advances in data handling and presentation techniques to improve internal processing. User requirements were studied and some modifications to existing charts were made to comply.

Under the New and Improved Concepts of Data Presentation - Nautical Charts Project, chart-user correspondence, technical waterway and harbor development reports, chart-user evaluation studies, were analyzed to provide background information and design studies for layout and content of nautical chart presentations. Criteria for the determination of nautical chart requirements for inland lakes and reservoirs were approved.

A study was begun to determine the feasibility of charting oil pollution zones and prohibited zones on appropriate Coast Survey charts.

A study of commercial casualty reports was assigned. The object is to determine their value for nautical charting and, if affirmative, establish criteria for processing them.

A representative of the Bureau is participating in a Bureau of Public Roads sponsored panel on urban mapping needs. Our primary interest is to influence the producers of these maps, and the periodic revisions, to subscribe to at least minimal Coast Survey standards and to present the data in a form that can be used directly as output in our proposed automated nautical chart compilation system. Operational planning is being conducted in conjunction with long-range chart planning for coverage and layout requirements.

Procedures and specifications are being developed and tested for processing systems of hydrographic data; (1) a policy recommendation was forwarded to the Office of Cartography; (2) all of the ADP techniques have been completed, tne machine plotting soundings are ready for comparison with the penciled smooth sheet (this method awaits verification scheduling); (3) the systems analysis and testing have been validated and a definite economics justification was determined for the use of automation in certain fields of nautical chart activity; and (4) microfilm tests were conducted and are now being evaluated for possible utilization in storage and retrieval of source materials.

A preliminary design of the task for the dissemination of chart-correction information has been formulated. The first phase will be to analyze methods of obtaining definitive information depicting the significance of the present chart correction system from the chart user. The results will be reviewed in correlation with the methods of dissemination suggested by Bureau employees. The second phase will be to promote a preliminary testing of the proposed action to better indicate the position the Bureau should take in anticipating and solving this problem. New techniques to improve data dissemination to the chart user were discussed. One concept was approved for research in order to find methods of efficient implementation.

A report on hovercraft operations in San Francisco Bay, received from the San Francisco Regional Office, was evaluated. This report contains useful information and comments on the use of hovercraft and problems created in nautical charting.

The Analysis of Natural Phenomena as They Affect Nautical Charts Project has been redesigned to group natural phenomena into three reporting task categories under physiographic and oceanographic changes: violent, progressive, and retrogressive. Earthquakes, severe storms, diastrophic forces, the action amd interaction of winds, waves, tides and currents, and other natural phenomena result in drastic, cyclical, or systematic changes in coastal topography accompanied by differences in depths of contiguous water areas. These changes must be translated into revised nautical charts, required for safe maritime navigation, by the determination of the need for, and the priority of, survey data.

A history of the Nautical Chart Division participation concerning the effect of the March 27, 1964, Alaska earthquake on the Bureau nautical charting program was completed and forwarded. The response criteria, developed coincident with the Alaska experience, were utilized to obtain pertinent damage data on the effect of the April 29, 1965, Seattle earthquake on the charting program. The minimal damage reported required no further response by the Nautical Chart Division.

A representative of the Division participated in a meeting on tidal hydraulics sponsored by the Corps of Engineers in San Francisco, Calif., May 24-26, 1965. Significant data were gathered on the generation, flow, flocculation (aggregation), and deposition of sediments; tidal currents and other natural phenomena having a direct effect on the Bureau nautical charting program. This will be correlated with other pertinent physical data to provide a basis for establishing survey priorities.

A report was prepared on the December 10-11, 1964, meeting in Urbana with representatives of the Department

of Geology, University of Illinois, to explore the possibility of relating Nautical Chart Division Project, "Analysis of Natural Phenomena as They Affect Nautical Charts," to the cooperative studies in marine geology performed under a Bureau grant to the university. Suggestions were made to reorient that phase of the marine geology project dealing with photogeology to produce data that would be beneficial to the Bureau's nautical charting program.

Ocean survey sheet coverage of the southeastern United States coast, complete with Loran "A" and "C" lattices, was designed for the Duke University Marine Laboratory.

Cartography Program.--This program was principally developmental in nature. This was a result of the ever-increasing speeds of commercial aircraft, the tremendous complexity of the airspace control system, and the continuously shrinking schedules for the revisions and reproduction of aeronautical charts. New emphasis was placed on automation of processes. A contract was awarded to study the problem.

Under the New and Improved Concepts of Data Presentation - Aeronautical Project, several models of relief portrayal were designed to develop the optimum depiction of land configurations as they relate to visual aeronautical charting requirements. An evaluation of the models indicated the feasibility of: (1) portraying mountainous terrain as "islands" of shaded relief, and other terrain with hypsometric tints; (2) uniting shaded relief and hysometric tints in such a manner that relative dimensions of the terrain are determinate; and (3) developing a more distinct separation of hypsometric tints which will allow the removal of contour lines to increase the legibility of the chart. As a result, several prototype charts are being printed to incorporate the indications of the study. In conjunction with the prototypes, the Naval Oceanographic Office is preparing shaded relief reproduction materials especially rendered for the purpose of preparing additional prototype charts.

The final report on Research Grant No. CGS-1171(G), a "Feasibility Study on Four-Color Process Printing," has been received and its recommendations are being studied for application to the design and production of aeronautical charts.

Desk evaluations of master graphics of simulated and actual airspace dockets were conducted to finalize data content, symbolization, and accuracy requirements for an operational evaluation of a master graphic or "compaid" (contraction for compilation of airspace docket) of proposed airspace dockets. The operational evaluation is now being conducted by application of master compaids

of selected actual airspace dockets, photographically reproduced to the various scales of the several chart series, in actual chart production.

An improved vignette used for the portrayal of floors and ceilings of controlled airspace is so satisfactory that further development work was terminated.

One aircraft position chart was designed and two were redesigned to satisfy the charting requirements of U. S. air carriers overseas operations. The new designs include the results of a comprehensive study of the properties of various projections, scale factors, and scales relative to operational requirements of air carriers.

Under the Automation of the Cartographic Process - Aeronautical Project, a contract for an operations research study of the aeronautical charting activities of the Coast and Geodetic Survey was awarded to the Planning Research Corp. The corporation assigned a four-man team to the study. The team has nearly completed the initial data collection phase of the study, proceeding in this phase by means of intensive interviews with selected personnel of each branch at all levels and with representatives of other divisions having informational interfaces with the Aeronautical Chart Division.

Under the Advanced Cartographic Development Project, several sample printings of suggested color changes, along with the addition of a shaded relief portrayal, were accomplished. Film positives of relief and the necessary masks were produced to aid in further study and development. In cooperation with the Aeronautical Chart Division, preparations are underway to make prototype charts depicting several development ideas of tint and relief portrayal.

The requirement to minimize the general prominence of vignette tint used for airspace portrayal, while simultaneously intensifying delimitation, was accomplished. A standardized procedure was developed and instituted to provide consistent symbolization on a production basis.

Work was begun on developing standardized procedures for producing and consistently duplicating soft-dot screens which are essential to the manufacture of vignetted negatives. Although some study of methods and materials was accomplished, production demands on both manpower and equipment has precluded any major effort to date.

Geodesy/Photogrammetry Program.--The research and development activities under the Geodesy/Photogrammetry Program were basic, applied, and developmental in nature, and supported the traditional missions of the Bureau in geodesy, gravity, mapping, and charting. These activities were directed toward the improvement of existing measurement systems in conventional geodesy through the util-

ization of new science and technology and the perfection of satellite geodesy as a potent new tool for the study of the size and shape of the earth.

