

U. S. DEPARTMENT OF COMMERCE

JOHN T. CONNOR, SECRETARY

COAST AND GEODETIC SURVEY

H. ARNOLD KARO, *Director*

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ANNUAL REPORT
OF THE
DIRECTOR OF THE COAST AND
GEODETIC SURVEY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1964



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**Annual Report of the Director of the Coast and Geodetic
Survey**

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OFFICE OF THE DIRECTOR

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

The Director attended the XII General Assembly of the International Union of Geodesy and Geophysics at Berkeley, Calif. The other members of the Coast and Geodetic Survey delegation included: L. R. Alldredge, C. E. Barthel, Jr., N. F. Braaten, D. S. Carder, S. D. Hicks, D. G. Knapp, B. K. Meade, J. H. Nelson, H. Orlin, D. A. Rice, W. Shofnos, J. B. Small, J. L. Stearn, L. W. Swanson, and C. A. Whitten.

The Director attended the United Nations Regional Cartographic Conference for Africa at Nairobi, Kenya; the Commonwealth Survey Officers Conference at Cambridge, England; the International Geophysical Year and Intermediate Committee at Los Angeles, Calif.; the dedication of the Charles Darwin Research Institute on Galapagos Islands.

The Director inspected the earthquake disaster areas in Alaska the day following the Prince William Sound Earthquake and personally issued orders and instructions to the various ships and field parties that were sent to the area. He made both the annual high and low water inspections of the Mississippi River with the other members of the Commission.

The Bureau sponsored proposal relating to medical care for vessel personnel was approved by the President on July 19, 1963 as Public Law 88-71. S. 1004 relating to the appointment of the Director and Deputy Director was passed by the Senate on June 1, 1964. S. 1336 relating to the pricing of charts produced by the Bureau was passed by the Senate on June 19, 1964.

Program Planning Coordination Staff

The Program Planning Coordination Staff was engaged in developing and coordinating long-range plans and analyzing short-range plans of the Bureau. The Staff reviewed proposals for future research projects, conducted a review of the Bureau's project structure, assisted in the allocation of funds under the budget ceiling for fiscal year 1965, and organized and coordinated exhibits and text material for a program review presentation. It also conducted a study, and prepared a summarized version, of a program structure for the

Bureau to group its activities among six major programs; completed the first phase of a study of program planning by other government agencies; completed a study of allocation of manpower and funds resources to Bureau programs; and coordinated a study of Bureau participation in the Upper Mantle Project.

Consultations were held with other government agencies regarding cost-benefit ratios, cost effectiveness and related techniques for assessing the economic impact of Bureau programs to strengthen resources allocation and for programs justification.

The Staff, in cooperation with the Weather Bureau, participated in formulating organizational requirements for an air/sea interaction research activity involving a number of government agencies and to be monitored by the Department of Commerce.

Staff members represented the Bureau on a number of interagency and international committees and panels. Preparations were coordinated for the United States participation in the United Nations Cartographic Conference for Africa held in Nairobi, Kenya, in July 1963. It also made arrangements for participation in an U. S.-U.S.S.R. Oceanographic Exchange Program.

The Chief attended the Fifth Venture in Executive Development seminar held at the University of Pittsburgh. Staff members attended various seminars pertaining to program planning and management techniques held in Metropolitan Washington.

Officer Personnel Staff

The increase in the authorized strength of the commissioned corps from 200 to 215 permitted the appointment of 49 new officers during the fiscal year.

The 12th through 14th officer training classes were completed and the 15th class was begun. The 15th class consists of one ensign and 13 deck officers; the officer is the first ROTC graduate to be released by one of the Armed Forces under Public Law 87-536 for appointment in the Coast and Geodetic Survey. One of the trainees will be appointed initially as a lieutenant (junior grade) under Section 23 of the Coast and Geodetic Survey Commissioned Officers Act of 1948, as amended. Three commissioned officers began advanced studies in oceanography one in geodetic science, and one in photogrammetry. Four officers were selected to begin advanced study in fiscal year 1965 in several different fields. Additionally, in

fiscal year 1965, one officer is scheduled to attend the Armed Forces Staff College; one was selected for a years study at Stanford University as a National Institute of Public Affairs fellow; and one was designated a Commerce fellow and will spend one year in the Weather Bureau.

Three commissioned officers were given special training at Westinghouse in computer programing; four officers have been selected for this training in fiscal year 1965. Five officers attended the electronics training course conducted in the Washington Office.

New Ship Staff

During the fiscal year the New Ship Staff continued to monitor all aspects of construction programs for new hydrographic and oceanographic ships detailed as follows:

Keel laying ceremonies for the first of the two Class I oceanographic survey ships, OSS-01 (OCEANOGRAPHER) were held at Gibbs Shipyards, Inc., on July 22, 1963, and September 10, 1963, for the second ship OSS-02 (DISCOVERER). The OSS-01 was christened USC&GSS OCEANOGRAPHER by Mrs. Luther H. Hodges at launching ceremonies on April 18, 1964. The Gibbs Shipyards, Inc., is now operating as Aerojet General Shipyards, Inc., a subsidiary of General Tire and Rubber Company. Completion percentages reported at the end of the period were 62.3 percent for OSS-01 (OCEANOGRAPHER) and 57.1 percent for OSS-02 (DISCOVERER).

A contract amendment covering replacement of the machinery automation system data logger by a computer at an agreed fixed price increase of \$200,000 per ship has been sent to the contractor for signature. Although work is proceeding on the change, the contractor has asked for an extension of performance period on the basis of delay in vendor production of automation components.

A contract was negotiated with the computer and automation system manufacturer covering all arrangements needed to complete the data acquisition system, including installation of the components during the first availability after delivery of each ship. Arrangements were made for attendance of Coast and Geodetic Survey technical personnel at computer training courses conducted by the manufacturer. Six men successfully completed the maintenance school, and six have completed or are scheduled to attend the programming school.

Although ship construction was slow, progress in development of features directly identified with survey operations has been good. Arrangements for the winches, handling gear, platforms and instrumentation are now clearly defined; the plotting center and certain of the pilot house equipments were modified and rearranged; the gravity room was enlarged; changes in equipment were authorized to provide a buoy tracking radar system and to replace the original navigational radars by a dual channel Decca system. The suitability of a narrow beam stabilized transducer of electronically stabilized type for installation on OSS-02 is under investigation.

Design studies were started by the Staff in December to develop an intermediate sized platform with full ocean survey capability in keeping with the recommendations of the Operations Research, Inc. study. In a working meeting between interested Bureau personnel and attended by Maritime Administration representatives in February the characteristics were tentatively defined as 265 ft. length overall x 48-ft. beam x 17-ft. height, 2,840 tons load displacement, with diesel driven twin controllable pitch propellers. Special features are a bow bulb for all principal underwater sound equipment, and handling gear for launching and retrieving buoys, exploration capsules, etc., provisions for carrying laboratory equipped van modules, multipurpose winches with remote controls, and an improved communications antenna system. Although prior commitments to construction projects limited further Staff activity, study of the innovations indicates they are both advantageous and feasible.

At the beginning of the fiscal year, we were advised that the contractor for our two Class II hydrographic survey ships, the MSS-20 (FAIRWEATHER) and the MSS-21 (RAINIER), design S1-MT-MA63a was in serious financial difficulty. On July 1, 1963, the Maritime Administration issued addendum No. 1 to the Contract to provide an agreement between the contractor, U. S. Navy and the Maritime Administration to enter into an advance payment pool agreement. The bonding company deposited \$828,000 and the Navy deposited an advance in progress payments of \$500,000. The Coast and Geodetic Survey's participation in the advance payment pool agreement was to approve an extension of the delivery dates of the two ships from November 18, 1964, and March 18, 1965, to February 18, 1965, and April 18, 1965, or an extension of three months for the MSS-20 (FAIRWEATHER) and one month for the MSS-21 (RAINIER). This extension amounted to approximately \$120,000 savings in liquidated damages if the ships were delayed. Progress shown on the Maritime Administration progress report as of July 1, 1963, was 1.6 percent for each ship.

On October 1, 1963, actual construction of the Class II ships stopped due to a labor dispute. The strike, affecting some 700 workers continued until February 8, 1964. The Design Agent, Phillip L. Rhodes Company continued to submit working plans for the construction of the Class II ships.

At the end of the period the progress as shown on the Maritime Administration progress report was 15.9 percent for the MSS-20 (FAIRWEATHER) and 15.7 percent for the MSS-21 (RAINIER).

Invitations for sealed bids for one Class II hydrographic survey ship, design S1-MT-MA72a were issued by the Maritime Administration on May 20, 1964. Bids will be opened on August 5, 1964. This ship is basically the same design as the MSS-20 (FAIRWEATHER) and MSS-21 (RAINIER) except that it is 10 feet longer. When delivered this new ship will be designated MSS-22 (MT. MITCHELL).

Upon completion of sea trials the Bureau accepted and commissioned the USC&GSS WHITING, CSS-29 in ceremonies held in New Orleans, La., on July 8, 1963.

A study for changing the general characteristics of the Class III ships has begun by the Staff and the Office of Ship Construction, Maritime Administration. The new concept will increase the length overall and beam of the ships allowing the engine room to be moved forward one compartment and will give a better general arrangement of the living quarters for both the crew and officers. Preliminary arrangement plans of the new design were submitted by the Maritime Administration and comments were made by the Staff for inclusion on the plans. The new design was designated S1-MT-MA70a. Completion of bidding specifications and contract plans were accomplished during the period. The two new ships will bear Coast and Geodetic Survey designations CSS-30 (McARTHUR) and CSS-31 (DAVIDSON).

A design study was initiated to change the general characteristics of the hull, living and working areas of the Class IV Wire Drag Ships.

From this study a new concept was developed for setting and retrieving of the drag. A working model was made showing the proposed stern section and ramp arrangement with machinery and stowage of buoys and associated equipment. From evaluation of the model it was determined this new concept will improve the methods of the wire drag operations.

Coast and Geodetic personnel are assigned to the staffs of the Maritime Administration Construction Representative at each of the shipyard sites with administrative control under this office.

During the fiscal year the Staff prepared specifications, where necessary, and issued purchase requisitions for the procurement of Government furnished equipment, instruments and supplies for the new ships under construction.

International Technical Cooperation Staff

Scientific and technical training of foreign participants was conducted under the sponsorship of the Agency for International Development (AID), the Military Assistance Program (MAP), and the fellowship programs of the United Nations (UN).

Under AID, 10 participants were accepted and given instruction in the following subjects: Geodetic surveying--Greece (1); photogrammetry--Chile (1), Colombia, (1) and Indonesia (6); and tides and currents--Guatemala (1).

From the previous fiscal year, 7 participants continued or completed their training program as follows: Geodetic Surveying--Colombia (2), Sudan (1), and Venezuela (1); hydrographic surveying--El Salvador (1); photogrammetry--Venezuela (1), and photogrammetry-reproduction--Nigeria (1).

Under MAP, 9 participants were given instruction as follows: Bureau functions and operations--Venezuela (1); map and chart construction--Brazil (1); photogrammetry--Chile (1), and Venezuela (2); and reproduction--Brazil (3). From the previous fiscal year, photogrammetry--Chile (1).

Under UN and UNESCO the following fellowship grants were completed in the current fiscal year as follows: Automatic data processing--Egypt (1) and tides and currents--Thailand (1).

The Bureau received 110 visitors from 42 countries as follows: Argentina (5), Australia (5), Brazil (5), Burma (1), Canada (4), Chile (1), China (1), Colombia (1), Denmark (1), Ecuador (2), England (5), France (2), Germany (3), Ghana (2), Greece (2), Guatemala (1), Holland (1), India (1), Indonesia (3), Iran (1), Japan (2), Liberia (2), Malaya (1), Mexico (1), Netherlands (1), New Zealand (1), Nigeria (1), Pakistan (2), Peru (2), Philippines (4), Portugal (1), Republic of Congo (4),

South Africa (1), Spain (1), Sweden (1), Switzerland (1), Thailand (3), Trinidad (1), Turkey (21), Uruguay (2), Venezueal (9), and Yugoslavia (1). In addition, 50 delegates to the Permanent Committee Meeting of the Federation Internationale des Geometres (FIG) and 23 foreign naval officers with the U. S. Naval Oceanographic Office from various countries of the world were received.

The Chief, Assistant Chief, and the foreign participants receiving Bureau instruction attended the consecutive annual meetings of the American Congress on Surveying and Mapping and the American Society of Photogrammetry. Translations from Spanish to English were prepared for the various Divisions and for the American Congress on Surveying and Mapping. A conference was held with AID officials on the training of professional seismologists and laboratory technicians. Discussions continued on the worldwide release of the four courses offered by the Bureau for class instruction. The Chief collaborated with AID on the final plans to initiate the new program in July 1964.

A review of a proposed "Agreement Between the Department of Commerce and the Agency for International Development" was made for the Assistant Secretary for Domestic and International Business of the Department.

Office of Public Information

The Office of Public Information was reorganized as of September 13, 1963. This report covers its activities for the 9½-month period.

When a decision was made by the Director to expand the publication information program of the Coast and Geodetic Survey, it was generally recognized that the Bureau had been operating for many years with comparatively little public exposure. The purpose in expanding the program was to acquaint the public more adequately of the Bureau's important role as the nation's oldest scientific body, of its expanding programs, of the major roles 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 and the Congressional Record; press conferences; interviews with C&GS 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 Staff

In keeping with the delegated responsibilities of the Scientific and Technical Publications Staff to secure the optimum dissemination and exchange of the scientific and technical data of the Bureau in all forms, during the first year of its existence as an organized staff, this organizational unit performed the following functions:

A close degree of coordination was established with the National Referral Center for Science and Technology, newly created in the Library of Congress with support from the National Science Foundation. A 35-page summary of "Information Resources of the U. S. Department of Commerce, Coast and Geodetic Survey," was prepared for use in the Referral Center's Directory of Information Resources in the United States -- Physical Sciences, Biological Sciences, Engineering.

A further detailed summary of Coast and Geodetic Survey science information activities was provided in answer to a science information survey being conducted by the House Select Committee on Government Research.

Project statements covering all phases of the Bureau's research and development efforts were forwarded to the Science Information Exchange conducted by the Smithsonian Institution, and a continuing channel of communication with this organization was established to ensure further adequate dissemination of information on the Bureau's scientific programs.

In a cooperative program with the U. S. Department of Commerce's Office of Technical Services (subsequently reestablished as the Clearinghouse for Federal Scientific and Technical Information), Bureau sponsorship was arranged for the translation under the Public Law 480 translation program of the following Soviet books in the Coast Survey's areas of technical interest: Gobi-Altayskoe zemletryasenie (The Gobi-Altai Earthquake), N. A. Florensov and V. P. Solonenko, eds.; and Inzhenernaya seismologiya (Engineering Seismology), by S. V. Medvedev. Arrangements were also made for the translation of several hundred pages of selected oceanographic articles from the Transactions of the Institute of Oceanology of the USSR Academy of Sciences, under Bureau sponsorship.

The Chief, Scientific and Technical Publications Staff, was appointed Vice Chairman of the Subcommittee on Standards for Department's Technical Communications of the Commerce Committee on Science and Technology. The ensuing close liaison in science information activities

achieved with other units of the Department of Commerce through this subcommittee made possible the publication, by this office, of a 42-page Inventory of Types of Technical Communications of Eight Bureaus of the Department of Commerce.

Similar staff representation on the Informal Inter-agency Geophysics Coordinating Group provided a channel for exchange of Bureau information with some 15 other Government agencies whose programs include studies in solid-earth geophysics.

Subsequent to the publication of Hearings on the Upper Mantle Project Before the Subcommittee on Coast Guard, Coast and Geodetic Survey, and Navigation, for which the technical record covering Coast and Geodetic Survey activities was provided by this staff, several additional summary reports relating to the Bureau's participation in the International Upper Mantle Project were prepared by this office for the Bureau of the Budget, The Federal Council for Science and Technology, and the National Academy of Sciences.

Editing and technical review of "A Ten-Year Program in Solid-Earth Geophysics, the Bureau's programmatic contribution to Solid-Earth Geophysics, Survey and Outlook, later published by the National Academy of Sciences-National Research Council, was accomplished by this staff.

An internal publication, Coast and Geodetic Survey -- Projected Research and Development Activities, Fiscal Years 1964-1965, was editorially prepared and published for the Office of Research and Development.

A science information survey was completed relating the Bureau's technical programs to those of the Organization for Economic Cooperation and Development.

A documentary motion picture film titled "To Help Man Find His Way," a revised general activities film describing the various technical programs of the Bureau, was produced by this office in cooperation with an outside contractor.

With the formation of a small editorial staff by the accession of four scientific and technical publications editors during the year, active attention was given to the establishment of a formal program for the preparation, editing, and compiling of new publications and revision of existing technical manuals of the Bureau. The release dates for these publications will extend into the next fiscal year.

OFFICE OF OCEANOGRAPHY

OPERATIONAL ACTIVITIES

Atlantic and Gulf Coasts and Puerto Rico

The ships HILGARD and WAINWRIGHT made wire drag surveys in Narragansett Bay, R. I., Buzzards Bay and Vineyard Sound, Mass., and off the coast of Long Island, N. Y. A Decca Navigator, Mark 12, was installed for evaluation purposes and preliminary tests were made. The wreckage of the Vineyard Light Vessel which had been lost for 19 years was located by the drag, positive identification made by a skin diver. The ruins of the collapsed Texas Tower No. 4 were located and cleared to a depth of 59 feet. Wire drag work was done in San Carlos Bay, Fla., West Bay, La., and off the coast of Texas near Freeport. This later work was controlled by Precise Radar Ranging System.

Hydrographic Field Party 220 conducted hydrographic surveys in Bull Bay and Charleston Harbor, S. C., during the first half of the fiscal year. At the close of the field season the party was disbanded and the personnel reported to Hydrographic Field Party 219 at Boulder City, Nev.

During the year, the East Coast Tide Party installed 2 portable and 4 standard tide gages, 58 standard gages were serviced, 400 bench marks were recovered, 30 were established, and 50 miles of leveling were run. The standard gages were installed at Cutler, Maine, Nantucket, Mass., Lewes, Del., and Port Aransas, Tex. At the request of the Parker River Wildlife Refuge, a portable tide gage was installed at Plum Island, Mass. A bubbler gage was put in operation at Cutler, Maine. A successful series of tide record was obtained for the Army Engineers from a portable tide gage located at Stoney Point Dike, Cape Cod Canal. The standard gage at Morehead City, N. C., was moved to the Duke University Marine Laboratory at Beaufort.

The ship EXPLORER worked off Cape Hatteras, N. C. Doing launch hydrography on Hatteras Shoals, 2 current stations and a special 3-week oceanographic program in cooperation with Duke University were completed. Also a hydrographic survey off Bodie Island, N. C., for use in wave refraction studies by the Coastal Studies Institute of Louisiana State University was completed. The ship ran a cable line survey for the American Telephone and Telegraph Co. from Atlantic City, N. J., to Brest, France. Loran C was carried to longitude 60°W

with reliable positions. The trackline was broken on both the east and west bound passages in order for the ship to refuel at Ponta Delgada, Azores. On the west bound passage a development was made of a portion of the Mid-Atlantic Ridge. The EXPLORER did inshore hydrography along the east coast of Puerto Rico, current stations were observed and a sparker gas survey was completed between the Virgin Passage and Charlotte Amalie in a cooperative program with Rice University. A reconnaissance survey of Charlotte Amalie was completed before returning. A wire drag survey was made in Roosevelt Roads for the Navy Department. Triangulation and photo-identification were completed in the San Juan area and hydrography in Bahia Flamenco, Culebra Island. On a trackline to Norfolk, Va., 130 BT casts were made; 1,378 nautical miles of towed magnetometer operation; 264 oxygen and 383 salinity samples were obtained; 5 core samples in over 500 fathoms obtained; and 13 oceanographic stations observed.

The ship MARMER did current survey work adjacent to the coast of South Carolina and in Chesapeake Bay. The ship made current observations at 15 stations at the Chesapeake Bay entrance bridge; 69 current stations, including a 29-day current station at other parts of the bay and took 42 bottom samples. The Marine Biology Department of Old Dominion College was assisted in obtaining water samples and investigations made of depths in Cambridge harbor for the Maryland Port Authority. The MARMER used an LCM-8 as a buoy transport and rigging platform with great success in retrieving current buoys.