Much effort was devoted to the Satellite Geodesy Project in establishing an operational capability for satellite triangulation within the Coast and Geodetic Survey.

In preparation for the execution of the National Geodetic Satellite Program (world net) a detailed theoretical error study was completed. The results give not only quantitative information about the overall accuracy which can be obtained, but make it possible to optimize and thereby economize the field work, by determining ahead of time the optimum number of missions which should be observed and the necessary number and optimum location of base lines which must be measured.

A considerable effort was spent to complete the computer program for the new single-camera simulation model, a necessary tool, not only for satellite triangulation, but for detailed analysis of high-precision photogrammetric sensors.

A considerably improved and more complex satellite triangulation program has been carried through all theoretical phases and expressed in corresponding mathematical formulations. This program will adjust rigorously up to 50 stations and handle single or multiple satellite missions when observed simultaneously from as many as seven stations. The program will handle, not only all anticipated spatial triangulation problems in connection with the worldwide Pageos program and the presently contemplated intensification nets, but will equally well reduce data collected from flashing light satellites, as presently contemplated by the National Aeronautical and Space Administration (NASA) for launching in the Geos series.

In support of the effort directed toward the formulation of computer programs for increased economy and increased accuracy, a detailed analysis of all experimental data was performed and summarized in a report.

Field work and testing of additional BC-4 systems (specifically 4 Department of Defense systems) have been completed. The corresponding data reduction process is in progress and preparation for data analysis has been completed.

A new preliminary position of Antigua was determined which proved the previously accepted position to be in error.

In the field of satellite dynamics, work is progressing on the preparation of an orbit ephemeris computer

program which will serve as a vehicle for obtaining precise predictions of Echo-type satellites. The program is modeled after the Smithsonian Astrophysical Observatory Differential Orbit Improvement (DOI) program, but has the advantage of being written in Fortran language. During this reporting period, those portions of the program were prepared which accept observations in the right ascension-declination system and carry through the orbit analysis to the determination of the final orbital elements.

The primary effort for the Precise Distance-Measurement Project, has been on refractive index studies at the Bureau of Standards at Boulder, and on cooperative Coast Survey and Standards, Laser geodimeter studies. A proposal was prepared by the Bureau of Standards for the investigation of a technique for measuring the path difference of particular optical frequencies for the purpose of determining the refractive index correction along a 10-mile horizontal path. A Model 2A Geodimeter, furnished by the Coast Survey, has been modified to measure the path diffence of various optical frequencies using discriminating filters. Some encouraging data have been obtained. This instrumentation is currently being modified to measure both wavelengths simultaneously. In addition, an optical system to measure the path difference between the red and blue line in the visible spectrum over a distance of 10 miles was designed and fabricated.

A 0.5 milliwatt Laser has been adapted to the Model 4D Geodimeter such that measurements can be made both with the mercury vapor light source and a 6328A. red line. Precise base line measurements and an 8-mile line have been successfully measured and reported to the American Congress of Surveying and Mapping. An improved photo multiplier has been tested and evaluated for the Model 4D Geodimeter. It is estimated that the range of the 4D will be extended by 3 miles. An experimental photon pot has been designed and is being fabricated in-house. This systdm is designed as an attachment to the 4D geodimeter and represents about the limit of the state of the art.

Sufficient data have been obtained on the precise base line at Beltsville to determine the geodimeter bias errors. Model 4D Geodimeter measurements have been compared with taped distances and no large bias error is apparent. Further analyses of these data are in progress.

Under the Reduction of Geodetic Measurements Project, work on conformal transformation of the gravitational field has been summarized in a paper presented to the International Association of Geodesy, Symposium on Mathematical Geodesy, Turin, Italy, in April 1965. The meeting passed a resolution calling attention to this new line of attack on geodetic problems and asking the International Association to encourage further research on these lines. It was also suggested that the investigation should be broadened to cover more general deform-

ations of space. In addition, a second paper on triply orthogonal coordinate systems was also presented at Turin.

Under the Numerical Photogrammetric Research Project, preliminary results of the new single camera had shown the desirability of additional sophistication. Thus, the analytical model was modified accordingly and now provides 26 degrees of freedom for simulating the complex geometry in a precision photogrammetric data acquisition system. The corresponding computer program provides the Coast and Geodetic Survey, in the field of satellite geodesy and photogrammetric components research, with a unique and flexible, complex, sophiticated tool. The program now furnished is believed to provide an essential tool for the Bureau's effort in establishing an adequate potential for precision analytical photogrammetry in its effort to find a new, economical approach for geodetic control determination.

At the Ballistic Research Laboratories in Aberdeen, Md., the programing documentation effort produced reports on the single camera and single model, written in Fortran language. Additionally, the programing for the rigorous adjustment of an unlimited strip triangulation has been finished and tested with excellent results on fictitious photography, with and without simulated measuring errors. These results are in complete agreement with the results obtained formerly from error theoretical studies.

The Development of Optimum Photogrammetric Data Acquisition Systems Project was directed toward the development and execution of a full-scale test to apply precision photogrammetric techniques to the measurement of minute earth crustal movements. The result of the data reduction, which is in process, has proven the feasibility of the method. The accuracy obtained so far is one part in 100,000 indicating the possibility of monitoring, by this method, earth crustal movements of half of a millimeter or less.

Under the Special Photogrammetry Applications Project, field tests were completed for subsurface current drogues and for the use of fixed reference points in open water areas. These tests were made in connection with the photogrammetric current survey of Long Island Sound this spring using color photography and color-coded targets to distinquish between the drogue and surface targets.

Under the Photogrammetry Systems Development Project, the error study planned for our stereocomparator was completed successfully. The manufacturer's engineer was informed of the kind and magnitude of the error in order that he might correct it. The instrument was then subjected a second time to the special error study and found acceptable. Systematic secondary nonlinear way and screw length errors introduced in overcoming the larger random error were finally compensated by changing the mathematical model used for comparator error compensation.

Experiments were made on the precise duplication of satellite camera plates for the purpose of improving the accuracy of stellar image measurement through the use of point images of stars and a reversal of photographic tone through contact printing using a point source of illumination.

A new glass grid for the analysis of the effects of film distortion with respect to aerotriangulation with eight camera fiducial marks was designed, procured, and calibrated. Two grid samples were measured and analyzed in connection with the study of the effect of film distortion made with aerial photography of our Ohio Camera Calibration Area. This study resulted in the decision that our present mathematical model for the compensation of film distortion is inadequate.

Analysis of the magnitude of color distortion or differential magnification was completed and our Aviogon-type aerial camera lenses were found to be adequately corrected in this respect. As a result of this study and preliminary results of color film distortion studies, the use of color photography was qualified for use on the most precise types of photogrammetric aerotriangulation.

OFFICE OF ADMINISTRATION

OPERATIONAL ACTIVITIES

Personnel Division

Continuing from last fiscal year, Personnel Division and National Maritime Union representatives worked closely to set forth a basic agreement covering unlicensed, non-supervisory personnel aboard Bureau vessels. The final agreement was signed by Bureau and Union officials on February 9, 1965. Subsequently, the General Work Rules were completed, reviewed, and approved. With the exception of the Sections covering Uniform Allowances and Payment for Security and Anchor Watches, they were effective June 15, 1965.