The ship HYDROGRAPHER did Raydist-control hydrography in the straits of Florida off Miami. All the Phleger cores (total of 52) obtained during this work were shipped to the Florida State University. Hydrographic surveys were made of the Sabine Bank and vicinity. Off Fort Walton Beach, Fla., Geological Echo Profiler (G.E.P.) operations were carried on and additional G.E.P. lines were added from Cape San Blas offshore to permit crossing the Florida Escarpment where a core was obtained in 1,700 fathoms. A total of 488 nautical miles of Geological Echo Profiling were run.

The ship SCOTT made a coast pilot field inspection between Jacksonville and Dry Tortugas via Key West and Miami, the Okeechobee Waterway and Caloosahatchee River between Stuart and Fort Myers, Fla., the St. Johns River to Lake Harvey, and Intracoastal Waterway to Norfolk, Va. The vessel was decommissioned December 31, 1963, and preparations made for her disposal. This 73-foot vessel was acquired for coast pilot inspection during fiscal year 1955 and was named in honor of Lt. (jg) Gordon D. Scott.

The ship PEIRCE did Hi-Fix controlled ship hydrography and launch visual hydrography in the Florida Keys. Hi-Fix controlled launch hydrography was done off Bull Bay, S. C., and in the vicinity of Charleston Harbor. The arrival of the PEIRCE at Savannah, on July 8, 1963, her home port was the occasion for official greetings by various city officials, representatives of military and travel organizations, and families of officers and crew.

The ship WHITING was commissioned at New Orleans, La., on July 8, 1963. Profiles were run off Bethany Beach, Del., on special project Sand Wave Research. Combined operations including shoran-controlled hydrography were conducted in Nantucket Sound and along the south shore of Nantucket Island. A digital recorder was installed for punched-tape data to be used on the X-Y plotter. Three 100-hour current stations were observed. An investigation in Canapitsit Channel was made and evidence obtained substantiated the existence of the rocks. Mr. F. N. Wood, III, great-grandson of Henry L. Whiting (for whom the ship is named), and family were visitors to the ship. Hiran-controlled hydrography in the Choptank River in the vicinity of Cambridge, Md., two launches and the ship completed a total of 370 lineal miles of sounding operations. A photogrammetric party assisted in locating photo-hydro signals and hiran station in Georgetown, S. C. Launch hydrography and combined operations continued until the project terminated with two 1:20,000 sheets and three 100-hour current stations observed. One incomplete sheet was turned over to the ship PEIRCE.

Pacific Coast, Alaska, and the Pacific Ocean

The Pacific Tide Party installed a new well at the Kwajalein tide station, relocated the Johnston Island station, and established the new bubbler type tide gage and seismic sea-wave warning station on Marcus Island. Station at Eniwetok was rebuilt. The station on Maui Island at Kahului Harbor, Hawaii, was rebuilt on the new Pier #2. During January, Typhoon "Susan" generated waves at Wake Island that were recorded at approximately 2 feet with periods of 10 to 12 minutes. The surprising similarity with tsunami generated waves was noted and a report made. On May 22, 1964, all personnel and equipment for the British Pacific Missile Range on Christmas Island were removed, thus eliminating all communications and transportation to that island. Remote tide metering equipment was completed at the Honolulu tide gage. During the year 10 standard tide gages were serviced, 23 seismic sea-wave stations serviced and 1 installed; 130 bench

marks were recovered, 9 established, and 16 miles of leveling run.

Hydrographic Field Party 219, continued surveys of Lake Mead, Nev. A continuous lowering of the lake required the releveing and relocation of two tide gages into deeper water. Hydrography was terminated in Overton Arm and resumed in Boulder Basin. The profiles in lower Granite Gorge were completed. Vertical and horizontal control was established in the Pierce Ferry area.

The ship PATTON was engaged in hydrography in Revillagigedo Channel, Alaska. Temperature and salinity observations were made, and three 100-hour current stations were monitored from dockside. The Aero Party 6410 assisted in the completion of a tellurometer traverse in Thorne Arm, obtaining excellent results. Photo-identification of horizontal control was begun in Nichols Passage. Hydrography, bottom sampling, and temperature and salinity observations were completed in Taku Inlet. Four communication towers on Point Lena were located for landmarks. A bubbler tide gage was installed at Cape Decision as a permanent addition to the Seismic Sea-Wave Warning System. On November 21, 1963 during "Open House" at the Ships Base, Seattle, Mrs. Katherine Cramer (nee Sobieralski) was aboard on the occasion of her first visit since christening the PATTON on Saturday, August 16, 1941.

The ship BOWIE was engaged in hydrography in Cook Inlet in the immediate vicinity of the Anchorage dock. Considerable shoaling north of Fire Island increased the limits of launch hydrography. At the request of the Army Engineers, the project area was increased 6 miles north of Anchorage. Work was started on photo-identification and control survey. The ship assisted the Coast Guard in locating a range on MacKenzie Point for navigating during the winter months. A bubbler tide gage was installed at Homer. The sales agent and tide gage at Yakutat were inspected. The commanding officer of the ship HODGSON, relieved commanding officer of the BOWIE February 10, 1964, for a more efficient consolidation of a joint command, as both ships would be engaged jointly on a current survey in the San Juan Islands area. The BOWIE and HODGSON conducted reconnaissance hydrography over the sunken tanker BUNKER HILL in Rosario Strait; a wire drag investigation cleared the wreck with an effective depth of 74 feet. A bubbler type tide gage was installed at La Conner, Wash., for the Army Engineers' use in clearing obstructions from navigable channels. The ship used two base stations for recording currents. This permitted the use of 6 current buoys with 18 meters in simultaneous operation.

Benefits from this new procedure are more stations can be occupied during a season and simultaneous observations give greater stability to the data obtained. The 29-day reference station and forty-five 100-hour stations were completed. Mutual cooperation with the Canadian Hydrographic Service was worked out on current surveys in Haro Strait and Strait of Juan de Fuca. Arrangements were made with the University of Washington to coordinate temperature and salinity studies with simultaneous current observations.

The ship HODGSON did hydrography in Possession Sound. The ships HODGSON and BOWIE worked together on the current survey in the San Juan Islands during the 1964 field season. The HODGSON continued on the current survey until April 9 when she went to Seattle to prepare for the Alaska Earthquake Damage Survey. Departure for Alaska was on April 20 and arrival in Cordova, Alaska, on April 25. A tagline was conducted at Cordova docks and a predredging survey of the fishing boat channel between Cordova and Port Whitshed was made. Portable tide gages were installed at Yakutat, Shag Rock (Orca Inlet), Port Gravina, Port Chalmers, Sawmill Bay, and Chenega Island, in Prince William Sound area; on Kodiak Island at Larsen Bay, Lazy Bay, and Uganik Bay; and along the peninsula at Chiguik, Sand Point, and King Cove. Triangulation was done in Unakwik Inlet, Prince William Sound. Reconnaissance hydrography was run in Whittier for the Alaska Steamship Co. and the Alaska R.R. to obtain the eastern limits of the shoal west of Marginal Pier. Working jointly with a Geological Survey party, a major fault was found in Prince William Sound and delineated with a profile of the seaward extension.

The ship LESTER JONES continued surveys in Kasaan Bay. The project area was completed with the exception of approximately 24 miles of hydrography around Grindall Passage. This area will be included in the Clarence Strait survey as that project progresses northerly. Photo-identification of shoreline was completed; current pole stations were observed for 50 hours at the entrance to Skowl Arm and in the entrance to Kasaan Bay. A tidal and hydrographic survey of Glacier Bay began with the installation of portable tide stations at Bartlett Cove, Mud Bay, Inian Cove, Willoughby Island, and Excursion Inlet. Two oceanographers from the University of Alaska Marine Laboratory, spent two days aboard collecting water and bottom samples. Temperature and salinity values were obtained from Nansen casts and from a small portable salinometer.

The ship PATHFINDER made a cable line survey between Guam Island and Baler Bay, Philippine Islands, for the

American Telephone and Telegraph Co. A deep-sea sounding line towards Midway Island began off Cape Flattery July 13, 1963. Enroute, a continuous bottom profile was obtained, total magnetic intensity recorded, and bathythermograph observations made. The sounding line was terminated south of Midway. After refueling, the ship resumed the sounding line and terminated it at Guam. The PATHFINDER departed Guam to begin the cable line survey. During the next five days, the reconnaissance sounding line was run toward Luzon, and was completed on arrival at Baler Bay. The return easterly line to Guam ended in Apra Harbor, Guam. All sounding operations for this project were completed and after refueling and taking on supplies, departure for Honolulu via Midway Island was taken. On September 24, 1963, after reversing course, the ship completed a rendezvous with Liberian freighter, SAPHO and took off an ailing seaman who was transferred to the Naval Hospital at Midway Island on September 25th. After fueling, the PATHFINDER, departed Midway for Honolulu. Operations in the vicinity of Maui Island were resumed and good progress was made. Operations were also begun along the west coast of Lanai Island, and whenever weather and sea conditions permitted, launch work was concentrated along the south coast of Maui Island. A seismic sea-wave warning was received March 27, 1964, and after steaming thru the night, the ship arrived at Nahului Harbor. The tsunami alert ended on the 28th, and on this date emergency instructions were received to close operations in the Hawaiian Islands and proceed to Cook Inlet, to assist in earthquake investigations. A deep-sea sounding line was run to Alaska and terminated April 8 upon arrival at the Kodiak Naval Base. The next day the PATHFINDER began Earthquake Damage Surveys in Resurrection Bay. This work consisted of hydrography, planetable surveys for new high-water line, and leveling to determine the maximum height of tsunami water level. All surveys were completed on April 18th. At this time the Commanding Officer declared the passage into Seward via Resurrection Bay safe for navigation. After refueling at Kodiak the ship sailed to Cook Inlet where the first of four reconnaissance sounding lines was run on April 22. Surveys were begun in the vicinity of Anchorage and continued until the 28th when the ship was brought alongside the City Dock. After shoran camps were established, hydrography was started in Cook Inlet between Fire Island and Forelands. During this time, a sea-scanner was installed in a sounding launch and tested until the sensing head was damaged. Operations on the Earthquake Damage Surveys were completed on June 1, 1964, and all shore camps equipment removed and brought aboard ship by Army helicopter. While surveys were progressing in Kamishak Bay, a launch party was continuing work at Kenai, at the end of the fiscal year.

The ship PIONEER sailed for the working grounds and after transiting the gravity range off San Francisco Bay from southeast to northwest, began a deep sea sounding line enroute to the ocean survey working grounds. Offshore from Cape Mendocino, Calif., three north-south trending lines between latitudes 45° and 51° were run across the Mendocino Scarp and then the trackline was run westerly to the work area. During this period at sea, the plastic Nansen bottle was modified with excellent results, attempts were made to obtain bathythermograph (BT) observations underway at 235 r.p.m. with not too satisfactory results. Thermoprobe tests were attempted in about 1,500 fathoms south of Oahu, a sea sled was fabricated and towed at full speed on one occasion with many specimens captured, the magnetometer performed well, and the gravity meter was in operation about 90 percent of the time on survey lines. Operations on Ocean Survey were suspended and the season closed when the ship departed Honolulu for Oakland, Calif., running a deep-sea sounding line enroute. Four Japanese scientists came aboard with a Japanese gravity meter and magnetometer. These instruments were tested and compared with Coast and Geodetic Survey instruments at the Oceanographic Equipment Evaluation Range off Pt. Reyes, Calif. On February 11, 1964, the ship PIONEER sailed on the International Indian Ocean Expedition, completed the gravity meter evaluation off Pt. Reyes, Calif., on February 13, and commenced a deep-sea sounding line to Hawaii. All normal underway observations were begun including hydrography, magnetics, gravity, BT observations, plankton tows, and biological productivity hauls. Surface biological tows were scheduled each evening for a period of 30 minutes and daily stops were made ½ hour after sunrise to sample for productivity measurements. BT observations were made on a 2-hour interval. The ship sailed on the Honolulu to Manila leg of the Indian Ocean Expedition, February 25, 1964; underway operations included hydrography, magnetics, gravity, BT observations, plankton tows, and biological productivity hauls. A land tie was made as the ship passed the Mariana Islands and another made to the end of the line near San Bernadino Strait, Philippine Islands. On the leg Manila to Singapore by way of Jesselton, Sabah, (Borneo), across the southern end of South China Sea; normal underway observations were made along the leg. Bottom dredging was accomplished in the vicinity of Seahorse Shoal, a seamount 66 miles west of Piedras Point, Palawan Island. Scuba divers explored the top for about 30 minutes, taking samples and underwater color photographs. An oceanographic station was observed off Jesselton with a bottom core taken and observations made by the deep-sea camera. On the track to Singapore with crossings of the shelf break were made off the coast of Sabah,

Brunei, and Sarawak. In addition to normal underway observations along the leg, Singapore to Calcutta via Penang, the Geological Echo Profiler (G.E.P.) was streamed several times and stops for bottom cores and grab samples were made. The water on this leg was generally too shallow for BT and magnetic observations. The ship departed Singapore on March 27, continuing oceanographic operations in Malacca Strait, Andaman Sea, Bay of Bengal, and Indian Ocean. In addition, a loop was made into the Indian Ocean in the vicinity of the Nicobar Islands and one in the vicinity of the Andaman Islands, also the western side of the Malay Peninsula, a loop was extended around the Langkawi Islands. The usual underway observations were continued on this leg. Upon arrival off the entrance to the Hooghly River, a pilot was picked up and the ship proceeded up river to Calcutta. A gravity land tie was made in Calcutta. On the leg from Calcutta to Colombo, subbottom profiling, echo sounding, grab sampling, coring, and rock dredge sampling were done along the Swatch of No Ground; a zigzag line was run across the Ganges Canyon obtaining subbottom profiles; bottom photography and dredging were also accomplished along the canyon. A land tie was made at Little Andaman, and then a trackline was run across the Bay of Bengal to the east coast of Ceylon. Enroute, several undersea channels were crossed and studied. The Trincomalee Canyon was developed with approximately a 2-mile spacing and investigated with subbottom profile, camera, core, and dredge. Lines were also run over canyons south of Trincomalee and a canyon on the west coast of Ceylon. In this area the continental slope and canyon walls along the east coast were exceptionally steep. An investigation of the deep scattering layer was made with the deep-sea camera and plankton net from 1 hour before to 1 hour after sunset. Observations were completed on the system of Nansen stations in the Indian Ocean centered about the equator. The ship was assigned the best berth in the harbor at Colombo, Ceylon, alongside the Queen Elizabeth Quay. Departure from Colombo for Penang, Malaysia, was on May 25. Enroute a second series of Nansen stations from 5° S. to 5° N., was completed, a GEP profile north of Sumatra, a camera station, and two unsuccessful thermoprobe attempts in the Andaman Sea. The usual normal underway operations and stops for biological sampling were conducted. On the legs of the trip from Penang to Phuket, Thailand, thence to Djakarta, Indonesia, observations consisted of the final series of Nansen stations 5° N. to 5° S., including standard stations at the equator and 90° E. Work in the Andaman Sea consisted of one GEP profile north of Sumatra and a thermoprobe lowering. A GEP profile and a 7-foot core were taken in the Java Trench. An investigation of the canyon south of

Sumatra near the entrance of Sunda Strait was made including 5 normal underway crossings and 3 grab samples. Between Djakarta and Palu, normal underway observations were made except in the western part of the Java Sea which was too shallow for BT observations. An investigation for the existence of a density front in Lombok Strait was completed consisting of continuous BT observations with Nansen casts and grab samples. A series of 5 BT's were taken off the northwestern end of Sumatra to investigate the periodic occurrence of what appeared to be tide rips. During the Indian Ocean Expedition official calls were made on the American Ambassadors at Manila, Colombo, Ceylon, and Djakarta, Indonesia; on the Consuls General at Singapore and Calcutta; on the Philippine Coast and Geodetic Survey, and Malaysian Geological Survey. Seminars at which the ship's scientists and native scientists were speakers were held at Bose Institute, Zoological Survey of India, Geological Survey of India, Birla Industrial and Technical Museum, and University of Ceylon. The ship held open house or a reception for the following ports, attendance figures follow the name: Manila 32, Singapore 55, Calcutta 460, Colombo 900, Penang 420, and Djakarta 300. Press conferences were held in Penang and Djakarta. During the visit to Djakarta the city celebrated the 437th anniversary of its founding.

The ship SURVEYOR continued the ocean surveys between the Hawaiian and Aleutian Islands. Seismic work was carried on in the Bering Sea during which time 12 lowerings of an ocean bottom seismometer were successfully completed. The seismic sea-wave detectors at Dutch Harbor and Attu were inspected and serviced. Gravity calibrations were made in the Strait of Juan de Fuca. Tests of the newly installed narrow beam transducer were made with excellent bottom definition obtained in depths under 200 fathoms. A seamount served as a future for comparison of results obtained with the UQN sounding equipment and with the Narrow Beam Transducer system. A new instrument called a "Multi-sampler" was tested and after a number of attempts, the cast was completed to a depth of 550 fathoms with good results. During an investigation of Thirty-five Fathom Bank in lat. 23°N., long. 161°W., a least depth of 33½ fathoms was recorded. On March 28, 1964, the SURVEYOR received instructions to proceed to Kodiak, Alaska, to take part in the Earthquake Damage Surveys to correct charts where the earthquake and seismic sea wave had made some of the important deep water harbors dangerous to enter. On April 2 the sounding line was terminated off Cape Chiniak. Westerly winds, snow, and fog prevented entering Chiniak Bay until the following day. Emergency work in the Alaska Earthquake disaster area was begun on April 4 with bench mark leveling at Womens

Bay, and recovery of control and signal building. Reconnaissance hydrography in St. Paul Harbor and Kodiak Channel was completed. After completing the installation of a tide gage at Kodiak, the ship sailed for Cordova. Enroute a reconnaissance line was run through Prince William Sound and Orca Bay. Hydrography was completed in the navigable channels to Cordova, a tide gage installed, and recovery and leveling of tidal bench marks begun. On April 9, the ship sailed for Whittier. A working party was sent ashore to sound the approaches and depths alongside the wharf prior to docking the ship. Reconnaissance hydrography, recovery and leveling of tidal bench marks, and installation of a standard tide gage was completed. On April 12, a reconnaissance hydrographic line was run enroute to Valdez. Launches and boats were put over, tide gage installed, triangulation recovered, bench marks of First Order levels searched for, a detailed hydrographic survey of Valdez Harbor begun. All work was continued under most adverse conditions of snow and wind until May 4 when the ship sailed for Perry Island. An examination of fore-shore, offlying rocks, and charted soundings was completed on May 5 and the ship sailed for Whittier to check some erratic soundings. A hydrographic line between Cape Hinchinbrook and Kodiak was begun and ended on the 9th. Surveys in the vicinity of Kodiak, Trinity, and Semedi Islands were terminated off Barren Islands on May 18 and a deep sea sounding line run to Seattle. The ship arrived in Seattle on May 22 and remained alongside at the Ship Base until departure for San Francisco on June 16. Enroute, a transit of the Oregon State University Gravity Range was made and the ship arrived in San Francisco on June 19. Gravity calibrations were completed on June 21 and June 23 the ship sailed for Prince William Sound, Alaska. Enroute, standard oceanographic stations were observed, and bottom cores obtained for the University of Washington. At the end of the sounding line the northeast leg of the Geological Echo Profile pattern was run into Prince William Sound. At the end of the fiscal year the SURVEYOR was in the Prince William Sound area completing earthquake fault line investigations.

Facilities Division

Under normal repair and maintenance activity, this Division has administered and furnished technical support for 27 repair contracts. An electronically stabilized narrow beam sonar system was installed on the ship SURVEYOR. This ship becomes the first in the United States using this type of equipment for oceanographic survey work. Medium range navigational radar

was installed on the ships EXPLORER, SURVEYOR, and HYDROGRAPHER. A recently developed radar plotter was installed on the ship WAINWRIGHT for wire drag work. The ships, PEIRCE and WHITING, have completed their shake-down period and have become operational.

Under the Budget Management responsibility of this Division, Cost Centers for Repairs to Vessels, Oceanography, Hydrography, and Tides have been consolidated for more efficient management. A number of standard specifications for ship repairs were prepared during the year. The ship SCOTT was laid up upon completion of the Coast Pilot work.