The Seattle Regional Office assumed responsibility for performing limited personnel services for the Portland, Oreg., and Alaska Field Offices, and Classification Act employees in Seattle. Personnel folders for the 45 employees involved were transferred to Seattle. The Norfolk Regional Office was delegated authority for personnel management functions, and 279 personnel folders were forwarded to that office.

Progress has continued under the Equal Employment Opportunity Program. The record shows that we now have 329 Negroes on the roll, as compared to 302 on June 30, 1964. Promotions to grades GS-7 through GS-11 increased considerably over previous years.

Program emphasis in the Classification and Wage Administration Branch was placed on Standards review and development, survey activities, wage marine analysis, and training operating officials to keep the compensation program current.

Standards Development.--Review was arranged and conferences held with operating officials on Civil Service Standards for Civil Engineering, GS-810-0; Supervisory Evaluation Guide, Part II; Cartographic Technician, GS-1371-0; General Series 501, 2001, and 2101; Publication Supply, GS-2090-0; Accounting, Part II, GS-570-0; Time and Leave, GS-590-0; Electronic Technician, GS-856-0. These officials' comments were transmitted to the proper offices.

Following complete field work on a comprehensive study of the Wage Marine Pay Plan, a recommendation was made for conversion from a graded system to a system of individual ratings and pay rates in keeping with industry practice. A three-step pay plan for each rate was recommended: an inhiring rate, a job rate, and a meritorious rate. Each pay rate was to be based on job performance. This system, which is used in progressive business and industrial pay plans, was designed to allow line management to retain its perogatives in salary administration.

Maintenance Review Surveys.--To conserve manpower and concentrate on appropriate targets for job analyses, an intensive study was made in the Nautical Data, Conventional Chart, Small Craft, Presswork, Negative Engraving, and Photo-Mechanical Branches. In accordance with out agreement with the Amalgamated Lithographers of America, Local 98, all wage board lithographic jobs were audited.

Field Travel.--Visits were made to the Seattle, Norfolk, and San Francisco Regional Offices; Gaithersburg and Ukiah Observatories; Albuquerque Seismological Laboratory; White Sands Missile Range and Vandenburgh Air Force Base; Tucson Magnetic Observatory and contract Seismological Observers at Salt Lake City and Eureka, Nev.; Boston, New York, and Los Angeles Field Offices; and Field Parties in New York. Audits were made at each location. Audits were also made on all ships at Norfolk, St. Petersburg, San Francisco, and Seattle in connection with the Wage Marine Study.

Staff Work and Special Studies.--The Branch participated in/or initiated a variety of special studies. Developed special program analysis for review of environmental science activities, Commerce (RESAC) study as well as a special program review by the Secretary's Office, Office of Personnel. Participated in the Interdepartmental Lithographic Wage Board wage rate survey.

New jobs were set up for regionalization at San Francisco and Kansas City and a field audit was made at San Francisco. Jobs at the Norfolk Regional Office were developed with on-site audits. Developed pay standards for tide observers, guide lines for classification delegation at Seattle Regional Office, a special engineer-technician utilization project for the 3-E Program, and guidance material for the Research Scientist Committee which was organized for evaluating Research Scientist positions.

Activity of the Training Branch in the field of Executive Development expanded. Bureau employees attended more than 60 courses in Executive Development - an increase of 100 percent in the number of similar courses attended the previous fiscal year.

Emphasis was placed on scientific and technical training as a means of better utilizing the capabilities of employees in the Bureau's expanding scientific activities. Employees participated in programs and courses conducted in-bureau, interagency, and non-Government training facilities under the Government Employees Training Act.

There was an increase in full-time graduate studies in the scientific fields. Sixteen employees were enrolled in such studies at 11 universities. Fourteen attended classes in oceanography, photogrammetry, geodesy, seismology, and geophysics; two attended classes in business

administration. One employee received the Career Education Award from the National Institute of Public Affairs and attended Stanford University on a full-time basis.

The Officer Training Program continued to provide accelerated training for newly commissioned officers preparatory to field assignments. The Earth Scientist Program and the Geophysicist Training Program also continued.

Shipyard training included the Quartermaster Surveyor and Yeoman Training Programs. As part of these programs, trainees were enrolled in technical correspondence courses. In addition, employees aboard ships and on field parties were enrolled in electronic and engineering correspondence courses.

Both interagency and non-Government facilities were used for training an increased number of employees in the application of automatic data processing.

Programs of special value in the recruitment and retention of quality personnel were the Earth Scientist, Yeoman Training, and Quartermaster Surveyor Programs.

The Earth Scientist Program has provided accelerated training in various scientific fields. Four employees have completed this training and were assigned in the fields of research and development, oceanography, geomagnetism, and seismology.

The Quartermaster Survey and Yeoman Training Programs have enabled the Bureau to recruit quality high school graduates through selected testing requirements which determine their ability for advancement to positions of Chief Quartermaster Surveyor or Chief Yeoman. These programs meet an urgent need because of the Bureau's increased oceanographic activities.

The Government Employees Training Act has enabled the Bureau to train, retrain, and develop the capabilities of its employees for greater productivity and flexibility of assignment. Over 1,000 employees participated in in-bureau, interagency, and non-Government training courses and programs.

The Bureau's participation in interagency courses increased during this fiscal year. Over 360 employees attended interagency courses. The diversification and availability of these courses for employees has been of great benefit to the Bureau.

In the Washington area, employees attended courses conducted by the Patent Office Training Laboratory in reading improvement, report writing, effective English usage, and letter writing.

Recruitment in colleges by the Employment and Employees Relations Branch continued this fiscal year. In line with

the Equal Employment Opportunity Program, two recruitment visits were made to Howard University. In addition, a branch member participated in a televised program which discussed the Federal Government's efforts to recruit quality personnel from minority groups.

Emphasis was placed on the preparation of brochures to be used in the Coordinated College Recruitment Program of the Department of Commerce.

The Board of Examiners established the register for Printing Plant and Lithographic Trainees on August 11, 1965. The register listed 66 eligibles and is now nearly depleted.

On March 4, 1965, a proposal was made for a new Surveying Aid announcement. This announcement, covering grades GS 2, 3, and 4, only, would be used for filling vacancies with mobile field units only.

Work on revised qualification standards covering positions of geodesist, grades GS 5 through 15, was completed during the year. The revision was submitted to the Civil Service Commission for approval.

Following preliminary surveys, conferences, and observations of systems already in use, the Branch completed its system for processing personnel records into an ADP system. Washington Office records were processed first and the first personnel roster using this system was completed by the end of December 1964. This involved coding approximately 2,000 records. In February 1965, the Seattle and Norfolk Regional Offices submitted approximately 300 transcripts each for review in the Personnel Division and submission to ECD.

By August we had formulated tentative plans for a Career Management Program. During the year preliminary steps were taken to identify and define career patterns for scientific and engineering positions and for vessel positions. Inventories were run to establish grade structure and identify promotional opportunities.

Nominations were submitted and approved for two Bureau employees to receive the Presidential Citation given at the 10th Anniversary of the Incentive Awards Act Program. Five employees received the Department of Commerce Gold Medal for Exceptional Service; two received the Silver Medal for Meritorious Service.

Project-Thrift, the special suggestion project sponsored by the Department of Commerce, was implemented during May and June.

During the fiscal year, $13,050 was awarded employees for sustained superior performance; $1,750 for special acts or services; and $965 for suggestions.