The Seattle Ship Base is now operational. Phase IV of the Norfolk Ship Base construction was placed under contract for completion of dredging and bulk-heading, the construction of a warehouse, and modifications to the existing building to install an oceanographic laboratory.

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; expert advice to litigants on datum planes, tide, and 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 ninth (June 15, 1963) edition of U. S. Coast Pilot 7, Pacific Coast - California, Oregon, Washington, and Hawaii, was delivered and approved for issue on December 26, 1963. Seven supplements dated January 4, 1964, were approved for issue by February 20; one supplement dated March 7 was approved on April 14. The second (1964) edition of the COAST PILOT MANUAL went to press on April 15 and was delivered on June 23. The seventh (March 21, 1964) edition of U. S. Coast Pilot 4, Atlantic Coast, Cape Henry to Key West, was in press at the end of the fiscal year.

Marine Information Specialists of Coast Pilot Branch directed closely, from office and field, the 4.6-month coastal and intracoastal inspections of the USC&GSS SCOTT which supplemented and completed the Coast Pilot 4 revision begun in the preceding fiscal year.

Tides and Currents Branch

A cooperative effort with the Weather Bureau was completed on the development of computer programs for the analysis and prediction of tides and tidal currents. The prediction programs were prepared in machine language for the IBM 7090, and the analysis program was written in Fortran IV and has been used only on the IBM 7030. Results are produced more economically and in a more expedient manner than with the older methods, and much time consuming work is eliminated. The 1966 Coast and Geodetic Survey tide and tidal current tables have been computed and edited by this method and will be the first such tables of this agency produced by electronic computer.

Tides in Boca Grande, Orinoco River Entrance, Venezuela, have been under study in the Branch for several months. Due to the wide secular variation in lunital intervals and tidal range, it is necessary to compute harmonic constants for each month of the calendar year, thus requiring machine settings for each month. This involved process was greatly simplified by IBM computer, and tide predictions for Boca Grande for 1964-65 were furnished the Instituto Nacional de Canalizaciones in Caracas, Venezuela. By comparison of observed and predicted tides for the first five months of 1964, average discrepancies of 0.1 foot in tidal heights and 20 minutes in time of tide are indicated.

Tidal bench mark index maps for Texas were revised and printed.

Records for 22 tide stations, operating in the area between Prince William Sound and Unimak Island, Alaska, were processed on a priority basis for the purpose of establishing preliminary tidal datum planes and change in land elevations due to the earthquake of March 27, 1964.

Processing of Sea Water Temperature and Density at tide stations was transferred to the Oceanographic Analysis Branch in April 1964.

Statistical Summary

Location	Hydrography				Topography		
	Nautical Miles of Sounding Lines	Square Miles	Nautical Miles Wire Drag	Square Miles	Miles of Shore- line	Miles Inspec- tion Shoreline	Control Stations Ident.
Maine to Cape Henry	2,093	111	53	29	-	-	-
Cape Henry to Florida	15,608	7,662	78	37	-	-	-
Chesapeake Bay	371	8	-	-	-	-	-
Gulf Coast	3,546	1,618	55	41	-	-	-
Puerto Rico and Atlantic	2,131	136	-	-	-	-	-
West Coast	2,207	34	19	1	-	8	-
Lake Mead	2,373	93	-	-	-	-	-
Northeast Pacific	45,070	385,211	-	-	-	-	-
Alaska	8,736	367	-	-	24	193	39
To and from project area	76,365	-	-	-	-	-	-
Total	158,500 ^a	395,240	205	108	24	201	39

^a Includes 13,095 New Jersey to France, 6,800 Guam to Philippines, 23,314 Indian Ocean Expedition.

Statistical Summary

	Triangulation			Oceanography							
	Stations Recovered	Stations Establish.	Traverse Electronic	Towed Magnetometer	Sea Grav- ity Meter	No. Bathy. Lowerings	Oceanogr. Stations	Drift Bot. Released	Biological Tows	Water Samples Analyzed	
	No.	No.	Miles	Naut. Miles	Naut. Miles	No.	No.	No.	Each	No.	No.
Maine to Cape Henry	12	-	-	-	-	-	-	-	-	-	-
Chesapeake Bay	2	-	-	-	-	-	-	-	-	-	-
Cape Henry to Florida	12	3	-	-	-	102	16	520	-	341	291
Gulf Coast	8	-	-	-	-	-	-	-	-	-	-
Puerto Rico & Atlantic	67	10	24	-	-	7	4	-	-	155	-
West Coast	9	-	-	890	889	-	-	-	-	-	-
Lake Mead	14	-	18	-	-	-	-	-	-	-	-
Northeast Pacific	10	-	-	64,475 ^a	56,026	1,885	76	-	284	3,157	1,785
Alaska	201	15	68	2,570	180	129	3	-	-	14	-
To and from Project Area	-	-	-	44,817 ^b	10,358	1,395	19	660	-	777	288
Total	335	28	110	112,752	67,453	3,518	118	1,180	284	4,444	2,364

^a Includes 21,221 N. M. Indian Ocean Expedition.

^b Includes 13,011 New Jersey to France and 6,600 Guam to Philippines.

Tide and tidal current predictions were furnished 19 foreign countries on a mutual exchange basis.

Tide records were obtained from a number of gage installations in the Hackensack River Basin, for the establishment of high water lines. This project was done in cooperation with the Division of Photogrammetry for the State of New Jersey.

A tentative proposal was submitted in regard to the establishment of 40 additional tide gages, to support a proposed cooperative Coast and Geodetic Survey program for delineating high and low water lines in Florida.

Preliminary instructions were initiated for the installation of 10 tide gages in a cooperative Coast and Geodetic Survey mapping program of the approaches to the Caloosahatchee River, Fla.

Statistical summary of work completed:

Tide records processed (station months)	1,260
Leveling records processed (stations)	278
Bench marks recovered	1,250
Bench marks established	116
Bench marks destroyed	14
Tide notes prepared (locations)	453
Tide notes prepared (hydrographic sheets)	72
Planes of reference verified (volumes of sounding records)	610
Descriptions and elevations of bench marks (stations)	230
Density and temperature records processed (station months)	1,452
Tidal current observations processed (meter days)	1,172
Harmonic analyses computed (stations)	13
Special tide predictions (stations)	13
Tidal data for small craft charts (number of charts)	13
Datum planes and tidal ranges determined (stations)	56

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. A part of the research activity previously centered in this branch has been transferred to the Office of Oceanography; a part of the

data processing function has been transferred to the Seattle Regional Office.

Fifteen branch employees participated in shipboard operations. Their total time at sea was about 2-man years. A major part of this resulted from the participation of five branch people aboard the PIONEER on the International Indian Ocean Expedition.

Oceanography.—52 oceanographic stations were taken in the Indian Ocean, 6 in the Pacific, and 27 in the Atlantic. A comprehensive drift bottle program was continued and a compilation, plotting and interpretation of some of the Atlantic returns was initiated. The branch assumed the responsibility for the reduction and tabulation of temperature-density observations at tide stations near the end of the period.

Coast and Geodetic Survey Report No. 4 to the Atomic Energy Commission on Preliminary Studies Relating to the Sea Disposal of Low-Level Packaged Radioactive Wastes was completed. Preliminary instructions for measuring deep currents with Swallow neutrally buoyant floats aboard United States Coast and Geodetic Survey ships were prepared.

Following is a summary of the oceanographic work accomplished during the fiscal year.

Oceanographic stations sent to NODC	90
Bathythermograph observations sent to NODC	3,419
Drift bottle cards returned	78
Oceanographic station sections completed	24

Marine Geology.—A second and more powerful Geological Echo Profiler (GEP) assembly was procured and used successfully aboard the PIONEER during the International Indian Ocean operation. A GEP investigation was conducted off the west coast of Florida and a preliminary report is in preparation of the results in the DeSoto Canyon area. An investigation of the submarine extension of faults associated with the Alaskan earthquake was under way at the end of the period.

Marine Geophysics.—Magnetic data obtained in the Atlantic Ocean was tabulated and supplied to the Magnetic Chart Section for inclusion in the world magnetic chart. Photostats of all gravity data sheets taken between latitudes 17°N. and 45°N. and longitudes 120°W. and 165°W. were furnished to the U. S. Naval Oceanographic Office. Over 3,000 magnetic observations between 28°N. and 41°30'N. from the west coast of the U. S. to 153°W. were compiled and transmitted to Dr. Victor Vacquier of Scripps Institution of Oceanography.

Computer programs for magnetic data reduction and for plotting profiles of total magnetic intensity against distance were prepared and made operational. Six magnetometer lines of the EXPLORER 1962 in the Gulf of Maine were plotted with the X-Y plotter. Also lines of PIONEER 1961 soundings, free-air gravity anomalies, and residual magnetic intensities were plotted with the X-Y plotter.

INTERNATIONAL AND NATIONAL COOPERATION

While on Indian Ocean expedition the Ship PIONEER cooperated with the following: Weather Bureau, meteorologists aboard; Geological Survey, geological studies at Flau and Guam; National Oceanographic Data Center, personnel training; Bureau of Commercial Fisheries, oceanographic stations for Stanford Laboratory and biological, plankton and sampling for Honolulu Laboratory; Scripps Institute; University of Southern California; and University of Hawaii. Cooperation with the following for training in Oceanographic methods: Bureau of Coast and Geodetic Survey, Philippines; Philippine Fish Commission; Maylasian Geological Survey; Fisheries Research Laboratory, Penang; Survey of India; and Marine Research Laboratory, Indonesia.

For Institute of Oceanography, Dartmouth, Nova Scotia: Washington, D. C. conference on processing tides and tidal currents.

For Canadian Hydrographic Service: Cooperation on circulatory current observations in Haro Strait and Strait of Juan de Fuca.

For Instituto Nacional de Canalizaciones, Caracas, Venezuela: conference with representatives in October 1963 on tidal predictions for Boca Grande, entrance to Rio Orinoco. Special predictions computed and sent to Caracas.

For the U. S. Navy Department: A wire-drag survey of the approach areas to Ensenada Honda, Puerto Rico, for safe entrance by deep draft craft.

Furnished results of tidal current stations near Annapolis in Chesapeake Bay Survey to the Naval Station, Annapolis, Md. Two stations occupied at their request.

Corps of Engineers, U. S. Army, various districts tide and tidal current observations. Charleston tidal current survey. Soundings and current records for erosion

studies at Edgartown, Martha's Vineyard, Mass.; installation of a bubbler type tide gage at La Conner, Wash.; hydrographic and topographic surveys along the South Carolina coast between Isle of Palms and Bull Bay for the purpose of constructing a model for study of effects of diverting the outlet of the Cooper River; and a hydrographic survey of an area approximately 6 miles north from Anchorage, Alaska.

U. S. Coast Guard, tidal current observations furnished by 2 lightships. Special current data near Sanibel Island, Fla.

Department of Justice, special tide and tidal current observations in Delaware River and Puget Sound, Wash., relative to pending litigation.

For Advanced Research Projects Agency: Lowering of seismometers in Bering Sea were made for recording arrival of seismic wave through varying strata.

For the Maryland Port Authority: A channel survey for deep draft vessels in the approaches to Cambridge, Md.

For the University of Alaska: Water sampling in the Gulf of Alaska and water and bottom samples with simultaneous current observations.

Scripps Institute of Oceanography, exchange of sea water temperature and salinity data. Monthly records furnished for entire series for Atlantic City, N. J., Baltimore, Md., San Francisco, Calif., Seattle, Wash., and Honolulu, Hawaii.

University of Hawaii, furnished tidal current data for stations in the Hawaiian Islands.

For the Coastal Studies Institute of Louisiana State University: Wave Refraction Studies along the coast of Bodie Island, N. C.

For Old Dominion College: Water samples were obtained in Chesapeake Bay.

For the University of Oregon: A gravity transect was run through the calibration area as proposed by University personnel off the Oregon coast.

For Rice University: Seismic Profiling was accomplished in Virgin Passage to Charlotte Amalie using a sparker for penetration of the subbottom.

For University of Washington: Coordinating temperature and salinity studies with simultaneous current observations; sediment core sampling in the North Pacific; cooperation with the Coast and Geodetic Survey ships HODGSON and BOWIE in the tidal current survey of the San Juan Islands, Wash.

For the American Telephone and Telegraph Co.: A hydrographic sounding line was run along a proposed cable route between the New Jersey coast off Atlantic City and Brest, France; and another was run for a cable route between Guam and Baler Bay, Philippine Islands.

OFFICE OF PHYSICAL SCIENCES

OPERATIONAL ACTIVITIES

Geodesy Division

The Geodesy Division planned and wrote instructions for, and supervised the execution of, the geodetic control field surveys and the office computations, including triangulation, traverse, leveling, base measurements, and astronomic and gravity determinations; operated latitude observatories; compiled, published and distributed geodetic control data for use of the Government and the public; compiled and published other matter relating to geodesy; cooperated with other Government agencies concerning control surveys and state coordinate systems; performed precise geodetic surveys for missile systems; operated three satellite tracking systems in performing three dimensional satellite triangulation over the eastern part of the United States to Bermuda; and cooperated with several states in establishing control surveys over the interstate highway system.

Horizontal Control.--Horizontal control surveys for mapping, charting, and as a basis for other surveying and engineering purposes were established by triangulation, electronic distance traverses, and combinations of electronic distance traverses and triangulation. Special purpose surveys included control as follows: for determination of earth movement along a proposed aqueduct in California, consisting of disconnected precise distances and directions for small quadrilaterals, in addition to triangulation arcs; first-order triangulation along selected routes in the vicinity of the March 1964 Alaska earthquake to form a basis for future studies as well as to determine previous earth movement; the completion of the Louisiana Offshore Oil Well Survey; the New York Worlds Fair Space Capsule location; the Arizona-California Boundary survey along the Colorado River; precise positioning for satellite triangulation tracking cameras; the first cross-country high precision Geodimeter traverse for strengthening the horizontal control network from Jacksonville, Fla., westward was begun. In conjunction with this traverse, tests were made for calibrating various electro-optical distance measuring instruments. One party operated the entire fiscal year establishing the precise control for positioning, testing, and research for satellites, missiles, and related operations for the Atlantic Missile Range; a similar party for the Pacific Missile Range; and a

party at the White Sands Missile Range was placed under the charge of the Bureau the latter part of the year. The Virginia highway control survey party operated during the year, and inspection was provided under cooperative agreements for highway control to be accepted into the national network as established by the States of Kentucky, Minnesota, Mississippi, Oregon, and Tennessee.

Five parties averaging 25 men each were on regular operations; five parties averaging 18 men each and one party averaging 34 men were on special purpose surveys; one party averaging 15 men was engaged in satellite camera triangulation; a party averaging 22 men was on the transcontinental precise traverse and Geodimeter base line measurement, and an average of 14 men were on mark maintenance and preservation work.

Several urban communities have shown an interest in establishing precise control surveys for mapping and engineering operations. A control network was established for the city of Akron, and the control work established by the city of Detroit was connected to the national network and additional bases were measured. Advice through conferences and letters was provided other cities and urban areas interested in precise basic control surveys.

During this fiscal year, a total of 54 horizontal control survey projects were processed and completed. This processing accounted for 3,363 points being added to the files. Major adjustments were completed in California, Louisiana, New Mexico, North Dakota, South Carolina, South Dakota, Utah, and the Territory of Guam.

IBM listings of adjusted data for several surveys were furnished to the U. S. Engineers, the U. S. Geological Survey, and to other organizations as requested. The major projects in this category are: West Virginia-Ohio-Pennsylvania area; city of Akron, Ohio; vicinity of Phoenix, Ariz.; Kemmerer area, Wyoming-Utah; Ogden, Utah, to Pocatello, Ida.; Glen Canyon area; Utah-Arizona; and a cross arc in Colorado and Kansas. Although adjusted data for these projects were available, final horizontal control data sheets for the files had not been completed at the end of the fiscal year.

Adjustments were completed for surveys along interstate highway routes in Kentucky, Minnesota, and Tennessee. The surveys for these projects were done by the States and our responsibility was to review the records, adjust the observations, and prepare final data for the files.

The processing of special surveys made for the Department of Defense continued during the year. Adjustments were completed for surveys in the vicinity of Cape Kennedy, Fla., Vandenberg AFB, Calif., Antigua Island, San Salvador Island, Eleuthera Island, Grand Bahama Island, and various projects in the vicinity of the Marshall Islands in the Pacific. Data for most of the points established in these special surveys are classified and therefore were not added to our regular files.

An adjustment was completed for first- and second-order surveys in the Territory of Guam. These surveys, involving 160 points, were done at the request of Guam officials to coordinate and strengthen existing horizontal control. A first-order arc was carried across the island and second-order supplemental stations were established.

A survey to obtain the geographic position of a time capsule at the New York Worlds Fair was accomplished early in 1963. The data from this survey shows the 1964 capsule is 10.4 feet from the time capsule which was established for the 1939 Worlds Fair.

Adjustments were completed for surveys to position various oil well platforms off the Louisiana coast. This project, an extension of the 1955 offshore survey, was done at the request of a Committee sponsored by the California Oil Company. A total of 118 points was established by a combination of triangulation and Tellurometer traverse surveys.

Three surveys in California, established for the study of horizontal earth movement, were processed. A report on movement in the vicinity of Wheeler Ridge, as indicated from surveys of 1932, 1953, and 1963, was furnished to the California Department of Water Resources. Movement along the San Andreas fault in the Salinas River Valley, as determined from surveys of 1944 and 1963, was reported in a paper, "Earthquake Surveys for Horizontal Movement in California," presented to the annual meeting of American Congress on Surveying and Mapping. The 1963 observations over the Hollister Winery quadrilateral showed the same systematic clockwise displacement, between points on opposite sides of the fault, as indicated from previous annual surveys since 1957.

The high-precision Geodimeter traverse surveys extending from Cape Kennedy, Fla., to Savannah, Ga., were adjusted to the Cape Canaveral datum. In October 1963 field operations were started to extend the high-precision surveys westward from Jacksonville, Fla. During the first

6 months of operations, considerable time was spent making tests with the Electrotape and Tellurometer comparison with the Geodimeter. A report on the results of these tests was being prepared at the end of the fiscal year.

Vertical control.--Four main multiple-unit level parties averaging 18 men each completed 102 unit-months of leveling in the United States in extending the basic control net and releveing.

A party of one unit completed two unit-months of leveling in Maine in connecting tidal bench marks to the level net. Leveling was run as part of the survey at Whiteman AFB, Mo., and Grand Forks AFB, N. D. Leveling was undertaken in Virginia as part of the highway program.

Special releveing projects were undertaken in New Orleans, La., and Houston-Galveston area, Tex. During the year 11,954 miles of single line levels were completed. Elevations were determined for 11,479 bench marks, of which 5,954 were new marks.

The following computations and adjustments were completed during the year: preliminary computations for 3,719 miles of first-order and 9,866 miles of second-order leveling; 26 least-squares adjustments comprising 2,655 miles of first-order, 8,679 miles of second-order, and 345 miles of third-order leveling; and the distribution of closing errors on 3,174 miles of first-order and 8,635 miles of second-order leveling.

Of the 26 least-squares adjustments, the equations required by the 5 largest adjustments were 110, 81, 69, 58, and 57. The computer obtained for the Leveling Branch during the spring of 1963 has proved very helpful in distributing closing errors and preparing lists of typed adjusted elevations in meters and feet.

Geodetic Astronomy.--Astronomic positions were observed at 22 stations in New England and 44 stations in New Mexico in continuation of the program for developing regional deflection coverage in those areas. Astronomic azimuths were observed at 27 stations for control of the Geodimeter traverse from Jacksonville, Fla., westward toward Greenville, Miss., and Baton Rouge, La. Thirty astronomic azimuths were observed in connection with the study of crustal movements in earthquake fault zones in California. Astronomic positions and azimuths were also observed, to control triangulation in various areas, provide tracking and geoid information on the Atlantic and Pacific Missile Ranges, and for various special applications requiring data on local orientation of the earth's gravity field.

Processing of astronomic data was maintained current with field work throughout the year. A total of 120 positions and 36 azimuths were computed. Look angles for several hundred satellite tracking events were determined in support of operations at the Coast Survey camera stations. Zenith telescope observations were processed monthly in connection with the determination of micrometer screw characteristics and level constants at the Ukiah and Gaithersburg latitude observatories.