The Coast and Geodetic Survey was one of seven Department of Commerce bureaus to attain 25 percent participation in the Savings Bond Campaign held during May.

The Bureau did its share in implementing the President's Youth Opportunity Program. A total of 49 young people were hired - 20 in the D. C. Metropolitan Area - in clerical and laboring positions at $1.25 per hour.

Administrative and Technical Services

The Division completed 2,508 procurement actions amounting to $5,602,667, a decrease of $708,082 over the previous fiscal year. A breakdown of the procurement activities is indicated below:

	No.	Amount
Negotiated contracts and grants	78	$1,682,334
Advertised contracts	70	1,261,591
Open market and other purchases	2,360	2,658,742
Total	2,508	$5,602,667

Excess property amounting to $168,350 was transferred to General Services Administration and other government agencies. The Bureau acquired, without cost, surplus property valued at $346,918 from other federal organizations.

Inbound and outbound shipments totalled 563 tons. Approximately 77 percent of the shipments were carried by motor freight; the remainder was transported by express, rail, air and mail.

The vessel SCOTT was sold to the highest bidder. During the year, 40 trucks and 3 trailers were sold and 56 trucks and 9 trailers were purchased. Sixteen claims for damages were settled for $2,574.

Requisitions for printing were processed in the amount of $164,939. An estimated expenditure of $59,902 was required for 296 job orders for housekeeping services.

The Bureau through a continuing records disposition program eliminated 2,985 cubic feet of records from Coast Survey space. Of this amount, 2,562 cubic feet were disposed of and 423 cubic feet were transferred to the Federal Records Center for future servicing from that facility. This action released for re-use 232 file cabinets, 731 linear feet of shelving and 1,329 square feet of floor space. The Archives Section accessioned and registered 6,334 field and office records and 800 project and monthly reports. During the year, 4,037 C&GS documents were retrieved and serviced from the National Archives and Federal Records Center.

The Division processed 1,578 temporary duty travel orders, 195 travel orders involving a permanent change of

station and 595 individual travel requests. Approval was obtained for 294 foreign travel requests, security clearances and passport clearances.

The Chief of the Division, in the capacity of Publications Officer for the Bureau, planned and coordinated the Bureau's publications program. Final production of all book and pamphlet publication was expedited. As a result of liaison with the Office of Publications in the Department, issuance of Bureau publications was effected on a definite schedule.

Administrative printing requests were monitored to determine facilities to be used, to arrange scheduling, to establish priorities and to expedite printing. Through cooperation and coordination with the Reproduction Division and the Department's printing facilities, deadlines were met and workloads were alleviated.

Ship's bases and ships were inspected by the Safety Officer and consultations were held with Regional Officers and Ships' Commanding Officers. Most geodetic field parties were visited and personal contact made with many of the field personnel. The Bilby Steel Tower Safety Committee met several times and recommended field testing of three manufacturers' items to improve safety conditions for personnel who are required to climb the towers. Chapters on Material Handling and Pressroom Safety were drafted and are now being field tested for adaptability prior to final issuance. During the year, the Coast and Geodetic Survey was awarded the Secretary's Award for Safety accomplishments.

Approximately 80,000 new maps were received and processed in the maintenance of the Bureau's collection of map source material. More than 75,000 maps were distributed from the files, of which approximately half were used in support of the cartographic program of the Bureau, and the remainder were issued in the practice of disseminating map information to the public and to other agencies of the Government. Over 25,000 maps were eliminated from the files as obsolete or superseded. Approximately 500 copies of early Coast and Geodetic Survey charts, many used in litigation, were issued, and hundreds of letters containing map information were sent out in response to specific inquiries.

Approximately 270 nautical charts, 130 aeronautical charts, and various other Bureau publications were verified or provided geographic names as part of the names-verification procedure for Bureau publications. In addition, name lists were supplied for 60 new hydrographic survey sheets and 180 planimetric maps. As a result of names research in the division and field reports, more than 140 cases of name conflict were submitted to and decided upon by the Board on Geographic Names, in an attempt to effect more uniformity among federal agencies

in place-name usage. In addition, about 160 cases of names disputes were settled with the Geological Survey by direct liaison, without recourse to the Board on Geographic Names. As a result of names research during the year, over 300 name changes were made on nautical charts and more than 200 such changes on aeronautical charts. About 170 letters were written during the year to reply to the names information requested by the public and others, most of which required considerable research.

Special sheets for the field investigation of geographic names were prepared for 27 different project areas. In response to this, 23 geographic names field reports were received and processed. In keeping with the program of maintaining names standards current, new Geographic Names Standards were made for more than 200 of the Bureau's charts and standard name-correction copies were made for Coast Pilots and Tide Tables.

Approximately 1,500 items were added to the card file of Board on Geographc Names decisions, alphabetical by states, during the year. Another card file of considerable value was also continued during the year, the alphabetical file of Atlantic coast place-name locations to which about 3,500 location cards were added. Public relations were maintained through the system of soliciting geographic names information from valuable local sources by mail. Approximately 65 solicitations were made and those consulted felt that they were a part of an interesting and important undertaking.

A file on source material and indexes for the compilation of aeronautical charts was continuously maintained. Approximately 1,900 aerial photographic indexes were received and processed. Source material was provided for the revision of 322 aeronautical charts, in keeping with the Bureau's aeronautical chart revision program.

In excess of 2,500 photographs and slides depicting Bureau subjects were accessioned and placed in the files. Over 10,000 photographic prints and slides were issued and more than 750 reels of motion picture films portraying Bureau activities were loaned.

The district offices and various schools and colleges throughout the country were the principal users of these visual aids. Other recipients included U. S. Naval Applied Science Laboratory, Brooklyn, N.Y.; U.N.T.V. United Nations, New York, N. Y.; Sanders Associates, Inc., Nashua, N. H.; National Science Foundation, Washington, D.C.; Grolier, Inc., New York, N. Y.; Merkle Press, Inc., Washington, D. C.; and McGraw-Hill Co. of Canada, Ltd., Toronto, Canada.

Numerous exhibits and display panels were prepared and placed at various regional and international boat shows throughout the country. In addition to scenic paintings for

exhibits, approximately 550 special maps, graphs, and charts were prepared for a variety of Bureau and Departmental needs.

The artistic illustrative work and the preparation of certificates was transferred to the Department of Commerce during the year.

Approximately 3,000 books and pamphlets were added to the permanent collection of the Bureau library and about 200 volumes were eliminated. More than 5,300 books and pamphlets were circulated and slightly over 100 books were loaned to other libraries. The Library borrowed about 550 books from other libraries.

Budget and Finance Division

Continued emphasis was placed on improving and simplifying procedures and reducing paper work. Some of the most significant accomplishments were included in the Bureau's Financial Management Improvement Program report to the Director, Office of Budget and Finance. The major accomplishments reported are as follows:

A number of procedural changes were made to simplify the accounting, payrolling, and vouchering processes and thereby effect monetary savings. Examples of changes made are as follows:

1. Special records of accounts payable, maintained on punched cards, were discontinued. This action eliminated work involved in coding, key punching, machine processing and manually pulling about 2,000 cards each month. The change in procedure resulted in an annual savings of over $3,000.

2. In fiscal year 1964, work was started to improve the procedures used in reconciling property accounts. This work was completed in fiscal year 1965. Also, the criteria for capitalization was changed from $50 to $100 and a large number of low cost items will be expended over a 5-year period. The improved procedures have resulted in an annual savings of over $2,000.