Gravity and Geoid Studies.--Gravity observations on land consisted mainly of traverses over primary level bench mark lines. Traverses were observed from Missoula, Mont., to Dickinson, N. D.; from Glyndon, Minn., to Sandoval, Ill.; from Wickliffe, Ky., to Vicksburg, Miss.; and from Rochelle, Ill., to Atlantic City, N. J. Approximately 720 stations were occupied along a traverse distance of 2,970 miles. The traverses served to extend the gravity base network and provide data for computing dynamic elevation differences along the various loops of spirit leveling.

A special gravity survey comprising 150 stations was accomplished on Merritt Island and Cape Kennedy, Fla., in connection with development of new rocket launch facilities. Other gravity survey schemes were observed on Kwajalein and Eniwetok, Marshall Islands; at Point Mugu, Calif.; and at U. S. Naval facilities at Norfolk, Va., and Seattle, Wash.

Gravity intensity was observed at several physical laboratories for the calibration of inertial devices and dead-weight balance systems.

LaCoste and Romberg sea gravity meters were operated in conjunction with oceanographic surveys of the USCGS ships PIONEER and SURVEYOR. The PIONEER's gravity meter was tested on the San Francisco evaluation range in July and October 1963 and February 1964. The SURVEYOR's gravity meter was tested over the same range in July 1963 and February 1964. The Japanese vibrating-string gravity meter was tested aboard the PIONEER on this range in October 1963.

In July 1963 the PIONEER observed a track line from San Francisco to Hawaii and then began oceanographic surveys from the Hawaiian Islands to the Aleutian Islands between the 158th and 165th meridians. In February 1964 the PIONEER followed track lines to Hawaii and then to the Indian Ocean where oceanographic operations were begun.

In July 1963 the SURVEYOR observed a track line from the west coast along the 40th parallel to her working grounds. Oceanographic surveys were accomplished from the Hawaiian Islands to the Aleutian Islands between the 170th and 180th meridians. In February 1964 the SURVEYOR resumed operations on the same working grounds, but shortly after the Alaskan earthquake of March 27 was diverted to special surveys in Alaskan waters.

Positions, elevations, and anomaly data were compiled for gravity traverses over primary bench mark lines from Monohans to Greenville, Tex., via Brownsville; from Missoula, Mont., to Dickinson, N. Dak.; from Glyndon, Minn., to Sandoval, Ill.; and from Wickliffe, Ky., to Vicksburg, Miss. Gravity anomaly data were processed for various special surveys in connection with national defense requirements. Numerous gravity values were determined by interpolation for U. S. Weather Bureau sites, physical laboratories, and test facilities as requested during the year.

Geoid heights were calculated for the entire state of Maine, based on 43 astro-geodetic deflections observed in 1962 and 1963. Results of a least-squares adjustment indicate a geoid rise of nearly 4 meters along the coast from Portland to the Canadian border. Geoid height data were processed for numerous Atlantic Missile Range tracking stations in the West Indies, and for 22 stations along a profile from Titusville, Fla., to Savannah, Ga.

The three components of the gravity anomaly field were calculated for a high-altitude trajectory over the Atlantic Missile Range.

Variation of Latitude.--The variation-of-latitude observatories at Ukiah, Calif., and Gaithersburg, Md., continued in operation throughout the year. At Ukiah, 4,046 star pairs were observed on 244 nights with complete observations on 182 nights. At Gaithersburg, 3,842 star pairs were observed on 289 nights with complete observations on 122 nights. Latitude observing records were transmitted weekly to the Central Bureau of the International Polar Motion Service in Mizusawa, Japan. The regular measurement of micrometer screw characteristics and level sensitivity values was continued throughout the year.

Satellite Triangulation.--Actual satellite triangulation observations had gotten underway shortly after the beginning of the fiscal year. One each of three BC-4 satellite tracking camera systems were in place at Aberdeen Proving Ground, Md.; Chandler AFB, Minn.; and Greenville AFB, Miss. Simultaneous observations were made on the Echo I satellite. Upon completion of this triangle, the

camera system at Minnesota was moved to Valkaria, Fla., where simultaneous observations were continued with the cameras in Maryland and Mississippi. This triangle was completed and the camera at Mississippi was moved to Bermuda. At the end of the fiscal year, observations were underway for the triangle Maryland-Florida-Bermuda. Indications are that these camera systems are capable of determining directions in space within a standard error of something better than one half second.

All camera stations had been tied to triangulation stations on the North American Datum of 1927. However, the tie to the Bermuda camera was only by high altitude flare triangulation from points on the east coast, and was considered very weak. When the satellite observations are completed, it is expected the latitude and longitude of the Bermuda camera will be determined within a standard error of about 5 meters.

Recovery and Maintenance Program.--An average of 14 men were on geodetic mark recovery and maintenance in Arkansas, California, Florida, Georgia, Indiana, Kansas, Louisiana, Massachusetts, Minnesota, Mississippi, Missouri, North Dakota, Oregon, Tennessee, Texas, Virginia, Washington, and Hawaii.

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. A total of 158 of these diagrams have been printed.

About 15,190 mailings of geodetic control data were made to organizations and individuals on our automatic mailing list. In addition, about 4,300 mailings were made in response to individual requests for information. Sales to users totaled \$12,739, and material valued at \$66,031 was distributed to those authorized free distribution.

New York Geodetic Computing Office.--During the past year this office was engaged in the adjustment of triangulation and traverse; the preliminary computation of geodetic leveling; the conversion of geodetic horizontal control data to the new format; the typing of lists of geographic positions and plane coordinates; and the editing and typing of descriptions of triangulation stations and bench marks. This office, which averaged about 18 employees during the fiscal year, was closed the latter part of June. All employees were given the opportunity to transfer to the Washington office and eight accepted.

Special Projects

After the Alaska earthquake of March 27, 1964, a level party was sent to Alaska to relevel the existing lines to determine the changes in elevation. Preliminary field elevations resulting from the releveling of 1964 when compared with original leveling of 1922 and 1923 shows a maximum subsidence of 5.6 feet near Portage. It is planned to relevel all of the existing lines in Alaska and provide additional new lines along existing roads to be used as a basis for future elevation changes.

First-order horizontal control surveys to determine movement in the Cook Inlet - Prince William Sound area, as a result of the March 1964 Alaska earthquake, were begun in the Anchorage area. The surveys were extended northward to Palmer and southward towards Seward and Whittier to determine relative movements and to provide a strong network for determinations of future earth movements. Basic control throughout this area consisted of work of many seasons and was not of sufficient precision to accurately determine movement. The present work utilizes new optical-electronic distance measuring equipment as well as angle observations to form a basis to determine small local movements as well as long range area movements.

Releveling was undertaken in cooperation with the California Department of Water Resources in the Delta Area of California which is located in the lowland region at the confluence of the Sacramento and San Joaquin Rivers. The maximum settlement was 2.158 feet at Stockton from 1912 to 1964. A releveling of 825 miles of lines was undertaken in the Galveston - Houston area of Texas to determine subsidence. In cooperation with several local agencies a releveling was undertaken of the net of lines in the vicinity of New Orleans and also a releveling along five lines radiating from the city. Based on preliminary field elevations the subsidence at New Orleans is shown to be about 1.2 feet since 1951 with a subsidence of 1.4 feet since 1938 determined south of New Orleans toward the mouth of the Mississippi River.

Tabulation of Field Activities

Triangulation Reconnaissance

State	Area
	Square Miles
Alabama.....	**
Alaska.....	795
Arkansas.....	2,000*
California.....	430
Delaware.....	**
Florida.....	**
Georgia.....	**
Idaho.....	1,550
Kansas.....	1,410
Louisiana.....	**
Maryland.....	**
Michigan.....	250
Minnesota.....	4,425
Mississippi.....	10*
Montana.....	2,475
New Jersey.....	**
New Mexico.....	3,600
New York.....	2,950
North Carolina.....	**
Oregon.....	2,100
Pennsylvania.....	4,150
South Carolina.....	340*
Tennessee.....	490*
Texas.....	6,195*
Virginia.....	2,580*
Washington.....	3,850
Total.....	44,090

** See table of Precise Geodimeter Traverse

* Electronic Traverse also planned

Earthquake Surveys

	Number of Stations		Area
	Old	New	Square Miles
Vicinity of Hayward, Calif.....	22	6	14,000
San Fernando to Bakersfield, Calif....	33	4	710
Cajon Pass, Calif.....	21	8	160
Total.....	76	18	14,870

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

State	Number of Stations	Area
	<u>Marked and intersection</u>	<u>Square Miles</u>
Alaska.....	13	6
Arizona.....	47	300
Arkansas.....	166	3,700
California.....	248	3,201*
Colorado.....	95	3,420
Florida.....	42	**
Hawaii.....	5	10
Idaho.....	42	1,430
Kansas.....	193	5,873
Kentucky.....	44	*
Louisiana.....	103	5,500
Michigan.....	24	250
Minnesota.....	111	290*
Mississippi.....	4	6*
Montana.....	49	1,350
Nebraska.....	143	4,400
New York.....	32	560
Ohio.....	122	85*
Oregon.....	274	2,535*
South Carolina.....	120	260*
Tennessee.....	78	500*
Texas.....	232	4,620
Utah.....	42	1,270
Virginia.....	212	2,745*
Washington.....	90	2,435*
West Virginia.....	5	80
Wyoming.....	105	3,445
Puerto Rico.....	5	2
Total.....	2,646	48,273

** See table of Precise Geodimeter Traverse

* Electronic Traverse also measured

Highway Horizontal Control Surveys

State	Marked Stations	Miles of Road
Kentucky.....	44	95
Minnesota.....	82	215
Mississippi.....	4	27
Tennessee.....	68	85
Virginia.....	174	395
Total.....	372	817

Precise Geodimeter Traverse

Locality	Reconnaissance (miles)	Observed (miles)
Alabama	50	-
Arkansas	80	-
California	635	-
Delaware	70	-
Florida	40	185
Georgia	20	-
Louisiana	385	-
Maryland	25	-
Mississippi	295	-
New Jersey	75	-
North Carolina	280	-
South Carolina	205	-
Texas	165	-
Virginia	120	-
Total	2,445	185

Astronomic Determinations

(Including old stations)

<u>Locality</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Azimuth</u>
California.....	9	9	34
Florida.....	25	21	29
Illinois.....	-	-	2
Kansas.....	-	-	1
Maine.....	13	13	-
Massachusetts.....	8	2	-
Mississippi.....	-	-	1
New Hampshire.....	6	6	-
New Mexico.....	54	55	-
Virginia.....	2	2	3
West Indies.....	<u>7</u>	<u>7</u>	<u>18</u>
Total	124	115	88

Geodimeter Base-Line Measurements

Locality	Length in Miles
Am 2-Bell 2, Ariz.	2.63
Bell 2-Union, Ariz.	3.86
Geller-Daly, Ariz.	2.82
Lacklner RM 3-Bellaire RM 5, Tex.	6.57
Lacklner RM 3-Wayne RM 5, Tex.	7.91
Bellaire RM 5-U of Houston, Tex.	7.60
Fire RM 3-Wayne RM 5, Tex.	6.22
Bellaire RM 5-Houston S Base, Tex.	11.59
Fire RM 3-Houston S Base, Tex.	6.84
Houston N Base RM 2-Houston S Base, Tex. .	5.29
Yarbrough-Glendale, Ark.	8.86
Garden-Keller, Kans.	13.51
Cairo-Bergner, Kans.	9.93
Martin-Gregg, Kans.	8.61
Davis-Turtle, Texas	12.77
Boyd-Allen, Texas	10.21
South-Kress, Texas	9.58
Livermore East Base-Livermore West Base, Calif.	3.80
Llano W Base-Llano E Base, Calif.	10.08
Eastland-D 23, Mich.	6.34
Purdy 2-Rouge, Mich.	9.37
Buck-High Knob 2, Va.	11.51
Buck-Pine, Va.	6.74
Felt, Va.-Saddle, N.C.	10.16
Roanoke-Lewis, Va.	9.92
Oneida-Boissevain, Va.	5.52
Tower Hill-Willis 2, Va.	6.64
McQueen-Grant, Va.	8.66
Total	<u>223.28</u>

Gravity Determinations
(Including old stations)

	<u>Base net stations</u>	<u>Level line stations</u>
California.....	27	--
Florida.....	144	--
Illinois.....	--	105
Indiana.....	--	40
Iowa.....	--	16
Kentucky.....	--	17
Louisiana.....	--	3
Maryland.....	4	--
Minnesota.....	--	60
Mississippi.....	--	57
Montana.....	--	172
New Jersey.....	--	15
New York.....	5	--
North Dakota.....	--	16
Ohio.....	--	64
Oklahoma.....	3	1
Pennsylvania.....	--	95
Tennessee.....	--	43
Texas.....	2	--
Virginia.....	3	--
Washington.....	6	--
Wisconsin.....	--	16
Marshall Islands.....	25	--
Total	<u>219</u>	<u>720</u>

Leveling

State	First- Order	Second- Order	State	First- Order	Second- Order
	Miles	Miles		Miles	Miles
Alaska.....	80	0	Nevada.....	37	116
Arizona.....	12	0	New Jersey..	0	7
California..	1,126	170	New York...	0	8
Connecticut.	1	3	North Carolina	0	5
Delaware....	164	0	North Dakota	195	1,889
Florida.....	60	0	Ohio.....	62	3
Idaho.....	2	87	Oregon.....	0	41
Louisiana...	673	0	Texas.....	817	19
Maine.....	0	100	Utah.....	17	272
Maryland....	114	0	Virginia... 144		271
Minnesota...	20	0	Wyoming....	0	14
Mississippi.	52	0			
Missouri....	93	681	Total.....	3,669	3,686

Summary of Geodetic Field Operations

	Fiscal Year 1964	Total to June 30, 1964
1st-, 2nd-, and 3rd- order triangulation stations.....	2,646	173,731
1st- and 2nd-order leveling (miles)...	7,355	483,371
1st-order base lines (taped).....	0	453
Geodimeter base lines	28	242
Precise Geodimeter Traverse (miles)...	185	936
2nd-order base lines (taped).....	0	59
Latitude Stations....	103	2,005
Longitude Stations...	98	1,809
Azimuth Stations.....	82	1,794
Gravity Stations.....	801	18,133

Photogrammetry Division

The Photogrammetry Division performs the topographic and other detailed surveying of land areas required for the control of hydrographic surveys, for the construction and up-to-date maintenance of aeronautical and nautical charts, for the location of aids to air and marine navigation, and for other Bureau purposes. The Division operated aircraft for aerial photography, made field surveys, and performed office photogrammetric processing using all types of photogrammetric measuring instruments. It collaborated with other offices of the Bureau in the application of photography and photogrammetry to the Bureau's varied programs such as the development and operation of deep-sea cameras and measurement of tidal currents; photogrammetric measurement of earth crustal movement; and the planning and operations of the Satellite Triangulation Program. The Division provided photogrammetric consultant services to federal, state, and local agencies and to private engineering firms, and performed special photogrammetric surveys for other federal agencies and states. It distributed photographs, survey data, and copies of manuscript maps to agencies of the government and to the general public.

Photogrammetric surveying and mapping were in progress during the year throughout the United States (including Alaska, Hawaii, and Puerto Rico) for hydrographic and nautical charting purposes, for the airport charting and aeronautical aid location program carried on for the Federal Aviation Agency, and for other Bureau and national cooperative programs.

A considerable part of the Division's total effort was devoted to the Alaska earthquake area during the last quarter of the fiscal year. Air Photographic Mission 6401, using the Coast Guard DC-4 aircraft, was activated immediately after the earthquake of March 27 and arrived at Anchorage, Alaska, on April 2. This mission obtained aerial photography of the severely damaged ports of Kodiak, Seward, Anchorage, Whittier, Valdez, and Cordova on April 4 for the preparation of chartlets showing the conditions of these ports immediately following the earthquake. The mission then continued aerial photography for seismological studies and for support of hydrographic surveys by ships arriving in the earthquake area in early April. Plans were made to continue using Air Photographic Mission 6401 in Alaska throughout the remainder of the photographic season and to dispatch Air Photographic Mission 6402 to the area for about one month in the first quarter of 1965 so as to obtain photography for seismological studies and for the support of an intensive hydrographic survey effort in the earthquake area in fiscal years 1965 and 1966.

Outstanding progress was made in the application of color aerial photography to mapping in fiscal year 1964. In the fall of 1963, the Eastman Kodak Company, at the request of the Coast and Geodetic Survey, furnished the first glass plates for color diapositives. These plates for color diapositives were very successful and are now available for purchase from that company. They provided the last link in the chain of instruments and materials needed for photogrammetric mapping with color. Because of these plates, recent improvements in the speed and resolution of color aerial films, and the availability of optical viewing plotting instruments, color aerial photography can now be used for all steps in photogrammetric mapping, that is, for aerotriangulation by either analog or analytic methods, and for map delineation on stereoscopic instruments. Color photography need no longer be considered as an adjunct to black and white photography; it stands alone as a complete photogrammetric procedure. This fact represents a landmark in the development of photogrammetry and will have far-reaching effects on the economy and effectiveness of photogrammetric mapping and resource evaluation.

The possibilities of analytic block aerotriangulation were dramatically demonstrated during the year by completion of the aerotriangulation over a small area at Salt Lake City, Utah, where repeat aerial photography and aerotriangulation will be done to measure crustal movement along a fault line. The horizontal positions and elevations of a large number of points targeted prior to aerial photography with a glass plate camera were determined with a mean square error of $1\frac{1}{4}$ inches throughout a square area 0.6 mile on a side. As a result of the success of this test, a new test was initiated in cooperation with the Geodesy Division late in the fiscal year to determine the adequacy of photogrammetric block aerotriangulation for establishing control for mapping and other purposes over a larger area. The new test will include analytic block aerotriangulation over a square area about 40 miles on a side. Part of the area will be photographed with both film and glass plate cameras to determine the relative accuracies of aerotriangulation with glass plate negatives as compared to film negatives with eight fiducial marks for film distortion compensation.

The new deep-sea stereoscopic camera system operated very satisfactorily on oceanographic cruises of the ships EXPLORER and PIONEER. During the Indian Ocean cruise of the ship PIONEER, 35mm. stereoscopic photography of the floor of the Mindanao Trench was obtained at a depth of 26,000 feet.

An important improvement in the procedures for photogrammetric measurement of tidal currents was made by substituting aluminum powder for fire foam to provide floating targets. The aluminum powder is made up in small paper packages that are dropped from a small aircraft to provide the desired density and placement of the targets during aerial photography. This procedure greatly simplifies the seeding of targets as compared to the former use of boats for this purpose.

The research and development phases of satellite triangulation were largely completed, and the Coast and Geodetic Survey system became operational for the use of satellites ECHO I and ECHO II to perform geodetic triangulation over lines up to 1,000 miles long. At the close of the fiscal year, three triangles, including Minnesota, Mississippi, Maryland, Florida, and Bermuda, had been observed; and approximately 30 percent of the data reduction had been completed.

Aerial and Laboratory Photography

Two air photographic missions took the aerial photography required for the nautical charting program, the airport survey program carried on for the Federal Aviation Agency, the special surveys done for other agencies, and for research and development work in photogrammetry. All aerial photography was single-lens, using panchromatic, infrared, and color film. The nine-lens camera, designed by the Coast and Geodetic Survey especially for coastal mapping, was retired and put in the Smithsonian Institute after many years of highly effective operation on Coast and Geodetic Survey projects. The first survey flight of this camera was made on April 30, 1937 and the last flight took place on June 17, 1962. The volume and type of photography taken during the fiscal year 1964 are shown in the accompanying table.

Air Photographic Mission 6402 is operated by a Coast and Geodetic Survey crew using a leased aircraft. This mission operated throughout the continental United States, Puerto Rico, and the Virgin Islands.

Air Photographic Mission 6401 is a cooperative Coast Guard-Coast and Geodetic Survey mission, using a Coast Guard DC-4 aircraft for long-range operations. This mission was assigned almost exclusively to Alaska during the last quarter of the year for photography of the Alaskan earthquake area. The cooperative Coast Guard-Coast and Geodetic Survey arrangement for an aircraft will be discontinued in the second quarter of fiscal year 1965 and

Coast Guard aircraft will be replaced by a leased aircraft to be operated by Coast and Geodetic Survey personnel in the same manner as Mission 6402.

The Coast and Geodetic Survey is participating with a number of other Government agencies and private firms in a program of "Color Photography Tests" sponsored by the American Society of Photogrammetry. Coast and Geodetic Survey participation in this effort includes the furnishings of an aerial photographer, the processing of color film and plates, and technical advice and assistance to the participants.

Linear Miles of Aerial Photography

<u>Program</u>	<u>Mission 6401</u>	<u>Mission 6402</u>	<u>Total</u>
Nautical Charting	1,645	2,965	4,610
Aeronautical Charting	230	5,305	5,535
Miscellaneous Projects	<u>2,600</u>	<u>1,290</u>	<u>3,890</u>
Total	4,475	9,560	14,035

Film Exposed

<u>Type of Film</u>	<u>No. Rolls</u>
Panchromatic	69
Infrared	6
Color	<u>66</u>
Total	141

Laboratory Processing and Printing

Aerial negatives developed	27,233
Nine-lens prints	296
Single-lens prints (black and white)	54,265
Single-lens prints (color)	4,800
Photographic plates (black and white)	2,231
Photographic plates (color)	1,150

Field Surveys

Photogrammetric field survey units operated along all coasts of the United States to establish control for hydrographic parties, to locate aids to navigation, to make surveys of maritime facilities for the preparation of small-craft charts, to field-edit chart drawings, and to provide control for photogrammetric mapping. Overall accomplishments are shown in the accompanying table.

These photogrammetric field units provided hydrographic control and support for 11 ships and 1 shore-based hydrographic party and made facility surveys for 19 nautical charts.

Twelve to fourteen field units continued airport surveys and surveys for the location of aids to air navigation in all of the states for the Federal Aviation Agency; other field units were engaged in cooperative work for the States of Arizona, California, and New Jersey and for the Corps of Engineers as reported under "National and International Cooperation."

Horizontal and vertical control surveys for the test area for photogrammetric measurement of crustal movement at Salt Lake City, Utah, were repeated to increase the precision of the ground control in accord with the high precision attained in the analytic block aerotriangulation mentioned earlier in this report.

Work continued toward the improvement of the accuracy of the field identification of ground control on aerial photographs, particularly for work done in Alaska. Special instruction panels were prepared and sent to field parties, including the Alaska ships, and a special course for ship personnel was prepared and will be given at Seattle during the winter of 1964-1965.

Office Activities

Photogrammetric office activities included the planning of surveying and mapping projects; directing and reviewing of aerial photography and field surveys; processing of aerial photography; aerotriangulation for positioning hydrographic control, landmarks and aids to navigation, and map control; photogrammetric measurements and electronic computer processing of data of the Satellite Triangulation project; compilation of maps and various terrain data from photography and field surveys; development and application of techniques for new Bureau programs and needs; special photogrammetric work for other agencies; training of employees and foreign students; technical assistance to other Federal, State, and local agencies, private firms, and foreign visitors; and active participation in national and international technical groups and societies.

Summary of Coastal Mapping
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			75	105	15
Cape Henry to Key West	240	240	335	420	25
Puerto Rico and Virgin Islands	-	-	50	50	-
Gulf Coast	400	425	195	285	-
Pacific Coast					
California	290	355	125	180	10
Oregon and Washington	70	70	-	-	80
Alaska					
Earthquake Area	55	55	95	105	-
Gulf of Alaska	125	125	90	185	-
Western and northern areas	-	-	-	-	-
Hawaii	145	145	65	95	-
Total	1,325	1,415	1,030	1,425	130

The larger part of the photogrammetric office activity was devoted to the Bureau's nautical chart program and to the airport charting program carried on for the Federal Aviation Agency, as reported under "National and International Cooperation." During the year office work was in progress on 28 surveying projects for hydrographic control and nautical charting in various areas along the coastline of conterminous United States and in Alaska, Hawaii, and Puerto Rico. A total of 175 specially prepared survey sheets together with aerial photographs were furnished to 11 ships and 1 shore-based hydrographic party for hydrographic operations. A summary of accomplishments under the nautical charting program is given in the accompanying table.

The ready facility of aerial photography with Mission 6402 permitted continuing surveillance 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. A total of 160 regular charts and 20 small-craft charts were corrected in this manner. In addition, 110 large-scale coastal maps were revised for chart compilation. Color photography greatly improved the ability to locate aids to navigation and landmarks by direct application of new photography to chart drawings and maps without field investigation; 435 aids to navigation and 329 landmarks were positioned in this manner.

In fiscal year 1964, much effort was devoted to the refining of all phases of numerical photogrammetry so as to take maximum advantage of the inherent accuracies of digital computers for aerotriangulation. Accuracies possible with photogrammetric aerotriangulation were demonstrated by the test project at Salt Lake City, Utah, mentioned earlier.

The full economy of numerical photogrammetry for aerotriangulation will, however, depend on the automation of both the photograph measuring engines and electronic computer programs. A considerable amount of automation of the latter was accomplished this year by reprogramming for larger computers and at the same time combining the existing programs to permit computer decisions for the automatic rejection of faulty data.

The final phase of analytic aerotriangulation, the block adjustment, was programmed for solution on the IBM 7030 (Stretch) computer of the Weather Bureau. Arrangement for the use of this large computer, and the procurement of our own IBM 1401 computer accessory for preparing the magnetic tape input for the Stretch computer,

have reduced computation time for a large block adjustment from approximately 30 hours on the IBM 650 to a few minutes, and eliminated several hours of card handling as well.

Another application of the IBM 1401 and Stretch computers was the solution of about 80 percent of the computing effort required for the Satellite Triangulation program. The work completed on this program in fiscal year 1964 could not have been accomplished without the use of the IBM 1401 and Stretch computers because of a lack of both manpower and computer facilities for such a large undertaking.

A precision stereo-comparator was installed and calibrated during the year for analytic aerotriangulation and for satellite triangulation. Both this comparator and the two monocular comparators were placed on two-shift operations insofar as manpower limitations permitted. Thus the total instrument capacity for plate measurements was increased considerably during the year but cannot yet be fully realized because of insufficient personnel.

Electronic Computing Division

An IBM 1401 Data Processing System was installed in October 1963. This system is being leased primarily to process geomagnetic data in connection with the International Year of the Quiet Sun (IQSY) program. The program is supported cooperatively by National Aeronautics and Space Administration, National Science Foundation, and Coast and Geodetic Survey. In addition, the IBM 1401 serves to prepare magnetic tape input for the Weather Bureau Stretch computer. Magnetic tape output from Stretch is converted back to punched cards or printed reports as appropriate on the bureau-operated IBM 1401. Other applications on the IBM 1401 computer include star identification from the Boss Star Catalogue, data reduction for 1965.0 Isogonic Chart series, reduction of aeromagnetic data to sea level, preparation of tapes of each geomagnetic element (D, I, H), payroll, cost accounting, charts inventory, and production control for the Office of Cartography.

Arrangements were made to utilize the Weather Bureau Stretch computer on some of the larger scientific and technical applications. The Stretch computer was used to relieve the IBM 1620 of the heavy load that had developed. Several programs had become very time consuming on the IBM 1620. The Stretch Computer has been employed on several steps of the satellite triangulation data reduction; the computation of earthquake hypocenters

and magnitudes; the resection and matrix reduction for analytic aerotriangulation; and various analyses of geomagnetic data. The Stretch computer is so large and fast that it accomplishes the hypocenter determination work in one-eighth of the time used on the IBM 1620. The unit cost per computation was reduced. The number of hypocenters computed has increased, so that greater productivity is achieved. Also the entire program can be handled in one pass instead of three. Additional options for the hypocenter computations are readily available in the Stretch program.

The IBM 1620 was relieved of most of the hypocenter calculations late in the year. Until that time, its top priority was the work of the Seismology Division. The IBM 1620 was utilized also on geodetic triangulation computations, some of the less time consuming satellite triangulation work, compilation and execution of "open shop" Fortran programs, and the production of analytical graphs through the Cal-Comp plotter.

The Cal-Comp plotter attached "on-line" to the IBM 1620 has been used to produce displays in graphical form for the seismological analyses as well as satellite triangulation data analyses.

The IBM 650 was used throughout the year but its usage diminished as the year progressed. Geodetic computations, analytical aerotriangulation, payroll, cost accounting, cartography production control, and special requests as appropriate were also accomplished on the IBM 650 until programs became operational on other computers. It is anticipated that the IBM 650 will be phased out and released by the close of fiscal year 1965.

The division has furnished assistance in qualifying personnel of other divisions for training in Fortran programming, basic computer concepts, and such specialized training that has been required. This included the administration of standard IBM aptitude tests for programmers. Aptitude tests were used in the selection of operator personnel for the division. Fortran programmer training has been monitored by this division for eight employees of this Bureau. Course materials were supplied by IBM.

Consultation and advice has been furnished to personnel of many divisions of the Bureau. This has ranged from advice on complex programming to the obtaining of prices and procedures on the acquisition of equipment such as key punches.

The importance of electronic computing to the Bureau is growing. The interest in this field is increasing continuously. Many opportunities exist for expanded accomplishments through electronic computing. The Electronic Computing Division expects this expansion to continue and is anxious to serve Bureau needs in the future as well as it has in the past.

Geomagnetism Division

The Geomagnetism Division, which was established as a separate Division one month before the beginning of the year under review, conducted all geomagnetic activities formerly assigned to the old Geophysics Division. This responsibility embraced a variety of work, with ramifications extending into many areas of technology and space science. The Division operated magnetic observatories and laboratories, planned and supervised field observations in geomagnetism, processed and disseminated the various categories of data resulting from this work, calibrated magnetic instruments, developed and tested instruments of improved designs, assembled and archived geomagnetic data from other sources, analyzed available data on the magnetic elements and their secular changes looking toward new editions of the basic magnetic charts of the world and of the United States, supplied geomagnetic data to the scientific community and to the general public, and pursued a number of scientific investigations involving geomagnetic phenomena. In addition, the Division implemented the Bureau's responsibility for collaboration with other agencies in this field.

The earth's magnetic field was monitored by means of continuous photographic recording equipment and appropriate control facilities at the Bureau's 10 magnetic observatories, located at Fredericksburg, Va.; Tucson, Ariz.; Boulder, Colo. (operated jointly with the National Bureau of Standards); Dallas, Tex. (operated jointly with the Graduate Research Center of the Southwest); San Juan, P. R.; Honolulu, Hawaii; Guam; and College, Sitka, and Barrow, Alaska. The San Juan Observatory is being relocated at a site near Cayey in order to preserve the integrity of the output against vibration and disturbances that increasingly impair the records at the existing site. Construction at the new site was near completion at the end of the year. The new facilities will allow for an improved and broadened program, e.g., a rapid-run magnetograph and new micropulsation equipment. The Boulder observatory was placed on a more satisfactory basis during the year with new construction to replace earlier, temporary facilities and the addition of a rapid-run magnetograph. A new, specialized observatory was under construction at Castle Rock, near Palo Alto, Calif., a cooperative venture

with the University of California and the Russell H. Varian Foundation. It will be unique in that it will be an experimental station relying chiefly on the Automatic Standard Magnetic Observatory. Preparations were also well advanced for a new conventional observatory to be established in the area near Spokane, Wash.

Under a continuing arrangement with the Office of Antarctic Programs, National Science Foundation, the magnetic observatories at the Byrd and South Pole Stations, which were set up during the International Geophysical Year of 1957-1958, and at Eights Station, established last year, were continued in operation. This program was also expanded to include field work done in conjunction with ground traverse expeditions.

For regional data on the secular change in the strength and direction of the geomagnetic field, observations were made at 42 magnetic repeat stations. The portable magnetograph, used at selected locations to facilitate cleansing of transient fluctuations from the repeat results, was replaced with a new three-component flux-gate instrument. Single-component flux-gate instruments were put in service for special surveys such as those at airport compass-testing hardstands.

Magnetic observations were made at five locations by personnel of other Divisions.

Additional three-component flux-gate instruments have been installed at four island sites in the Pacific Ocean under a program supported by the National Science Foundation for the International Year of the Quiet Sun (IQSY). The sites selected are on Midway, Adak, Koror, and Majuro Islands. The purpose of this network is to obtain data on the worldwide patterns of the geomagnetic solar quiet daily variation, which has long suffered from the large gaps in the Pacific area.

The magnetic standards have been maintained at the Fredericksburg Magnetic Observatory largely through routine use of a proton vector magnetometer, assuring the highest accuracy in the calibration and testing of all other geomagnetic instruments. The original prototype instrument was replaced during the year by a newer pattern characterized by improved signal/noise ratio. The original proton vector magnetometer coil system was being prepared for use at the San Juan Observatory in conjunction with a modern proton magnetometer. Another proton vector magnetometer was installed at College.

A chronic difficulty at Barrow has been the instability of instrument piers arising from changes in the active layer of ground over the permafrost. Improvement has been achieved by the use of special pier tops supported by floatation in pools of mercury.

Towed magnetometer data from Bureau vessels and also from other agencies have been processed by means of newly developed programs on Bureau electronic computers.

A special series of observations and recording was made at several sites on the island of Puerto Rico, to investigate the daily variation curves as they are locally modified owing to the effect of the island on the electric currents induced in the sea.

A considerable gain in speed and flexibility of processing hourly and other regularly spaced values from the observatories has been achieved through the use of magnetic tape files on the new IBM 1401 computer. The programs include provision for interpolation of missing data for short intervals when this is warranted.

The punch-card file of some 215,000 worldwide magnetic observations was posted on magnetic tapes shortly after installation of the Bureau's IBM 1401 computer along with 20,000 new observations, including land, marine, satellite, and aeromagnetic data. Several requests have been received for copies of these tapes. A cooperative project with the National Aeronautics and Space Administration (NASA) has resulted in an extensive screening and classifying of the various types of data.

A separate tape file of annual mean values from magnetic observatories back to 1900 was also established. This file, after thorough editing, will become one of the basic sources for an internationally adopted file for data of this kind. When completed, these data will be forwarded to NASA and thence to the appropriate international scientific organization.

Input data were supplied for the program to reduce worldwide magnetic observations to epoch 1965.0 for use in constructing new world magnetic charts, which are scheduled to be published by the U. S. Naval Oceanographic Office early in 1965, and the more detailed U. S. charts, to be published by the Bureau shortly thereafter. The actual drawing of the isogonic and other isomagnetic lines is to be accomplished in part by means of automatic plotters programed by analytic techniques developed and refined within the Bureau, with support by the Oceanographic Office. Testing and modification of the analytic procedures,

involving both polynomial fitting by quadrangles and subsequent treatment by spherical harmonic analysis, with altitude corrections and adjustments for mutual consistency, has proceeded throughout the year.

The annual-change patterns for magnetic declination, horizontal intensity, and inclination were prepared for inclusion on the 1965 charts. The geographic positions of the magnetic dip poles were determined by special analytic procedures. Results were compared and data exchanged with both Canada and Great Britain as regards the magnetic pole positions and the patterns of annual-change isolines. Another special study was necessary to rectify the annual-change patterns in the Indian Ocean.

Declination and annual-change data were supplied to the Nautical Chart Division for compass roses on 347 nautical charts.

Seismology Division

On March 28, 1964, shortly after midnight, this Division was notified that a violent earthquake had occurred in the vicinity of Anchorage, Alaska. Preliminary evaluations indicated a magnitude of 8.5 which established it as one of the most violent earthquakes to be recorded on the continent of North America.

The Seismic Sea-Wave Warning System went into routine operation following the earthquake. Pertinent data were received in Honolulu and three advisories and one warning message were sent out to all areas in the Pacific that might be affected by the resulting wave. Warnings were received in ample time to minimize damage from the seismic sea wave in all localities except ports and islands in the Gulf of Alaska, which were too close to the epicenter for the warnings to be effective.

The Technical Director of the Seismological Laboratory in Albuquerque, N. Mex., was directed by the Chief of Seismology Division to send men and equipment immediately to the Anchorage area to record strong earthquake motions and aftershocks. Most of the personnel reported to the Laboratory in the next few hours and began assembling and crating the necessary instruments. Preparation of the equipment which amounted to about 5,000 pounds was completed late that evening. The Washington Office made arrangements for transporting both men and material to Anchorage.

The Director of the Bureau, two seismologists, and two oceanographers from the Washington Office and four

seismologists from Albuquerque arrived in Anchorage on Sunday night, March 29. The first of five portable stations was installed and began operation at Elmendorf Air Force Base outside Anchorage at 9:30 a.m., March 30 (Alaska time). The other four temporary seismograph stations were installed on the following places and dates: Cordova, March 31; Kenai, March 31; Kodiak, April 1; and Gulkana, April 2. A strong motion seismograph was set up at Elmendorf Air Force Base on March 30, and another was placed in the Federal Building in Anchorage on April 9. Wood-Anderson seismograph systems from the California Institute of Technology were installed on Middleton Island on April 7 and at Seward on April 13. These units are operated on a cooperative basis with the California Institute of Technology. The initial station installations at Anchorage, Cordova, Kenai, Gulkana, and Kodiak were at relatively noisy locations which limited the magnifications to the range 2,000-4,000. All instruments with the exception of those at Kenai have been moved to new sites within their respective areas which will permit higher magnification. During June, the station at Kenai was moved to Homer and on July 1, a new station was installed at Valdez. Since the earthquake, the original equipment has been continuously upgraded. Wood-Anderson torsion seismometers have been installed at the College Observatory and all of the temporary stations were equipped with crystal clocks. The entire program resulting from this earthquake is an excellent example of positive leadership, prompt action, and interdisciplinary cooperation of which the Coast and Geodetic Survey can be justifiably proud.

Eight hundred and fifty-two earthquakes which are related to the Prince William Sound earthquake of March 28, 1964, have been located by the Coast and Geodetic Survey for the 4-month period following this disaster. These aftershocks, which represent sudden releases of strain energy stored in crustal and upper mantle rock, have magnitude ratings which range up to 6.3 on the Richter Scale. The main earthquake has been assigned a magnitude rating of 8.5.

The aftershocks have occurred in a band which extends some 350 miles from the Prince William Sound region to an area southeast of Kodiak Island. These earthquakes have usually occurred at locations ranging between 5 and 20 miles below the surface of the earth, although depths outside this range have been observed. Surface thrusting, with vertical displacements up to 16 feet, has been reported on Montague Island, a large island at the mouth of Prince William Sound. This surface faulting has been traced by Coast and Geodetic Survey oceanographic teams for some 15 miles along the ocean bottom south of Montague Island.

The approximate energy released by the main March 28 earthquake was 1.4×10^{24} ergs. This is over 99 percent of the total energy released in this sequence. Of the 852 aftershocks recorded during the 4 months immediately following the main event, only 6 registered magnitudes above 6.0 on the Richter Scale. All of these occurred within the first 10 hours following the principal shock and account for 0.21 percent of the total release of energy. The remaining 846 located aftershocks have contributed only 0.01 percent of this total energy. Of these, 163 were in the magnitude range of 5 to 6; 575 in the range of 4 to 5; and 108 below the level of 4. The tendency is for the number of shocks occurring to increase greatly as lower magnitude ranges are considered. These figures reflect the finding that the magnitude threshold for locating all earthquakes in this region is approximately 4.5. The frequency of aftershock activity fell rapidly as indicated by the fact that the Survey was able to locate 333 aftershocks that occurred during the initial 3½-day period, while only 349 were located during the entire month of April; 100 during May; 37 during June; and 32 during July of this year.

An exhaustive study of this event and its aftershock sequence is the major effort of the Data Analysis and Research Branch at this time. Fault plane solutions, using available methods, are being performed for all shocks for which reasonably sufficient data exist. The regional crustal and upper mantle velocity structure is being determined and corresponding refinements in epicenter location, focal depth, and origin times are immediate goals.

Cooperative studies are being carried out with the Divisions of Photogrammetry and Geodesy and the Office of Oceanography. In addition, related studies are in progress by the scientists of the University of Alaska, Columbia University, U. S. Geological Survey, Corps of Engineers, and others. These organizations are making a concerted effort to correlate all of the aspects and results of this cataclysm.

Of the proposed 125 Standard Seismograph Stations of the Worldwide Network (Vela Uniform), 100 have been installed and are equipped with standard, identical sets of ultrasensitive seismographs and related instrumentation. During this year 13 of these were installed. For the 25 remaining systems still to be installed 18 vaults are under construction, 3 locations are firmly committed, and 4 are under negotiation.