3. A new procedure was installed to verify that overtime has been approved. The new procedure saves time and helps even out the workload. In addition, the standard simplified payroll system used to pay about 163 officer personnel was replaced by a mechanized payroll system. These actions have resulted in annual savings of $1,000.

A new chapter in the Bureau Finance Manual was issued. This chapter prescribes procedures to control the timing of payments of grants, made by the Bureau, to educational and

nonprofit organizations. In addition, eighteen revisions were published on previously issued chapters.

Two employees in the Finance Branch of the Budget and Finance Division attended a course in Statistical Sampling for Financial Management, conducted by the Graduate School, U. S. Department of Agriculture. The course was completed in 16 weeks during the period of September 16, 1964, through January 13, 1965.

A limited study was made to determine the feasibility of using statistical sampling in the examination of vouchers. The study indicated that due to the relatively small volume of each of various types of vouchers under $100, use of statistical sampling would not result in significant savings.

The following funds, from sources indicated, were made available to the Coast and Geodetic Survey during fiscal year 1965.

Available Funds

Appropriations:		
Salaries and Expenses		
Appropriated funds	$27,205,000.00	
Unobligated balance carried forward from fiscal year 1964	1,465,121.05	
Reimbursement Program	9,680,026.94	
Transfer from the Department of Commerce, Office of the Secretary	22,000.00	
		$38,372,147.99
Construction of Surveying Ships		
Appropriated funds	9,000,000.00	
Unobligated balance carried forward from fiscal year 1964	16,422,919.25	
		25,422,919.25
Construction and Equipment, Seismological Laboratory		
Appropriated Funds	575,000.00	
Unobligated balance carried forward from fiscal year 1964	13,072.73	
		588,072.73
Total funds available		$64,383,139.97

Engineering Division

A major effort of the Division was in support of research and development projects and the implementation of automatic data acquisition and processing, particularly in the area of hydrographic surveys. With the exception of a few instruments and systems developed in-house and located in the Washington, D. C., area, maintenance responsibilities have been transferred to the Regional Offices.

Procurement of frequencies for communication and for navigation systems, assignment of call letters, and monitoring of communication regulations are responsibilities of the Division.

The Division continued to evaluate new systems and to recommend their use when so indicated. Establishing of lists of electronic equipment needed by operating divisions, preparation of specifications for such equipment, and monitoring of its procurement remained responsibilities of the Division. Monitoring of the design and procurement of the automation system for the oceanographic sensors related to the computer complex of the Class I vessels continued to be the responsibility of the Division.

NATIONAL AND INTERNATIONAL COOPERATION

As part of the Bureau's policy, cooperation was extended to other Government agencies, to national societies, and to private concerns of national scope. On the interagency level, this was in addition to the usual liaison, reimbursable work, and the normal exchange of maps. These activities included the provision of aeronautical chart bases to numerous other agencies and cooperation in the form of geographic consultation to the Office of the Geographer of the State Department and to various Members of Congress.

As a mutually beneficial service, all advance quadrangles of the Geological Survey covering coastal areas were reviewed in the Division for agreement in geographic nomenclature. Of 980 sheets reviewed, about 130 were returned with corrections, effecting consistency in name usage. A similar service was performed for the Shipping Branch of the Census Bureau, and for proof reading of Coast Guard Light Lists for correctness and agreement in geographic service.

The Division continued to be represented on the interagency Board on Geographic Names. Through the efforts of this liaison, existing differences in nomenclature between the various Federal maps were considerably diminished. This included such important agreements as the uniform naming of many nationally famous geographic sites.

Special cooperation was extended to the Department of Justice and other departments of our Government. Consultation was extended the Department of Justice relative to interpretation of geographic features and the delimitation of jurisdictional areas and seaward boundaries in Louisiana; along portions of the coasts of Florida, Washington, California, and adjacent to the mouth of the Columbia River.

Various officials of the Department of Commerce were served through interpretation of coastal geographic phenomena relating to matters of prime importance in commerce and litigation.

Activities in international cooperation through the practice of international exchange of maps and publications and through other media were continued. Nearly 120 letters concerning this exchange were prepared and numerous special services were performed along this line. The exchange of charts with member maritime nations was also beneficial.

APPENDIX

PUBLICATIONS ISSUED

Tides, Tidal Currents, and Oceanography

The following Tide and Tidal Current Tables were published by the Government Printing Office:

Tide Tables, East Coast, North and South America, 1966.
Tide Tables, West Coast, North and South America, 1966.
Tide Tables, Europe and West Coast of Africa, 1966.
Tide Tables, Central and Western Pacific and Indian Oceans, 1965.
Tidal Current Tables, Atlantic Coast, North America, 1965.
Tidal Current Tables, Pacific Coast, North America and Asia, 1965.

Soviet Oceanography 1964: A Trip Report, by R. S. Dietz.

Coast Pilots

United States Coast Pilot 4, Atlantic Coast, Cape Henry to Key West, Seventh Edition, 1964.
United States Coast Pilot 9, Pacific and Arctic Coasts, Cape Spencer to Beaufort Sea, Seventh Edition, 1965.

Photogrammetry

Aerotriangulation: Image Coordinate Refinement, by M. Keller and G. C. Tewinkel, Technical Bulletin No. 25, March 1965.
Aerotriangulation Strip Adjustment Using Fortran and the IBM-1620 Computer, by C. T. Horsfall, March 1965.
Aerotriangulation Strip Adjustment, by M. Keller and G. C. Tewinkel, Technical Bulletin No. 23, August 1964.
Satellite Triangulation in the Coast and Geodetic Survey, Technical Bulletin No. 24, February 1965.

Seismology

Earthquake Investigations in the Western United States, 1932-1964, by D. S. Carder.
The Tsunami of March 28, 1964, as Recorded at Tide Stations, by M. G. Spaeth and S. C. Berkman.

Seismological publications issued, or in press, included the following:

Seismological Bulletin, January 1963 through December 1964.
Seismological Bulletin, Antarctic, 2nd quarter 1964 through 2nd quarter 1965.
United States Earthquakes, 1963, by C. von Hake and W. K. Cloud.
Quarterly Engineering Seismological Bulletin, 4th quarter 1963 through 1st quarter 1964.

Abstracts of Earthquake Reports for the Pacific Coast and Western Mountain Region, 1st quarter 1964.
The Annotated Bibliography on Tsunamis.
The Puget Sound, Washington, Earthquake of April 29, 1965.
Earthquake History of the United States, Part I, by R. A. Eppley.
Libyan Earthquake of February 21, 1963, D. W. Gordon.
Seismic Safety Net, SHOAL Event, August 1964, W. V. Mickey and L. M. Lowrie.
Seismic Disturbances Generated by Titan III 624A Solid Motor Sled Test, October 1964, W. V. Mickey and T. R. Shugart.
Project DUGOUT, Strong Motion Seismic Measurements, May 1965, L. M. Lowrie and W. V. Mickey.
Identification of Seismic Phases, SALMON Event, May 1965, L. M. Lowrie.
Average Seismic Background Noise at Cape Kennedy, Florida, 1964, May 1965, W. V. Mickey and G. N. Smith.
Ground Motions Induced by SATURN Missile Launches, April 1965, W. V. Mickey and T. R. Shugart.
Seismic Noise Survey, Patrick Air Force Base, Report II, W. V. Mickey and T. R. Shugart.
Earth Vibrations from a Nuclear Explosion in a Salt Dome, SALMON Event, L. M. Lowrie, W. V. Mickey and T. R. Shugart.
A Study of the Long Period Motions Observed at Hattiesburg and Columbia, Mississippi, from Event SALMON, May 1965, T. R. Shugart.

Magnetism

Ten volumes of magnetograms and hourly values as follows were published:

Magnetograms and Hourly Values: College, Alaska, 1961; Sitka, Alaska, 1961; Honolulu, Hawaii, 1961; Fredericksburg, Va., 1963; Byrd Station, Antarctica, 1961; Tucson, Ariz., 1962; Guam, Mariana Is., 1961; San Juan, P. R., 1962; Sitka, Alaska, 1962; South Pole Station, Antarctica, 1961.

Magnetic Results-Filchner Ice Shelf Traverse, 1963-1964, by Michael Phelan.

PAPERS PUBLISHED

Alldredge, L. R., Rebuttal to Criticism by Dr. Ostinso of Genesis of the Arctic Ocean Basin; Science, July 1964.
Dietz, R. S., Sudbury Structure as an Astrobleme; J. Geology, Vol. 72, No. 4, pp. 412-434, July 1964.
Tewinkel, G. C., Status of Computational Photogrammetry in the U.S.A.; Proceedings of International Congress on Photogrammetry, Sept. 1964.
Swanson, L. W., Aerial Photography and Photogrammetry in the Coast and Geodetic Survey; Photogrammetric Engineering, Sept. 1964.
Dietz, R. S., and Butler, L. W., Shattercone Orientation at Sudbury, Canada; Nature, Vol. 204, No. 4955, Oct. 17, 1964.

Jones, B. G., and Harris, W. D., Repeat Mapping for a Record of Shore Erosion, Cape Kennedy; Shore and Beach, Journal of American Shore and Beach Preservation Association, Vol. 32, Oct. 1964.
Woodcock, L. F., and Lampton, B. F., Measurement of Crustal Movements by Photogrammetric Methods; Photogrammetric Engineering, Nov. 1964.
Brune, J. N., Travel Times, Body Waves, and Normal Modes of the Earth; Bulletin of Seismological Society of America, Dec. 1964.
Alldredge, L. R. and Fitz, J. C., Submerged Stabilized Platform; Deep-Sea Res. Vol. 11, pp. 935-942, 1964.
Alldredge, L. R., Geomagnetism of Ocean Basins; Encyclopedia of Ocean Sciences, 1964.
Dietz, R. S. Commotion in the Ocean: The Growth of Continents and Ocean Basins; Hidka Comm. Volume, Studies on Oceanography, Tokyo, 1964.
Dietz, R. S., and LaFond, E. C., Lonar Crater, India: A Meteoritic Crater? Meteoritics, Vol. 2, No. 2, pp. 111-116, 1964.
Dietz, R. S., The 'Lunar' Crater in the Arizona Desert; New Scientist, No. 376, Vol. 21, p. 256, 1964.
Dietz, R. S. Wave-Base, Marine Profile of Equilibrium, and Wave-Built Terraces: Reply. Geological Society of America Bulletin, No. 75, pp. 1275-1282.
Dietz, R. S., Carsola, A. J., Buffington, E. C., and Shipek, C. J., Sediments and Topography of the Alaskan Shelves; Papers in Marine Geology, Shepard Commemorative Volume, Macmillian Co., N. Y., pp. 241-256, 1964.
Holden, J. C., Upper Cretaceous Ostracods from California; Palaeontology, Vol. 7, Pt. 3, pp. 393-429, 1964.
Tocher, D., Earthquake Intensity and Magnitude Scales; Part 1, A61 Data Sheet 47a, Geotimes, Vol. 8, No. 8, pp. 19-20, 1964. Part 2: A61 Data Sheet 47b, Geotimes, Vol. 9, No. 1, pp. 19-20, 1964.
Tocher, D., Earthquake and Rating Scales; Geotimes, Vol. 8, Vol. 8, pp. 15-18, 1964.
Elvers, D. J., and Yellin, M., Geological Structure of the Aleutian Trench Southwest of Kodiak Island; Journal of Geophysical Research, Vol. 7, No. 2, Jan. 15, 1965.
Hickley, T. J., Some Recent Systems Development by U. S. Coast and Geodetic Survey; International Hydrogrphic Review, Vol. XLII, No. 1, pp. 41-56, Jan. 1965.
Schmid, H. H., and Schmid, E., A generalized Least Squares Solution for Hybrid Measuring Systems, C&GS, Washington, D. C., Jan. 1965.
Dietz, R. S., Letter to the Editor: Project Gondwana; Geotimes, Vol. 9, No. 7, Mar. 1965.
Lander, J. F., Notes on Observatory Seismology in Africa; Earthquake Notes, Vol. 36, pp. 16-17, March-June 1965.
Nichols, H., and Perry, R. B., Bathymetry of Adak Canyon, Aleutian Arc, Alaska; Geological Society of America Bulletin, Vol. 76, pp. 365-370, Mar. 1965.
Dietz, R. S., Soviet Research in Oceanography; Geotimes, Vol. 9, No. 8, pp. 11-12, Apr. 1965.

Hickley, T. J., Systems Development at Coast and Geodetic Survey; DATA, Magazine of R&D Management, Vol. 10, No. 4, pp. 42-46, Washington, D. C., Apr. 1965.
Dietz, R. S., Review of Bombarded Earth; Geographical Magazine, Vol. 38, No. 1, London, May 1965.
Dietz, R. S., Review of Physiographic Diagram of the Indian Ocean; Science, Vol. 148, May 7, 1965.
Malloy, R. J., Seafloor Upheaval; Geo-Marine Technology, May-June 1965.
Perry, R. B., and Schimke, G. R., Large-Amplitude Internal Waves Observed Off the Northwest Coast of Sumatra; Journal of Geophysical Research, Vol. 70, No. 10, pp. 2319-2324, May 15, 1965.
Goodheart, A. J., Iseley, C. W., and Hicks, S. D., Deep Sea Tide Gage, Ocean Science and Ocean Engineering, Vol. I, pp. 304-312; Transactions of the Joint Conference and Exhibits of Marine Technology Society and American Society of Limnology and Oceanography, June 14-17, 1965, Washington, D. C.
Lander, J. F., Jordan, J. N., and Black, R., Aftershocks of the February 4, 1965, Rat Island Earthquake; Science, Vol. 148, No. 3675, pp. 1323-1325, June 1965.
Tocher, D., VELA UNIFORM Aleutian Islands Seismic Experiment, 1964; VESIAC Special Bulletin, pp. 1-5, June 1965.
Poling, Austin, C., A Taped Base Line and Automatic Meteorological Recording Instruments for Calibration of Electronic Distance Measuring Instruments; International Hydrographic Review, Vol. XLII, No. 2, pp. 173-184; July 1965.
Algermissen, S. T., and Bardsley, S. R., Evaluating Oil Shale by Log Analysis; World Oil, Aug. 1965.
Jordan, J. N., Bates, C. C., and Black R., Patterns of Maximum Amplitudes of P_n and P Waves over Regional and Continental Areas; Bulletin of the Seismological Society of America, Vol. 55, No. 4, pp. 693-720, Aug. 1965.
Algermissen, S. T., The Program in Engineering Seismology of the Coast and Geodetic Survey; Earthquake and Geologic Hazards Conference, pp. 54-60, 1965.
Burns, R. E., Results of Tests Evaluating the Behavior of Free-Falling Gravity Coring Devices in Water; Deep Sea Research Journal, 1965.
Burns, R. E., Sea Bottom Heat-Flow Measurements in the Andaman Sea; Journal of Geophysical Research, Nov. 15, 1964.
Oshiver, A. H., Stone, R. B., Clark, J. R., and Berberian, G. A., Factors in Measurement of Absolute Sea Surface Temperature by Infrared Radiometry; Inst. of Science and Technology, University of Michigan, Proceedings of the Third Symposium on Remote Sensing of Environment, pp. 737-762, 1965.
Rinehart, J. S., Explosive Workings of Metals in Applied Mechanics Review; 1965.
Smith, J. T., Jr., Color - New Eyes for the Interpreter of Photographs Made from the Air. Ansonian, No. 1, 1965.
Tewinkel, G. C., Slope Corrections in Aerotriangulation Adjustment; Photogrammetric Engineering, Vol. 31, No. 1, 1965.