The effectiveness of this standardization program has been augmented by the Seismological Data Center which has been in full operation during this year. The Center provides: (1) a reference library containing current seismological textbooks and journals; (2) study facilities to accommodate 12 visiting seismologists at one time; and (3) a unique, new information handling system designed to copy, reproduce, study, and disseminate all seismograms recorded by all stations in the network.

The information system provides three convenient, low-cost types of seismogram copies for those who wish to use them in seismological research. For scanning on high-resolution microfilm readers, it furnishes seismologists with 70 mm. microfilm chips, and 35 mm. and 70 mm. strips and rolls which provide high-contrast, sharp images of the original seismograms. For annotation and detailed study, the system makes available full-size, hard-paper, seismogram copies measuring approximately 35.5 x 92 cm.

During the year, 210,000 seismograms from the network were collected at the Center and copied on 70 mm. film for our permanent archives. In addition, 430,000 copies were made and disseminated in response to requests from seismologists throughout the world.

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.

In August 1963, a new program was written which could find coherent data from a file of largely uncorrelate readings and compute a preliminary location. This program, which was considered almost impossible technically 18 months earlier, increased the capacity for processing much more data without additional employees.

This procedure was incorporated into a new major system program which was written for the Stretch computer. Containing over 2,000 Fortran instructions, this is by far the most sophisticated epicenter program every written, climaxing nearly 4 years of development in this field. In one pass it finds coherent data from a chronological file of largely uncorrelated P phase arrival times, computes an accurate epicenter and magnitude, and gives the standard errors of all parameters. It requires an average of four seconds to accomplish this.

The Fortran programing simplifies future modifications and can readily be understood by most scientists. The search and intervening logic features save the work of several geophysicists and will permit an almost unlimited increase in work load without a significant increase in staff. The epicenters located will have improved accuracy as a result of the increase in number of iterations, tightened convergence criteria and improved elevation corrections.

Several special programs were written to accomplish specific phases of the hypocenter location process. Bulletins for the Antarctic and the World are compiled and published automatically. This requires the sorting of phase readings and their assignment to the proper earthquake, the identification of all phases and their collation into the bulletin format. In line with this, it is now possible to search chronological data files of the past and correlate them with specific seisms.

An unmanned station project was approved by the Advanced Research Projects Agency (ARPA) to be carried out in the Aleutian Islands in conjunction with the Texas Instruments Corp. (TI) ocean bottom seismograph program which is scheduled for August and September 1964.

Two geophysicists were assigned to the USC&GS ship SURVEYOR to monitor a similar project during the summer of 1963. They assisted the TI technicians in operating the undersea equipment and reported on the procedures. This information was used for further planning purposes.

It was decided that the Bureau would fabricate an unmanned station around the magnetic tape recorder developed by Precision Instruments Corp. The engineered system is self contained and will operate from 10 to 14 days unattended, recording on magnetic tape. Power is supplied by a thermoelectric generator and time and motor drive are provided by a precision frequency control timing device which is accurate to 1 part in 1 million. Radio time is also recorded automatically. The recording system will accommodate a variety of seismometers, however, 3-component Willmore Mark II seismometers with a peak magnification of 50,000 were used with the five systems which were procured for this project. These were shipped to Adak where they are transshipped to previously prepared sites on Amchitka, Atka, Semisopochnoi, Tanaga, and Ulak Islands. Preparations were made to supply the stations by surface craft and helicopter. As a precautionary measure the stations were manned and a standard hot stylus recorder was installed at each station as a back-up for the magnetic recording. The equipment was being delivered at the end of the year by the Coast Guard.

The entire project is under the auspices of ARPA. The primary participants are Texas Instruments Corp. who are responsible for the underwater phase, and the Coast and Geodetic Survey which has the responsibility for the land phase with the exception of a long range seismic monitoring trailer which is being operated at Adak by the Air Force. The Coast Survey has contracted for helicopter service. Excellent cooperation has been received from the Air Force, the Coast Guard, and the Navy in matters of logistics.

A special study and reworking of a program obtained from the Southwest Center for Advanced Studies were completed. The method has been adapted for Microearthquake Monitoring such as was carried out at the Shoal site. Also, it will be useful in aftershock studies.

The format of the cards used for exchanging seismic data has been modified and standardized so that they may be used directly by participants in all Vela Uniform projects.

Preliminary work on the Bureau study of the seismicity of the United States for the year 1963 is in progress. A tabulation is being made of the reports from United States stations on all earthquakes in this country including Alaska and Hawaii of magnitude 4 or greater. A computer program to evaluate station capability by determining the radii of perceptibility for events of a given magnitude has been obtained from the Seismic Data Laboratory of the United ElectroDynamics Corp. and it has been used to advantage in this project.

Six mark II strong motion seismographs were purchased from United ElectroDynamics for installation in California. These were newly developed by the company based on specifications and recommendations of the technicians at Albuquerque.

Accelerograph No. 79 was installed at the Los Angeles Department of Light and Power Fairmont Reservoir; a UED AR-240 strong motion instrument was installed at the Hollister station; Coast and Geodetic Survey strong motion seismograph No. 10 was installed at Oroville Dam; a UED AR-240 was transferred from Hollister to Devil's Canyon in southern California; strong motion instrument No. 63 was shipped to Japan; and the Coast Survey strong motion instrument formerly at Wheeler Ridge was installed in the basement of the New Pacific Telephone and Telegraph building in Sacramento where it will operate in concert with an AR-240 strong motion instrument purchased by the company and installed on the roof of the building. In addition, accelerograph No. 80 was transferred to this building from the New Mint building in San Francisco where it was replaced by an AR-240.

A cooperative agreement was made between the Survey and the California Department of Water Resources for the purpose of expanding the strong motion network and to conduct basic research into the general seismicity, seismic acceleration and displacement factors, earth stress conditions and related seismic information in the State of California. This program is the result of the demand for more precise information on which structural criteria for dams, reservoirs, tunnels, bridges and even private dwellings are based.

Matching funds were provided in the 1963 agreement and the following progress was made:

- (a) Seven of 12 proposed strong motion seismographs were installed.
- (b) Two trailer mounted sensitive seismographs were purchased from the Geotechnical Corp. and will be delivered during July 1964.
- (c) The teleseismic station at Oroville Dam was installed and has been in operation since July 1, 1963. A Bureau seismologist is in residence.
- (d) Twenty of the 50 agreed upon seismoscopes were installed by the close of the period.
- (e) A tripartite tiltmeter was installed at Wheeler Ridge and testing continues.

This agreement was renewed for fiscal year 1965 on essentially the same terms.

Present instrumentation in the underground vaults at the Albuquerque Laboratory consists of a standard seismograph which is operated as station ALQ of the Worldwide Network and two Wood-Anderson torsion seismometers. In addition, various experimental combinations of instruments have been set up during the year, including among others a Benioff variable reluctance fed into a Texas Instruments amplifier which recorded at a gain of 1,000,000.

The facilities for the development and testing of instruments were improved during the year by the addition of a paint spray booth and the acquisition of a test chamber where instruments can be tested in various controlled conditions of temperature and pressure.

Calibration curves were determined for various instruments using a Willmore bridge; field procedures were developed which made use of this technique.

The first unmanned stations developed by Sprengnether Instrument Co. were procured and tested. One was sent to Nevada to monitor the Shoal explosion. This operation and subsequent field tests led to modification and improvements so that the unit is now operational. It is planned to install a triangular network, using these instruments, which will be about 40 miles on each side with the Laboratory at one apex of the triangle.

In addition, calibration tests were completed on the long period Sprengnether Blast Vibration Meter and operational testing in surface vaults was conducted on eight long period horizontal and four long period vertical seismographs to determine the effects of environmental changes and the effectiveness of environmental controls. A comprehensive program was initiated to determine the reliability and lifetime of the components of the standard seismograph systems in order that repairs and replacements might be scheduled prior to failure.

Routine operations of the Safety Net at the Nevada Test Site continued throughout the period of this report. Project Dribble was monitored from Hattiesburg, Miss., although several delays forced the retrieval and storage of instruments already fielded. Even at present, instrumentation is still in preparation for the Salmon even which has been postponed for over one year.

A special safety net with locations at Fallon, Hawthorne, Reno, Austin, Tonopah, and Lovelock, Nev., was installed for Project Shoal. Five mobile stations equipped with the new NGC-21 seismometer system and small Benioffs were set up in a crossed array configuration. The Shoal event was monitored by the largest number of sensors yet fielded for such an experiment. In addition to the 5 mobile stations the Party operated 4 vibration meters, 7 velocity meters, and 11 Wood-Anderson stations for the Atomic Energy Commission plus 24 strong motion instruments and 8 seismoscopes for the Defense Atomic Support Agency. Thirty-five records of the event were obtained and given field analysis.

In connection with Shoal a microearthquake study was made both prior to and after the event. High seismic activity was indicated to the east of the site. Hypocenter locations relative to depth of focus, sequence of occurrence and spacial distribution were found to fit a definite pattern which was not altered by the event.

Calculations involving the seismic energy release and values related to creep strain recovery in a fifteen minute quadrangle adjacent to the Shoal quadrangle in Nevada revealed interesting features. Proportional strain

values were derived for each microearthquake for 22 days. It was found that the area of maximum strain recovery coincided with the location of a subsequent earthquake of sufficient magnitude (approximately $m_b = 3.8$ to be registered on teleseismic stations to a distance of about 800 km). The accumulative seismic energy release in the defined quadrangle was about three orders of magnitude less than the earthquake.

Research and development was carried out on many phases of seismology. Phase shift curves for the response of the standard long period seismographs were determined theoretically and by analog computer. A long period noise study was initiated which will not be completed for several months.

Phase velocities were computed for Albuquerque, N. Mex.; Dugway, Utah; and Golden, Colo., from eight Russian nuclear explosions at Novaya Zemlya using the single station method. Extensive traveltime and amplitude data from nuclear events have been collected for some time. Eight sources have produced sufficient information so that it was possible to revise the surface focus tables of Jeffreys-Bullen, the most widely accepted tables in use. Generally the curves are $1\frac{1}{2}$ to 2 seconds early but there are significant deviations from this condition. These changes in slope will necessitate an alteration in the earth model. Similarly the velocity/radius relationship will be different so that a change in the traveltimes for all depths will have to be made. In the future, deviations from the mean traveltime against distance will be shown such that statistical statements of hypocenter precision may incorporate the variations of the traveltime values.

The relative amplitude of P and S phases recorded at 20 standard stations from the Nevada Test Site (NTS) event of September 13, 1963, were calculated in an attempt to utilize the techniques described by Press, Dewart and Gilman (Jour. Geophys. Research, Vol. 68, No. 10, 1963). The amplitudes were reduced to ground motion and various ratios were plotted against distance from NTS. As a comparison, the records of two Nevada earthquakes of approximately the same magnitude as the NTS event were treated in a similar manner.

A computer program was written to calculate the particle trajectories obtained from digitized strong motion records. The method is unique and allows the results to be displayed on an x-y plotter which greatly facilitates the identification of the various wave types and permits direct reading of angles of emergence, onset times and other phase characteristics. The method was used to analyze seismograms from the Shoal event but the trace resolution and variations in recording speed limited its effectiveness.

A Titan III solid rocket fuel propellant destruct test was monitored for seismic effects on June 13 at the Naval Ordnance Test Station, China Lake, Calif. A Titan III motor was impacted on a concrete and earth target at about 600 ft./sec. The motor was assembled on a test sled and fired down the Supersonic Naval Ordnance Research Track (SNORT) with the ignition point 3,900 ft. from the target. Seismic measurements were made at five stations (24 seismic data channels) ranging from 3,600 to 40,000 ft. from the target.

A final report on the 1963 El Salvador seismic array was completed. This array was established to evaluate the analysis system known as the "UK Method" which makes use of a velocity phased correlogram, i. e., the data are summed for two orthogonal subgroups of the array and a cross product is obtained from these sums. Dr. Thirlaway of the United Kingdom Atomic Energy Commission has reported a high degree of success in identifying source types using this system. Theory predicts that the improvement in signal to noise ratio over that of a single sensor will be proportional to the N for an array having N elements properly spaced. Although some improvement has been noted in the recordings from El Salvador it is not of the order predicted.

The Coast Survey's Seismograph exhibit at the New York Worlds Fair was installed during the week of April 20, 1964. The background noise of the building and surrounding area was so high that a very low gain was required in order to record a suitable trace. Father Lynch of Fordham University gave his permission to install a seismograph in his vault and bring the signal into the display on a leased telephone wire. This system is now in successful operation.

The Chief of Division appeared as an expert witness for the Atomic Energy Commission in a public hearing held in Santa Ana, Calif., relative to the application for licensing an atomic reactor at San Onofre, Calif. The applicants were the Consolidated Edison Co. of Southern California, San Diego Gas & Electric Co., Bechtel Corp., and Westinghouse Electric Corp.

Chief of Division visited the seismological installation at Aldermaston, England; Eskdalemuir and Edinburgh, Scotland; and the Earth's Science Division of the United Nation's Educational, Scientific, and Cultural Organization in Paris, France. At Aldermaston, Dr. H. Thirlaway explained and demonstrated the United Kingdom's work in seismometry, computer and analytical techniques for detecting and identifying nuclear explosions and his approach for distinguishing them from equal yield

earthquakes. At Eskdalemuir, the new vault which is to house the standard seismographs was inspected. This vault is very modern in design and encompasses a number of features that should improve the operating conditions for the sensitive short and long period seismographs. Dr. P. Willmore, at Edinburgh, discussed the organization of the new international seismological center at the university and showed the building in which the Center will soon be housed.

The Chief of the Seismological Field Survey attended the annual meeting of the Earthquake Engineering Research Institute, San Francisco, Calif.; also, he attended a meeting of the ground shock evaluation service conducted at Lawrence Radiation Laboratory, Livermore, Calif.

The Division Chief attended a meeting in Albuquerque, N. Mex., with a representative from the Advanced Research Projects Agency and personnel at the Laboratory. The Aleutian program initiated for ARPA was discussed relative to capital equipment requirements, personnel, field logistics, and analytical techniques. The invitation to bid for most of the capital equipment was prepared and distributed to potential manufacturers. A similar meeting was held in Washington with Air Force and Texas Instruments representatives to coordinate the field logistics for the Aleutian Project.

Chief of Division, as an official United States delegate, attended in Paris the Intergovernmental meeting on seismology and earthquake engineering under the sponsorship of the United National Educational, Scientific and Cultural Organization. Representatives from 53 nations, totaling 104 delegates, were in attendance. Many resolutions requesting UNESCO support were approved by the delegates. They included purchase of capital equipment (seismographs, tide gages, strong motion instruments, etc.), support for establishing seismic and tide stations in undeveloped countries, training programs for station technicians in interpretation of seismic data, and evaluation of magnitude and intensity scales.

W. V. Mickey, Chief, Special Projects Branch attended an AEC meeting in Hattiesburg, Miss., concerning the 5 kt nuclear detonation in a salt dome planned for early September. The Coast Survey will participate in the experiment with seismographs recording earth motions from about one km out to the limits of perception of the seismic signal.

SEISMIC SEA WAVE WARNING SYSTEM

During the year, the Seismic Sea Wave Warning System continued its expansion adding American Samoa to the areas receiving warnings and Suva, Fiji, and Marcus Island to the list of reporting tide stations.

The "Annotated Bibliography on Tsunamis" was completed and forwarded to the International Union of Geodesy and Geophysics for reproduction and distribution. A contract was made with the Hawaii Institute of Geophysics for support of a project to issue a supplement to the bibliography. The Fifth Edition of the "Communication Plan for Seismic Sea Wave Warning System" was issued.

The March 28, 1964, Prince William Sound tsunami revealed a weakness in the warning procedure in that the dissemination to the public of proper action to be taken during seismic sea waves by some local agencies was inadequate. Consequently, fact sheets and throwaways describing tsunamis and the proper procedures when warnings are issued are being prepared. These will be given wide dissemination in areas of tsunami danger.

Basic research on tsunamis has continued, both in the Washington Office and at the observatory in Hawaii. Close coordination has been continued with the Defense Communication Agency in an effort to improve communication times between Honolulu Observatory and the various units in the warning system. A broad reorganization of communication methods and precedences used by the various U. S. military services has been instituted. A concerted effort is being made to further improve transmission times under the new plan.

National and International Cooperation

National Agencies.

Nuclear Test Detection Office of the Department of Defense, was furnished general information on the Swiss seismic event and the Azores earthquakes of February 1964.

A special harbor line survey of the Portland, Oreg., waterfront for the Corps of Engineers of the Army was continued. This includes second-order geodimeter traverse for the establishment of some 60 harbor line reference monuments, aerial photography and the preparation of shoreline maps at a scale of 1:4,800 to show the shoreline detail and the pierhead lines.

The Washington Naval Ordnance Laboratory was furnished information on the effects of the Alaska earthquake on gyroscopes at Seal Beach, Calif. Bureau of Yards and Docks, was furnished information concerning seismic zone rating of Memphis, Tenn., seismicity of Naples, Italy, and a description of the Coast Survey contributions to the Seismic Probability Map, now published by Uniform Building Code. Naval Oceanographic Office was furnished references on seismicity of Mendocino escarpment.

Office of Civil Engineers of the Air Force, was furnished general information on the Alaska earthquake, and the relationship between zones and intensity ratings. Climatic Control Center was furnished information on the seismic probability of Barcelona, Spain, and Sembach, Germany. Kirkland Air Force Base, N. M., was furnished data on the Prince William Sound earthquake of March 28, 1964. Magnetic surveys were made to test the suitability of compass swing areas at 13 air fields within the United States, most of which were at Air Force bases. Such areas are used for compensating and calibrating navigation compasses mounted in aircraft. The areas must be magnetically smooth and the value of magnetic declination must be accurately known so that the deviations of the aircraft compass may be determined.

The Geological Survey was furnished general information on the Alaska earthquake series, photocopy of Washington record for their exhibit at the National Academy of Sciences Meeting, and information on Ecuador, Peru, and Chile seismicity.

The Bureau of Reclamation was furnished April 1963-March 1964 summaries of seismic readings from Flaming Gorge and Glen Canyon.

The National Bureau of Standards was furnished general information on the Alaska earthquake of March 28; daily reports were sent from several magnetic observatories to various field stations of the Central Radio Propagation Laboratory for use in forecasting ionospheric conditions; and a staff member of the Boulder Observatory accompanied a special expedition sent to Alaska by the National Bureau of Standards to the path of totality of the solar eclipse of July 10, 1963, and during the eclipse he obtained geomagnetic data which were presented at a subsequent scientific meeting.

The Airport Obstruction Charting Program was continued throughout this year for the Federal Aviation Agency. This program provides for the preparation of special Airport Obstruction Charts and Turbine Data Sheets; for the location of air facilities (omni directional ranges, TACANs, and similar aeronautic aids to navigation); and for the preparation of mosaics of airports for noise abatement studies.

Airport Obstruction Charts and Turbine Data Sheets are used by the Federal Aviation Agency and the airlines to administer and comply with safety regulations pertaining to the gross takeoff and landing weight of aircraft with respect to the length and gradient of runways; obstructions along the takeoff and landing flight paths; and other factors.

Aerial photography for this program was taken by Missions 6401 and 6402 in all states. Twelve to fourteen 2- or 3-man survey parties were assigned to field surveys for the program in all of the states. At the end of the year 456 Airport Obstruction Charts and 225 Turbine Data Sheets were on issue. Accomplishments during the year were as follows:

Summary of Accomplishments - Airport Program

Type of Activity	Airports Surveyed	New Edi- tions Pub- lished	Revised & Reissued
	Number	Number	Number
Airports and air facilities photographed	134		
Airports Surveyed	128		
Noise Abatement Mosaics completed	24		
Air Facilities Located	48		
Airport Obstruction Charts		18	79
Turbine Data Sheets		22	6

The Information Officer of the Federal Aviation Agency was furnished a negative of the Washington records for reproduction of an article on the Alaska earthquake in the "FAA Journal."