Carder, D. W., Travel Times from Central Pacific Nuclear Explosions and Inferred Mantle Structura; Bulletin of the Seismological Society of America, Vol. 54, pp. 2271-2294.

Harrison, W., Lynch, M. P., and Altschaeffl, A. G., Sediments of Lower Chesapeake Bay, with Emphasis on Mass Properties, Journal of Sed. Pet.

Harrison, W., Malloy, R. J., Rusnak, G. A., Terasmae, J., Possible Late Pleistocene Uplift Chesapeake Bay Entrance; Journal of Geology, Vol. 73, No. 2, Mar. 1965.

Harrison, W., Wilson, W. S., Development of a Method for Numerical Calculation of Wave Refraction; Coastal Engineering Research Center.

Jordan, G. F., Malloy, R. J., and Kofoed, J. W., Bathymetry and Geology of Pourtales Terrace, Florida; (Summary) Guidebook of Field Trip Geological Society of America Convention - On South Florida Carbonate Sediments.

Kofoed, J. W., Nichols, H., and Perry, R. B., Bathymetry of Bowers Bank, Bering Sea; Journal of Surveying and Mapping, Vol. 24, No. 3.

Malloy, R. J., Crustal Uplift Southwest of Montague Island, Alaska; Science, Nov. 20, 1964.

Oshiver, A. H., Grief for Conference on Oceanographic Exploration from Satellites, Oceanography from Space; Woods Hole Oceanographic Institution, Reference No. 65-10, pp. 217-218.

Oshiver, A. H., and Berberian, G. A., Sensing Sea-Surface Temperature by Airborne Infrared Radiometry; Geo-Marine Technology, Vol. 1, No. 4, pp. 22-26.

Peter, G., Elvers, D. J., and Yellin, M., Geological Structure of the Aleutian Trench Southwest of Kodiak Island; Journal of Geophysical Research, Jan. 15, 1965, pp. 353-366.

Articles for Reference Books

"Geography" - 1965 (1966) Encyclopedia Brittanica Supplement.

"Exploration and Discovery" - 1965 (1966) Encyclopedia Brittanica Supplement; Information Please Almanac, 1966 Edition; The World Almanac, 1966 Edition; Encyclopedia Americana Annual; New International Year Book; and Year Book of The Editorial Guild of New York City.

PAPERS PRESENTED

Hessler, V. P., and Townshend, J. B., A review of the IAGA Resolutions on the Classification of Geomagnetic Rapid Variations; presented at the Boulder VLF Symposium by Dr. Hessler, Aug. 1964.

Algermissen, S. T., Energy and Depth of Foci of the Aftershocks of the Prince William Sound Earthquake of March 28, 1964; at the 15th Alaskan Science Conference, College, Alaska, Sept. 1964.

Algermissen, S. T., The Direction of Faulting in Some of the Prince William Sound Earthquakes of March and April 1964; at the 15th Alaskan Science Conference, College, Alaska, Sept. 1964.

Annexstad, J. O., Geomagnetic Micropulsations at College With the Helium Magnetometer; at the Alaska Science Conference, Sept. 1964.

Schmid, H. H., Analytical Photogrammetric Instruments and Photogrammetry Applied to Three-Dimensional Geodesy; International Society of Photogrammetry, Lisbon, Portugal, Sept. 1964.

Carder, D. S., Jordan, J. N., and Gordon, D. W., Surface Focus Travel Times at Teleseismic Distances; at the Eastern Section of the Seismological Society of America Meeting, Ann Arbor, Mich., Oct. 1964.

Oshiver, A. H., Factors in Measurement of Absolute Sea Surface Temperature by Infrared Radiometry; at the Third Symposium on Remote Sensing of Environment, Ann Arbor, Mich., Oct. 1964.

Waugh, J. E., Photogrammetric Procedures in Tidal Current Surveys; at the Hydrographic Dept., Royal Navy, London, England, Oct. 1964.

Algermissen, S. T., The Prince William Sound, Alaska, Earthquake of March 28, 1964 and Aftershock Sequence; at the Annual Meeting of the Geological Society of America, Miami, Fla., Nov. 1964.

Karo, H. Arnold, Emergency Charting of the Alaska Earthquake Disaster Area; at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Manila, Philippines, Nov. 21-Dec. 5, 1964.

Meade, Buford, K., Comparison Tests of Electro-Optical and Microwave Distance Measuring Instruments; submitted to the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Manila, Philippines, Nov. 21-Dec. 5, 1964.

Murphy, L. M., An International Tsunami Warning System for the Pacific; at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Manila, Philippines, Nov.-Dec. 1964.

Nelson, J. H., and Campbell, J. B., Geomagnetic Instrumentation and Data Center Activities; distributed at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Manila, Philippines, Nov. 21-Dec. 5, 1964.

Orlin, H., The Coast and Geodetic Survey Marine Gravity Program; at the Symposium on Extrapolation of Gravity Anomalies to Unsurveyed Areas, Ohio State University, Nov. 1964.

Rice, D. A., Daugherty, K. I., and Decker, B. L., Significance of a Unified World Gravity System; at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Manila, Philippines, Nov. 1964.

Schmid, H. H., The Method of Passive Satellite Triangulation by USC&GS and Basic Considerations for the Future Development of Computational Photogrammetric Methods; at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, Manila, Philippines, Nov. 1964.

Whitten, C. A., Cartographic and Geodetic Effects of Alaskan Earthquake; Miami Beach Meeting of the Geological Society of America, Nov. 19, 1964.

Whitten, C. A., Geodesy, Panel Discussion: What Would Constitute an Adequate State-Wide Program of Earthquake Investigation?; Earthquake and Geologic Hazards Conference, San Francisco, Calif., Dec. 7-8, 1964.

Whitten, C. A., Crustal Movements Associated with the Alaskan Earthquake; Fourth Western National Meeting, American Geophysical Union, University of Washington, Seattle, Wash., Dec. 29, 1964.

Hanson, R. H., Satellite Triangulation Program; at the Symposium on Analytical Photogrammetry, USC&GS, Washington, D. C., Dec. 1964.

Slama, C. C., The New Stellar Single Camera Program; at the Symposium on Analytical Photogrammetry, USC&GS, Washington, D. C., Dec. 1964.

Harding, S. T., Seismological Investigation of the Prince William Sound, Alaska, Earthquake and Aftershocks; at the 1964 Regional Meeting of the American Geophysical Union, Seattle, Wash., Dec. 1964.