Continued use was made of the laboratory facilities at the Fredericksburg Magnetic Observatory by other Government Agencies, particularly by the National Aeronautics and Space Administration. Goddard Space Flight Center of the latter agency was furnished information on the exact location of epicenters associated with November 14, 1963 eruptions near Iceland. In addition a comprehensive program was instituted to provide digital magnetic data from observatory records in connection with satellite surveys of the magnetic field phenomena in space. The data are being scaled from magnetograms by a commercial firm, using special equipment that facilitates the digital processing of the output.

The Atomic Energy Commission was furnished consultant services and evaluation of seismicity factors for reactor sites at Oyster Creek, N. J.; Haddam, Conn.; and Bodega Head, San Onofre, and Malibu, Calif. The seismic history of Union County, Ky., was furnished.

The Library of Congress was furnished information from the table in Special Pub. No. 282, "Earthquake Investigation in the United States," damage caused by major U. S. earthquakes from 1865 through 1961, based on the 1950 evaluation of the dollar and recent Idaho earthquakes.

Special magnetic surveys of small tracts of ground were made for several agencies to facilitate their programs involving possible effects of magnetic irregularities.

A special mean-high-water line survey of the lower Hackensack River was completed for the State of New Jersey. This project, started in the last fiscal year, involved tide-controlled infrared aerial photography, field surveys for the establishment of tidal datums and detailed inspection of the shoreline, preparation of mosaics, and compilation of planimetric maps at scale 1:9,600.

Work continued on a combined geodetic-photogrammetric survey of the Colorado River boundary between the States of Arizona and California. Positions of some 34 monuments were established by geodetic surveys and positions of the remaining 215 will be determined by analytic aerotriangulation. Arrangements were made for preparation of planimetric maps of the boundary during the next fiscal year.

Earthquake and other information was given to the following: The Geotechnical Corp., University of Michigan, Texas Instruments Inc., Southern Methodist University, Columbia University, Oregon State University, Bechtel International Corp., Tonto Forest Seismological Observatory, University of Washington, Esso Research and Engineering Co., and Pittsburgh Plate Glass Co. Information about the purchase, construction and operation of seismographs was supplied to Washington and Lee University, Lexington, Va.

At the College Observatory, research continued in collaboration with the Geophysical Institute of Alaska for recording, power spectrum analysis, and other studies of geomagnetic rapid fluctuations.

The Tucson Observatory collaborated with the University of Arizona by providing space and facilities for a new Lightning Laboratory.

International Agencies

The Coast and Geodetic Survey, with support by the National Science Foundation, continued to operate one of the subcenters of World Data Center A for the collection and exchange on a worldwide basis of data in geomagnetism, seismology, and gravity.

All magnetic-activity reports from the Bureau's observatories were prepared and forwarded to the international permanent center in the Netherlands. This work represented the Bureau's cooperation with the Association of Geomagnetism and Aeronomy, International Union of Geodesy and Geophysics.

Observations for intercomparison and standardization of magnetic instruments were a continuing activity, especially at the Fredericksburg Observatory. Of special interest was the visit of two observers from the Dominion Observatory of Canada to Fredericksburg for this purpose.

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.

OFFICE OF CARTOGRAPHY

OPERATIONAL ACTIVITIES

The Office of Cartography explored many avenues to increase manpower utilization and to obtain maximum use of equipment resources to meet demands made on the charting programs for sea and air navigation. As a result of these efforts improvements are evident in operations and production, but certain areas of both programs continue to lag behind desired goals. These areas of concern are the increasing number of hand corrections and backorders in nautical charting, and the gradual deterioration of the base information on visual charts of the aeronautical chart program.

The aeronautical chart program requires the production of charts more quickly, more frequently, and in greater volume than ever before. The rapidly expanding aviation industry produces a corresponding growth in the national airways system which delays the adoption of a stable format for the aeronautical charts. At present, the Bureau produces ten series of charts to satisfy all segments of aviation and the Controller chart series for use by the Federal Aviation Agency (FAA). The problem is becoming increasingly difficult as more charts are being placed on a fixed schedule and production time is being compressed to include them. Under present operating resources, the Office is approaching the saturation point.

The overwhelming charting demand on the Office in both the nautical and aeronautical programs must be met with limited resources. The necessity for both of these programs in the interest of public safety and the economic growth of the transportation industry has been repeatedly proclaimed by numerous authorities. Budgetary limitations relative to these programs should be recognized as false economy to the extent that expanded expenditures will eventually be necessary if accepted Government responsibilities are to be met.

Both the nautical and aeronautical programs extend across departmental lines. Coast Guard activities in the field of navigational aids and U. S. Army Engineer activity in harbor and channel improvements have a direct impact on the revision workload in nautical charts. The Federal Aviation Agency is responsible for the design, operation, and management of the national airways system. To meet the rapidly expanding demands of aviation, the FAA has pursued a vigorous program to develop a safer, more efficient airways system. The President's Task Force on National Aviation Goals (Project Horizon 1961), and the

Task Force on Air Traffic Control (Project Beacon 1961) set the tempo for this increased activity. The only possible way that the airways system can be described or used is in the form of aeronautical charts published by the Coast and Geodetic Survey. Every modification or change in the airway system by the FAA directly effects the aeronautical charting revision program of this Bureau.

The absence of a coordinating authority in these two far reaching programs is glaring. In view of this, it is recommended that all segments of Government involved with these programs squarely face the problem and work toward national programs for nautical and aeronautical charting. Groups similar to the Interagency Committee on Oceanography are a recommended approach. In order to enjoy any measure of success, such a recommendation must receive support and concurrence from the highest level departmental authorities.

NAUTICAL CHART DIVISION

In July 1963, the Nautical Chart Division began operational efforts for automated cartography. The objective was to study implementation of cartographic display techniques related to basic hydrography and future charting needs. A complete system has been evaluated involving the flow of information beginning with raw data input at the time of a survey, including the processes of computation, machine plot, and record disposal for archival needs. The fundamentals of transmitting this survey data flow are now being developed and tested. The Division began system studies of charting practices and the preparation of nautical chart specifications for future Automatic Data Processing (ADP) requirements.

On April 26, 1964, the Hydrographic Verification Section of the Marine Data Division was transferred to the Nautical Chart Division.

To produce and maintain an adequate supply of the 794 nautical charts issued by the Bureau, 441 drawings were forwarded to the Reproduction Division as follows: 20 new charts, 1 reconstruction, 212 new editions, 151 new prints, 37 reprints, and 20 overprints. Fifteen charts were cancelled by improved coverage. A total of 1,148 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. During the year, 4,356 items (surveys, letters, etc.) were received and all critical information was immediately furnished the mariner.

The conversion of Intracoastal Waterway Charts to the small-craft route format is well underway. Two route charts now cover the coastal waters of New Jersey. Except for the part between Casino Creek, S. C., and Brunswick, Ga., published small-craft route charts are available for the waterway from Norfolk to Miami and across Florida to Tampa.

At the close of the fiscal year, all charts affected by the Atlantic coast storm of March 11, 1963, had been revised and printed to show "poststorm" conditions.

Nautical charts of the Alaska earthquake area were quickly updated to show postearthquake conditions by the issue of 11 chartlets, 2 new editions of a chart and 1 chart supplement. Where feasible, chartlets were revised and reissued when new surveys or additional information was received that required chart correction. In addition, 32 notices were prepared for publication in the Weekly Notice to Mariners.

During the year, 20 charts were forwarded to the Reproduction Division for overprinting. This method of applying excessive hand corrections eliminated the need of either destroying 104,881 copies of the charts or the addition of 430,542 hand corrections to them by the Distribution Division.

Eighty-six correction chartlets were compiled and forwarded to the Naval Oceanographic Office for printing and insertion in the Notice to Mariners. This number includes ten correction chartlets, one Provisional Edition of chart 8525 and a supplement to chart 8529 reflecting postearthquake conditions in Alaska. A correction chartlet is a small, revised drawing at chart scale, made for issuance with each affected chart and for insertion in the Notice to Mariners.

Twenty-nine surveys were reviewed in 1963 and the same number in 1964. Twenty-one surveys are awaiting or are being reviewed, four more than at the beginning of fiscal 1964. The assignment of other work to the reviewers such as the completion of American Telephone and Telegraph Co. cable route surveys, presurvey reviews, security program of the vault, training of cartographers, and the development of ADP procedures has restricted the time available for regular review work.

During the past year, 28 surveys were verified of which 4 were completed after the transfer of the section to the Nautical Chart Division. The backlog of unverified and unreviewed hydrographic surveys on hand now stands at 345, an increase of 21 over last year. Studies are in

progress to develop procedures for processing surveys with only selective verification in order to advance the date of complete application of the surveys to the charts.

During 1964, 54 surveys were registered against 79 in 1963. About 80 surveys are waiting to be smooth plotted in the processing offices or aboard ships. These do not include 60 ocean surveys in various stages of completion. Review addendums were completed for 6 surveys which previously had been given only a preliminary verification and review. Additional review addendums are still required on 52 surveys.

About 115 certified copies of charts and surveys were furnished to the Department of Justice, law firms, attorneys, and private individuals to be used in litigation. Litigation pending in the damage to the ship ISLAND MAIL off Smith Island, Wash., necessitated extensive research and the furnishing of numerous certified copies of surveys and charts to the Department of Justice.

For security purposes, about 1,300 film copies, 14" x 17" or 20" x 24" in size, were made of original hydrographic surveys and furnished to a repository in accordance with our established programs.

In the Division's rotating training program, 13 employees were reassigned to other operating functions including hydrographic verification and related field duty. The training of five new employees began this year. All employees were advised on available extension courses of the U. S. Department of Agriculture Graduate School and a limited number financially supported for elected subjects. Several employees received brief courses offered by the U. S. Patent Office at no cost. Eight engineering students completed the Division's specially designed Education Program for Beginners. A few employees were given concentrated training in Automatic Data Processing. Every effort to aid loyal and industrious employees (of the GS-1371 category) in the proper selection of further studies for their development is being continued, thereby affording them an opportunity for the possible admission to the GS-1370 classification.

NEW SMALL-CRAFT NAUTICAL CHARTS PUBLISHED
IN FISCAL YEAR 1964

<u>No.</u>	<u>Title</u>	<u>Scale 1:</u>
120-SC	Shinnecock Bay to East Rockaway Inlet, N. Y.	20 & 40,000
369-SC	New York Harbor, N. Y. & N. J.	40,000
542-SC	Jamaica Bay and Rockaway Inlet,	
550-SC	Chesapeake Bay-Eastern Bay and South River, Md.	40,000
562-SC	Cape Charles to Norfolk Harbor, Va.	40,000
682-SC	Snake River-Lake Sacajawea, Wash.	20,000
826-SC	Little Egg Inlet to Cape May, N. J.	40,000
833-SC	Neuse River to Myrtle Sound, N. C.	40,000
835-SC	Cape Fear River to Casino Creek, N. C., S. C.	40,000
841-SC	St. Simons Sound to Tolomato River, Ga., Fla.	40,000
843-SC	Tolomato River to Eau Gallie, Fla.	40,000
855-SC	Okeechobee Waterway--St. Lucie Inlet to Fort Myers, Fla.	40 & 80,000
856-SC	Fort Myers to Charlotte Harbor, Fla.	40,000

NEW CONVENTIONAL NAUTICAL CHARTS PUBLISHED
IN FISCAL YEAR 1964

260	Falmouth Harbor to Buzzards Bay, Mass.	20,000
261	Martha's Vineyard--Eastern Part-- Oak Bluffs Harbor, Vineyard Haven Harbor and Edgartown Harbor, Mass.	10 & 20,000
264	Martha's Vineyard--Menemsha Pond, Mass.	20 & 40,000
562	Cape Charles to Norfolk Harbor, Va.	40,000
612	Georges Bank (Special chart for fishing industry)	220,000
666	Sacramento River--Sacramento to Colusa, Calif.	20,000

NAUTICAL CHARTS CANCELLED DURING FISCAL YEAR 1964

<u>No.</u>	<u>Title</u>	<u>Cancelled by Chart</u>
309	East Penobscot Bay, Maine	307 & 310
346	Edgartown Harbor, Mass.	261
347	Vineyard Haven-Martha's Vineyard, Mass.	261
473	San Carlos Bay and Caloosahatchee River, Fla.	856-C
474	Main Entrance to Charlotte Harbor, Fla.	856-SC
578	Shinnecock Bay to Great South Bay, N. Y.	120-SC
826	Little Egg Harbor to Longport N. J.	826-SC
827	Longport to Cape May, N. J.	826-SC
833	Neuse River to New River Inlet, N. C.	833-SC
834	New River Inlet to Southport N. C.	833-SC
835	Southport to Socastee Creek, N. C., S. C.	835-SC
836	Socastee Creek to McClellanville, S. C.	835-SC
841	Brunswick River to Nassau Sound, Ga., Fla.	841-SC
842	Nassau Sound to Matanzas Inlet, Fla.	841-SC
843	Matanzas Inlet to Mosquito Lagoon, Fla.	843-SC
844	Mosquito Lagoon to Eau Gallie, Fla.	843-SC
1289	Okeechobee Waterway-including Lake Okeechobee, Fla.	855-SC
3075	Georges Bank (Eastern Part)	612
3076	Georges Bank (Western Part)	612
5529	Sacramento River--Sacramento to Fourmile Bend, Calif.	666
5530	Sacramento River--Fourmile Bend to Colusa, Calif.	666
8285	Chatham Strait--Killisnoo Harbor, Alaska	8247

AERONAUTICAL CHART DIVISION

To meet the demands of civil and military aviation, the Aeronautical Chart Division produced a total of 2,062 charts in several series during this fiscal year. This represents a net increase of 141 charts over the previous year. The following new charts were produced: 1 aircraft position, 251 Instrument Approach Procedure, and

5 Local charts. Four Alaska Visual Navigation charts, and four VFR-IFR Planning charts were produced and are now being tested and evaluated. The catalog of Aeronautical Charts and Related Publications was revised for publication in a new folded single sheet format.

Charts maintained during 1964 include:

- 183 Visual Navigation charts with 288 issues,
- 102 Radio Navigation charts with 1,322 issues,
- 1,753 Instrument Approach and Procedure charts with 4,313 issues,
- 6 Aircraft Position charts with 9 issues, and
- 18 Auxiliary charts with 5 issues.

Five new Local Charts of Jacksonville, Denver, Phoenix, Indianapolis, and Milwaukee were published during the year. They employ a completely new format to meet user demands: (1) Communication frequencies are centralized on the face of the chart, (2) check points are flagged, (3) check point names are common to traffic controller use, (4) excessive ground features are eliminated, (5) the smaller size is folded to 5 x 10 inches for cockpit convenience, and (6) the elimination of back-up print saves production time.

The five remaining Route charts were discontinued for lack of any further requirement. Chart No. 3095, Shannon-Cairo-Bombay, was also discontinued. One new Aircraft Position chart (No. 3087) of the Central Pacific was published.

Compilation and drafting in the form of reproduction copy for 145 Oil Burner Charts were furnished to the Federal Aviation Agency (FAA) for publication in the Airman's Guide. The FAA was also furnished 139 pages of ceiling and Visibility Minimums for 106 airports.

Four charts of a new series, Alaskan Visual Navigation Charts, were published for test and evaluation. These charts are printed back-to-back to provide maximum coverage with minimum number of charts and are folded to 5 x 10 inches for ease of handling in the cockpit.

A new Planning Chart was printed and distributed for test and evaluation. This new chart is printed back-to-back in two parts that join to form a composite of the continental United States for flight planning Visual Navigation on one side and Radio Navigation on the other.

SUMMARY OF AERONAUTICAL CHARTS PRODUCED

Series	No. in Series 7-1-63	New Charts	New edi- tions	Re- prints	No. in Series 6-30-64*	
Visual Navigation:						
WAC U.S. & Alaska	62	-	54	1	62	(62)
Sectional	88	-	165	6	88	(88)
Local	23	5	46	2	28	(28)
Jet Navigation	4	-	4	4	4	(4)
Route	5	-	-	-	-	
Planning	1	-	1	-	1	(1)
Aircraft Position:	6	1	6	2	6	(6)
Radio Facility:						
Enroute Low Altitude	28	-	364	-	28	(14)
Low Alt. Area Arrival & Departure	34	-	442	-	34	(34)
Low Alt. Area & Mult. Departure (SID)	34	-	260	-	20	(4)
Enroute Intermediate Alt.	8	-	104	-	8	(4)
Enroute High Altitude	4	-	52	-	4	(2)
Enroute Alaska	4	-	52	-	4	(2)
RF 191 Enr. Hawaiian Cht. (Hono. Area)	2	-	9	-	1	(1)
Caribbean	3	-	39	-	3	(1)
Instrument Approach Procedures:	1,598	251	3,426	636	1,753	(1109)
Auxiliary:						
Outline Maps	8	-	-	3	9	(9)
Geomagnetic	1	-	-	-	1	(1)
Azimuthal	1	-	-	-	1	(1)
Projections	4	-	-	-	4	(4)
Miscellaneous	3	-	-	2	3	(3)
Total	1,921	257	5,024	656	2,062	(1378)

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

The new methods in chart construction, procedures in chart scheduling, and modernization of equipment put into effect during the year resulted in more efficient operation and utilization of manpower. Examples of these changes are: Considerable time is saved by reviewers in checking corrections as the source of each change is noted on aeronautical standards when the correction is applied. Aircraft Position Charts are published on a preset schedule rather than on the basis of exhaustion of stock or the occurrence of major changes in chart information. Each chart is revised twice each year in specified months, thus providing better service to the public as information is kept current and new editions can be anticipated. An improved manner of filing has been devised that reduces the time required in recovery of obstruction and airport data. This was accomplished by the installation of Selectomatic machines which provide quick reference to essential charting information. Aeronautical chart history standards are microfilmed and mounted on cards to provide easy reference and recovery of information. The cards may be examined on a viewing screen or a print obtained near original size. A compilation procedure of airway revisions on Radio Facility Charts has improved the uniformity of charted data and eliminated duplication of effort. From the legal description of the airway revision a single graphic interpretation is prepared rather than an independent interpretation by the cartographer of each respective chart series. This single compilation is on a large-scale aeronautical chart on which all of the airway revision has been accurately plotted, carefully reviewed, and all computations checked. Photographic copies of the manuscript are distributed to cartographers for application of the data to five different chart series.

REPRODUCTION DIVISION

Significant production gains were made over last fiscal year as follows: Chart completions (all categories) totaled 5,385, an increase of 15 percent. Total copy requirements rose 18 percent to nearly 37.6 million. Some 18 percent more aeronautical charts and copies were delivered and, although nautical chart job orders remained substantially the same in number, copies produced were just under 2.1 million or 24 percent over last year. Miscellaneous chart and related job requirements also increased about 13 percent over the prior year.

In support of various Bureau activities and as an aid to other bureaus and agencies, 11,000 miscellaneous service and supply orders were completed. Whiteprint production of Planimetric, Obstruction, and Central Airspace Reservation Facility (CARF) Charts totaled 13,950.

Operating economies effected through more efficient production control, improved manpower and machine utilization, and more efficiently established paper stock issuance and spoilage control made possible these significantly favorable comparisons:

Only 7 percent more press (machine) hours in 1964 over 1963 produced 10.4 percent more "sheets thru press" with an additional 18 percent chart copy total.

Charts Completed

	<u>1963</u>	<u>1964</u>	<u>1963</u>	<u>1964</u>
Nautical	408 + 36*	397 + 51*	1,680,000	2,084,000
Aeronautical	3,910	4,615	29,143,000	33,833,000
Miscellaneous	<u>329</u>	<u>373</u>	<u>1,014,000</u>	<u>1,653,000</u>
	4,647	5,385	31,837,000	37,570,000

* +36 and +51 are back-printed charts not included in completion totals.

Paper used was held to a minimal 3/4-million sheets (6.6 percent) increase or a total for the year of 12,630,000. Press sheet production required was 30.247,000 or 2,858,000 above 1963.

Two time-consuming "manufacturing" requirements have for several years deterred and sidetracked what might have been significant research or development project results. The Graphic Arts Development activity has been unable to divorce itself from the tedious task of making interposing tone-valued screens. During this year, however, the now fully developed vignette-making procedure was incorporated into the regular workload of the Photographic Branch.

Unfortunately, added impetus in development work did not materialize. Remaining nondevelopment tasks, the failure to replace one separated employee, uncertainty as to this activity's status within the confines of Department and Bureau R & D programing, and the continuing preoccupation with project preparation, revision and reporting all tended to preclude any substantial development progress.