Swanson, L. W., Aerial Photography and Photogrammetry in the Coast and Geodetic Survey; Congress of International Society of Photogrammetry, Lisbon, Portugal, 1964.

Harding, S. T., The Prince William Sound, Alaska, Earthquake of March 28, 1964; Forty-fourth Annual Meeting of the NAS-NRC, Washington, D. C., Jan. 1965.

Karo, H. Arnold, Some Aspects of Modern Surveying; at the meeting of Virginia Association of Surveyors, Natural Bridge, Va., Jan. 30, 1965.

Algermissen, S. T., Some Seismological Aspects of the Prince William Sound, Alaska, Earthquake of March 28, 1964; at the Third World Conference on Earthquake Engineering, Wellington, New Zealand, Jan. 1965.

Hotine, M., Rapid Topographic Surveys in New Countries; American Congress on Surveying and Mapping, Washington, D. C., Mar. 1965.

Karo, H. Arnold, Our Stake in the Oceans; at meeting of the Rotary Club, Savannah, Ga., Mar. 29, 1965.

Keller, M., Documented Computer Programs for Problems in Computational Photogrammetry; at the ACSM-ASP Convention in Washington, D. C., Mar. 1965.

Lampton, B. Frank, The Mathematical Compensation of Film Distortion for Analytic Photogrammetry; at the 1965 ACSM-ASP Convention, Washington, D. C., Mar. 1965.

Thorson, Curtis W., Accuracy and Methods of Observations for Second-order Astronomic Latitude and Longitude; at the Twenty-fifth Annual Meeting of the American Congress on Surveying and Mapping, Washington, D. C., Mar. 1965.

Bailey, L. F., New Techniques for Array Data Processing; Seismological Society of America, Washington, D. C., Apr. 1965.

Bossler, J. D., A Study of the Zero Error in the Model MRA3 Tellurometer; Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Brune, J. N., Analysis of the Propogation of Long Period S-Waves in the Mantle; Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Brune, J. N., Mantle Rahleigh Wave Radiation Pattern the Source Mechanism of the Hindu Kush Earthquake of July 6, 1962; Seismological Society of America, St. Louis, Mo., Apr. 1965.

Brune, J. N., The Sa Phase from the Hindu Kush Earthquake of July 6, 1962; Seismological Society of America, St. Louis, Mo., Apr. 1965.

Dracup, Joseph E., The 1963 Control Surveys for Akron, Ohio; Annual Meeting of American Congress on Surveying and Mapping, Washington, D. C., Apr. 1965.

Gordon, D. W., Jordan, J. N., and Carder, D. S., Analysis of Surface Focus Travel Times; Annual Seismological Society of America Meeting, St. Louis, Mo., Apr. 1965.

Hotine, M., Geodetic Applications of Conformal Transformations in Three Dimensions; International Association of Geodesy Symposium on Mathematical Geodesy, Turin, Italy, Apr. 1965.

Hotine, M., Triply Orthologonal Coordinate Systems; International Association of Geodesy Symposium on Mathematical Geodesy, Turin, Italy, Apr. 1965.

Miller, G., Tsunami Ray Tracing Program at Tsunami Symposium, Sapparo, Japan, Apr. 1965.

Orlin, H., (with Dehlinger, Peter, and Gallagher, John N.), Gravity Survey North of Hawaii; Annual Meeting of American Geophysical Union, Washington, D. C., Apr. 1965.

Parkin, Ernest J., Geodetic Surveys for Earth Movement Studies Along the California Aqueduct; Annual Meeting of American Congress on Surveying and Mapping, Washington, D. C., Apr. 1965.

Rinehart, J. S., A Preliminary Investigation of Earth Tremors Generated by Old Faithful Geyser; Seismological Society of America Meeting, St. Louis, Mo., Apr. 1965.

Schmid, H. H., Precision and Accuracy Considerations for the Execution of Geometric Satellite Triangulation; 2nd International Symposium on Use of Artificial Satellites for Geodesy, Athens, Greece, Apr. 1965.

Smathers, S. E., Experiment with a LASER Geodimeter; at the American Congress on Surveying and Mapping, Washington, D. C., Apr. 1965.

Taggart, J., (with Tocher, D.), Aleutian Islands Seismic Experiment - 1964; at Annual Meeting of the Seismological Society of America, St. Louis, Mo., Apr. 1965.

Wilson, C. R., and Annexstad, J. O., Conjugate Relationships for Giant Pulsations, at College, Alaska, and Macquarie Island; presented by Dr. Wilson at the Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Hastings, J. V., Kuberry, R. W., and Elvers, D. J., A Portable Fluxgate Magnetograph; presented by R. W. Kuberry at the Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Hurwitz, L., Knapp, D. G., Nelson, J. H., and Watson, D. E., A Spherical Harmonic Analysis for Epoch 1965.0 for Use in Constructing World Magnetic Charts; presented by L. Hurwitz at the Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Watford, O. B., Francis, W. A., Walker, G. B., and Fabiano, E. B., Isomagnetic Patterns in Regions of the 1965 Dip Poles; presented by O. B. Watford at the Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Peter, G., Weeks, L. A., and Burns, R. E., Geophysical Measurements in the Andaman Sea and Across the Andaman-Nicobar Arc; presented at the Forty-sixth Annual Meeting of the American Geophysical Union, Washington, D. C., Apr. 1965.

Kofoed, J. W., Marine Geology Research in the Office of Research and Development, USC&GS; Conference on Continental Shelf Morphology and Sediments, Coastal Research Center, Washington, D. C., May 1965.

Harris, W. D., Checking, Calibration and Maintenance of Photogrammetric Instruments; presented to the United Nations Economic Commission for Africa, Addis, Ababa, Ethiopia, June 1965.

Rinehart, J. S., Dynamic Fracture Strengths of Rocks; VII Symposium on Rock Mechanics at University Park, Pa., June 1965.

Rinehart, J. S., Effects of Transient Stress Waves; XV Annual Earth Sciences Orientation Session, Dallas, Tex., June 1965.

Lander, J. F., Advances in Data Processing Techniques in the Epicenter Program; at the Eastern Section Meeting in Ann Arbor, Mich., Aug. 1965.

Chovitz, B., Application of Satellite Orbit Analysis to the First Order Worldwide Satellite Triangulation Net; 2nd International Symposium for Use of Artificial Satellites, Athens, Greece.

Chovitz, B., Dynamical Considerations Associated with the Geometric Determination of Position for Satellites; Symposium or Trajectories of Artificial Celestial Bodies as Determined from Observations, Paris, France.

Harrison, W., Krumbein, W. C., and Wilson, W. S., A Model of Sedimentation at an Inlet Entrance; Geological Society of America Meeting in Miami, Fla.

Malloy, R. J., and Harbison, R. N., Detailed Sparker Survey of the Gulf of Maine; presented by R. N. Harbison at the Ocean Science and Ocean Engineering Conference and Exhibit, Washington, D. C.

Malloy, R. J., Submarine Tectonics of the 1964 Alaska Earthquake; at the Fourth Western National Meeting of the American Geophysical Union, Seattle, Washington, Dec. 1964.

Stewart, H. B., Jr., Dietz, R. S., and Shepard, F. P., Submarine Valleys off the Ganges Delta; presented by L. A. Weeks at the 22nd International Geological Congress at New Delhi, India, Dec. 1964.

Weeks, L. A., and Harbison, R. N., The Island Arc System in the Andaman Sea; presented by L. A. Weeks at the 22nd International Geological Congress at New Delhi, India, Dec. 1964.