During fiscal year 1964, the Reproduction Division continued its program of training in the graphic arts. Six employees were enrolled in the Metropolitan Washington School of Printing and one employee attended George Washington University. The courses attended were as follows:

Metropolitan Washington School of Printing: Survey of Lithography, 3 employees; Offset Stripping and Negative Work, 1 employee; Offset Photography II Halftone, 1 employee; and Offset Presswork II, 1 employee.

George Washington University: Basic Principles of Statistical Methods (for Quality Control), 1 employee.

In addition to taking training courses, the Division participated in giving training by furnishing two instructors to conduct the negative engraving portion of the Bureau's training program for cartographic draftsman.

A Bar Chart Recorder, an operations recording device installed in the Presswork Branch, electronically produces a chart showing production, idle, or down-time for each press. Major press operations are recorded impersonally and automatically with the entire three shifts fully monitored on a single chart. In addition, a press sheet (production) count is provided. When fully implemented, the continuously and accurately recorded data will serve as a major management tool.

Each fourth week, Radio Facility Chart production requires preparing and handling some 500 or more film negatives in a brief time period. To overcome a costly trimming chore, arrangements were made with a supplier to furnish film precisely cut to fit the needs of pin-resister punching and preregistration layout and platemaking procedures. Both man hours and lapsed time were reduced as were material costs thru the reduction in waste.

DISTRIBUTION DIVISIONS

The first of this fiscal year was the beginning of a new system of processing all distribution transactions concerning the receipt and issue of charts and publications through Automatic Data Processing Equipment. The transactions of all Regional and Field Offices were included to enable monthly reports to show quickly the total Bureau inventory and distribution of charts and publications.

The total issue of charts and related publications for the past three years and the distribution of this issue by category is shown in the following tables.

DISTRIBUTION OF NAUTICAL AND AERONAUTICAL CHARTS - FISCAL YEAR 1964

	NAUTICAL CHARTS				AERONAUTICAL CHARTS			
	Conventional		Small-Craft		Visual Flight		Instrument Flight	
	Copies	%	Copies	%	Copies	%	Copies	%
Free Issue:								
Coast & Geodetic Survey	17,527	1.1	4,672	3.9	10,785	.2	139,096	.6
Coast Guard	10,651	.7	844	.7	3,628	.06		
Federal Aviation Agency	164	-	9	-	319,297	5.4	4,948,320	21.5
Congressional	4,748	.3	667	.6	594	.01	36	-
State & Local Governments	1,504	.1	157	.1	1,729	.02	-	-
Foreign Governments	13,480	.8	538	.4	758	.01	505	-
Other Government Agencies	24,483	1.6	1,636	1.4	34,124	.63	395,586	1.7
Miscellaneous	5,743	.4	2,610	2.2	4,261	.07	9,804	.1
Mobilization Reserve	19,913	1.2	100	.1	-	-	-	-
Total Free Issue	98,213	6.2	11,233	9.4	375,176	6.4	5,493,347	23.9
Reimbursable:								
Department of Air Force	-	-	-	-	2,553,510	43.7	109,425	.4
Department of Army	-	-	-	-	11,700	.2	-	-
Department of Navy	865,141	54.5	6,330	5.3	696,150	11.9	6,000	.1
FAA (special printings)	-	-	-	-	35,000	.6	113,315	.5
Other Special Printings	-	-	-	-	70,550	1.2	-	-
Total Reimbursable	865,141	54.5	6,330	5.3	3,366,910	57.6	228,740	1.0
Total Sales to Public	567,800	35.8	95,782	79.7	1,645,037	28.2	14,419,533	62.6
Total Issued	1,531,154	96.5	113,345	94.4	5,387,123	92.2	20,141,620	87.5
Condemned	55,648	3.5	6,749	5.6	458,829	7.8	2,881,449	12.5
Total Issued and Condemned	1,586,802	100.0	120,094	100.0	5,845,952	100.0	23,023,069	100.0
Total Air Force Charts Issued -----					1,141,637			

CHARTS AND RELATED PUBLICATIONS ISSUED

	1962	1963	1964
Nautical Charts	1,475,858	1,712,172	1,706,896
Aeronautical Visual Flight Charts	4,995,986	5,710,168	5,845,952
Aeronautical Instru- ment Flight Charts	47,403,945 ^a	20,873,321	23,023,069
Miscellaneous Maps and Charts	82,989	68,726	118,225 ^b
Coast Pilots	21,971	15,528	11,171
Tide and Current Tables	67,967	74,802	63,951
Tidal Current Charts	c	c	6,288

- Includes over 29 million charts furnished as a military requirement which was ended after fiscal year 1962.
- Includes Chart No. 1 carried as Nautical chart before 1964, Distance tables carried as Coast Pilots before 1964, and Nautical catalogs.
- Included with Nautical Charts.

The number of nautical and aeronautical chart agents increased during the year from 495 to 527 and 611 to 664, respectively. Inspections during the year were made of 58 percent of the nautical and 44 percent of the total aeronautical chart agents. All but a small portion of each were found to be performing their duties in a satisfactory manner.

There was an increase of 1,125,000 hand corrections applied to nautical charts in the Washington, New York, and San Francisco Offices over last year. The total for fiscal 1964 was 8,439,237 hand corrections to 847,698 charts.

A meeting was held on September 17, 1964, with personnel of the Naval Oceanographic Office to explore ideas on the adequacy of and the necessity for hand corrections to nautical charts.

To effect a more uniform flow of properly scheduled nautical charts to the Distribution Division, weekly meetings were held with a member of the Distribution Division's Production Management Staff, the Operations Officer of the Nautical Chart Division, and the Production Manager of the Reproduction Division.

The following new equipment was procured for the Finishing Branch: (1) a heavy-duty saddle stitcher, (2) an electric lift truck, (3) three humidistats for humidity determination, and (4) an attachment for the KK folder. This leaves, however, a standing list of other seriously needed new equipment for better efficiency under increasing work loads. The KK folder is now 14 years old and often running three full shifts. A sheet counting machine would provide the Systems Manager accurate count of charts delivered to the Finishing Branch and thus allow better inventory accounting. Increasing bindery duties create unnecessary manpower problems for lack of a book trimmer.

NATIONAL AND INTERNATIONAL COOPERATION

NATIONAL AGENCIES

A series of meetings by representatives of the U.S. Naval Oceanographic Office, U. S. Coast Guard, and the Coast and Geodetic Survey were held during the months of April, May, and June 1964, for the purpose of reviewing each agency's responsibilities in respect to the publication of the Weekly Notice to Mariners.

Three cooperative projects were completed by the Nautical Chart Division for the U. S. Navy. They were: (1) revision and overprint of Navy Oceanographic Office anchorage data on sixteen charts, (2) published three new OFFICIAL USE ONLY charts, (3) revised two OFFICIAL USE ONLY charts.

A special request was filled for the Baltimore District of the Corps of Engineers in the researching of charting changes to the Hunting Creek area since 1906.

Personnel from the Aeronautical Chart Division accompanied Federal Aviation Agency (FAA) officials on a flight to the west coast to review data to be included in proposed pictorial display charts. Personnel also visited the FAA's National Aviation Facilities Experimental Center to evaluate use of translucent lithographic paper for controller charts.

A meeting with representatives of the Post Office Department and the Office of Cartography was held relative to revision schedules and reconstruction of Post Office Route Maps.

Personnel of the Distribution Division met with FAA representatives to explore means to improve distribution of Radio Facility Charts within the FAA.

Reproduction Division personnel attended technical meetings and seminars with the following organizations: (1) National Association of Photo-Lithographers, (2) Graphic Arts Technical Foundation, (3) Canadian Graphic Arts Industries Association, (4) Rochester Institute of Technology, and (5) American Congress of Surveying and Mapping.

INTERNATIONAL AGENCIES

In accordance with an agreement formulated at the 8th International Hydrographic Conference, Monaco, May 1962, most maritime nations are participating in production of bathymetric plotting sheets of the world's oceans. These plotting sheets are forwarded to International Hydrographic Bureau headquarters in Monaco for compilation of the 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 Ocean. As of June 30th, the Nautical Chart Division's Bathymetric Unit had completed eight plotting sheets. Two have been forwarded to IHB, and the other six will be forwarded as soon as a few minor corrections can be made. Considerable data has been received, processed, and filed for the next year's work.

The Executive Committee Meeting of the International Cartographic Association in Florence, Italy, was attended by a representative of the Aeronautical Chart Division, who later visited Zeiss Aerotopograph Company and the Zuse KG Company in Germany to inspect various automated cartographic systems.

OFFICE OF RESEARCH AND DEVELOPMENT

Considerable success was achieved in recruiting eminently qualified scientists to formulate definitive and substantive research projects to meet the Bureau's requirements under its six major programs. Specifically, senior scientists in the fields of the origin of ocean basins, satellite geodesy, theoretical geodesy, large-scale seismic experimentation, and theoretical investigations from existing seismological data joined the Bureau. These senior scientists together with other members of the scientific staff have been able to give more meaningful direction to the Survey's research effort. All projects were reorganized to more closely orient them towards the Bureau's long-range goals - and objectives redefined. Complete research plans were formulated, fiscal and manpower requirements were determined, and detailed project descriptions were prepared. These project plans are continually being reviewed within the Bureau, the Department of Commerce, and by the National Academy of Sciences-National Research Council Advisory Committee to the Coast and Geodetic Survey. These reviews ensure that the research and development efforts are clearly related to the missions of the Bureau and the Department; that they are based on sound scientific principles, coordinated with national and international research programs, and efficiently managed.

Oceanography Program.—Research activities under this program were both basic and applied in nature, and included development of critically needed instrumentation. This research will increase man's knowledge of the oceans, the ocean basins, and the action of the processes therein; and will seek applications of this knowledge for specific uses in forecasting physical events, controlling the environment, safeguarding human life and property, and promoting the economic growth and welfare of the nation. An accomplishment of note which crossed the lines of the various projects was the cruise of the ship PIONEER in the International Indian Ocean Expedition. Several observations obtained from this cruise contributed substantially to our research studies.

An eighteen months operations research study of the National Program for Ocean Surveys was two-thirds completed. The contractor started the study with an investigation and analysis of the ship building requirements of the Coast and Geodetic Survey for a program of systematic oceanographic surveys along the lines suggested by the National Academy of Science Committee on Oceanography and developed by the Interagency Committee on

Oceanography. A detailed report of this phase was submitted. One immediate use of the report was to develop a modification of the Bureau's 1965 budget submission to include funds for a smaller ocean survey ship than had earlier been planned at an estimated saving of \$3 million. The study is continuing with investigations and analyses of the Survey data user requirements, instrumentation, personnel, oceanographic buoys, ship design, governmental and nongovernmental contributions to the program, etc.

Under the Estuarine Studies Project investigations of contrasting types of estuaries were conducted under grants to the University of Southern California and the University of Georgia. The study of the sedimentological characteristics of Charleston, S. C., and Choptank, Md., estuaries conducted in cooperation with the University of Southern California has been completed. A study of the estuary in the vicinity of Sapelo Island, was started in cooperation with the Marine Laboratory of the University of Georgia, and the Sapelo Island Research Foundation. Fourteen tide gages were installed in the major portions of the estuary and in several of the interconnecting waterways. Tidal records from these gages have been given initial processing. Requirements for an instrument buoy to be used in estuarine studies have been defined. A temperature sensor chain was developed, laboratory tested, and calibrated. Telemetering and recording systems have also been laboratory tested and are now ready for field tests. Development of current and salinity equipment has been initiated, and some presently available equipment has been laboratory and field evaluated.

Under the Continental Shelf Physiography Project investigations relative to the physiography and sub-bottom features of the continental shelf were conducted in the geographical areas of the Florida Platform, Western Gulf of Mexico, Aleutian Islands, and Alaskan Peninsula. Collection of data by hydrographic surveys and bottom sampling, compilation of the bathymetry, preparation of special map projections, and interpretative studies are in various stages of completion for each of these geographical areas. A portion of the Western Gulf area has been investigated in detail under a grant to the Florida State University.

A contract with a company in Pasadena, Calif., made in fiscal year 1963 for basic research studies on "Modes of Generation of Tsunami Waves" was completed as part of the Tsunami Research Project. An effort to recruit a senior scientist with specific interest in tsunamis was successful at the close of the fiscal year.

The Tide Research Project was extremely productive. In the analysis of mean sea level oscillations, in cooperation with scientists at the Institute of Geophysics and Planetary Physics, University of California at San Diego, a high resolution of the sea level spectrum between zero and two cycles per day was developed. This was reported to the International Union of Geodesy and Geophysics (IUGG). In accordance with an IUGG resolution endorsing a data collecting and editing program by the above institute, the Coast and Geodetic Survey furnished punched cards of long series of hourly heights at two tide stations as well as miscellaneous other tide and sea water temperature and density data. Studies of the secular trend of sea level brought this information up-to-date. A low-pass filtering technique was developed to delineate trends that are masked by a straight line regression procedure. A method of calculating tidal harmonic constants from observations obtained at random times was developed. This method was initially conceived to analyze current observations obtained photographically, but is equally appropriate to broken series of tide records. The method was tested with both computed and observed data; the preliminary results were reported to the American Geophysical Union. The objective evaluation of the Coast Survey, Doodson, and the least-squares method of analysis has been initiated. Three new and improved tide gages for use on the continental shelf were assembled for testing. A study of the tidal characteristics of the Chesapeake Bay was completed.

A Deep-Sea Floor Research Project was started this year, in cooperation with the University of Illinois, to study the origin and evolution of ocean basins. An extensive library research has been initiated to determine the directions for selected emphasis in the investigation of the ocean basin origin. In the study of continental drift an earth model has been prepared, and cartographic fitting of continents and smaller land masses, based on the 1,000-fathom depth contours, was initiated to determine the order of fit and probable drift patterns. Removal of postdrift depositional and accretionary masses is being studied to improve the fit. Field investigations were conducted to gather data on bathymetry, deep-sea channels, and deep-sea deposits, both ancient and modern, as part of the investigations of deep-sea deposits and bathymetry.

As part of the Oceanology and Marine Geophysics Project, data were collected during the International Indian Ocean Expedition on magnetic and gravity fields, subbottom profiles, and sediments samples. Analysis of this data has been started. An interpretation of the

gravity and magnetic data collected by the ships PIONEER and SURVEYOR in the North Pacific Ocean in 1961 has been completed. During the year, considerable success was achieved in developing instrumentation for investigation of the marine geophysics. The development and testing of multisensors including the temperature-salinity-pressure probe was conducted. This system is now field tested, modifications are being made in certain of the parts, and its output is now amenable to computer data processing input. The development of a sea-bottom heat-flow measurement capability as a research project was completed. With the successful measurement of heat flow during the International Indian Ocean Expedition, the measurement itself will be a normal Bureau operational procedure. The automatic logging of magnetic data from ships underway has reached the operational stage and is now being programmed for computer processing. An electrically stabilized narrow-beam transducer for an echo sounder was developed and installed on the ship SURVEYOR. Preliminary results of tests conducted in March 1964 seem very favorable.

Geomagnetism Program.--The research and development efforts of the Coast and Geodetic Survey under its geomagnetism program were specifically designed to advance knowledge of the earth's magnetic field and to apply this knowledge where appropriate to promote the nation's commercial, industrial, and scientific activities in such areas as electromagnetic communications, space exploration, navigation, and the national defense. In conducting this research during fiscal year 1964, the Bureau developed cooperative programs with the University of California, the University of Hawaii, and the Russell Varian Foundation of Palo Alto, Calif.

Under the Magnetic Field and Its Variations Project investigations on the sources of the main magnetic field and its secular changes conducted in fiscal year 1963 were concluded, reported to the International Union of Geodesy and Geophysics meeting at Berkeley, Calif., and subsequently published. In addition, methods and procedures were studied and adopted for analytically defining the vector magnetic field of the earth, using all available data of acceptable quality. The analytic description will define the field in approximately the same detail as heretofore portrayed by the standard series of world magnetic charts. Plans for compiling these charts by machine methods, utilizing the analysis described above, were virtually completed. A grant was made to the University of Hawaii to continue the detailed study of the geomagnetic field time variations on small islands affected by the conductivity of the surrounding sea water. It is hoped that this study

will lead to the identification of an "effective magnetic center" on the island of Oahu. The Coast and Geodetic Survey operated an array of variographs in Puerto Rico, the data have been partially analyzed and studies have been initiated to (1) determine the preferred planes of shorter period bays and fluctuations and the relationship of these preferred planes to eddy current effects, (2) determine the effects field eddy currents have on the rapid and longer-period fluctuations, particularly in the San Juan and Cayey areas, and (3) gain a further general understanding of the eddy current effect so that a theoretical model of eddy current origin can be computed in two dimensions for Puerto Rico.

The magnetic observatory established at Boulder, Colo., as part of the Cooperative Magnetic Observatories Project was transferred from the research and development project to the regular operations of the Geomagnetism Division. Cooperative contractual agreements were signed by the Coast and Geodetic Survey and the Varian Foundation of Palo Alto, Calif., for the establishment of a cooperative observatory in the San Francisco Bay area. This installation, to be known as the Castle Rock Magnetic Observatory, will be equipped with a new remote recording instrument. A contract was let to fabricate this equipment, and an agreement was made with the University of California at Berkeley to participate in the operation of this observatory by locating the read-out equipment on the campus. Preliminary discussions were held with the University of Miami in Florida on the establishment of another joint observatory in that vicinity.

The efforts expended on the Instruments and Methods Development Project were particularly fruitful. The concept of the underwater stable platform was further developed. This platform will permit the taking of geomagnetic, tidal, wave measurements, and other oceanographic data in deep water areas. A test in 4,200 feet of water off Catalina Island, Calif., was conducted. Results of this test proved that the concept is feasible and that the platform is sufficiently stable to meet the requirements. Detailed plans have been prepared for the fabrication of the next generation of the underwater stable platform and for tests in depths up to 12,000 feet. Plans for the instrumentation to be placed on this platform have been prepared. Tests of the Automatic Standard Magnetic Observatory (ASMO) conducted at the Bureau's Fredericksburg observatory indicate that the data collected by the ASMO are equal or better than that obtained by traditional equipment. Reliability of the equipment will be tested over an extended period at Fredericksburg. A contract was let to construct an

Automatic Standard Magnetic Observatory - Remote (ASMOR). The magnetic detector elements of this ASMO are placed in locations sufficiently remote that they will be undisturbed by manmade noises and the data telemetered to a convenient receiving station. In addition, the ASMOR will provide the capability of obtaining analog as well as digital records on magnetic tape. Upon completion, the ASMOR will be placed at the Castle Rock Magnetic Observatory and the recording device will be located at the University of California, which is about 45 miles away. The Observer-in-Charge will be able to take part in the academic life of the University of California and conduct cooperative research with the faculty. Steps have also been taken to improve the methods of reducing the data recorded on the magnetograms currently being produced by the traditional observatory instruments. The performance requirements for a magnetogram scaler were defined and the design of the mechanical portions of the instrument started.

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: (a) the improvement of existing measurement systems in conventional geodesy through the utilization of new science and technology; and (b) the perfection of satellite geodesy as a potent tool for the study of the size and shape of the earth.

The research efforts conducted on Satellite Geodesy has been almost exclusively concentrated in support of the geometric satellite triangulation method. Progress has been made in other related projects, but such effort was undertaken primarily to support the most critical area of the research and development effort in the National Satellite Program. Specifically, theoretical and practical problems in establishing at the Coast and Geodetic Survey a unique capability for executing a worldwide geodetic satellite triangulation with an Echo-type satellite, which is to be launched during the calendar year 1966 by National Aeronautics and Space Administration (NASA). A mathematical model of the contemplated 36-station net was derived and successfully tested. The electronic computer program will allow the study of the propagation of various observational errors, thus supporting the planning and logistics of an optimum field operation. Numerous auxiliary programs have been designed for the various steps in the data reduction, including programs for production control based on statistically significant accuracy tests. A fully operational prototype program for the execution of

geodetic satellite triangulation for a 7-station net was designed, tested and applied to the first operational results on the 800-mile test triangle (Aberdeen, Md.; Chandler Air Force Base, Minn.; and Greenville Air Force Base, Miss.). The results obtained demonstrated not only the field operational capabilities of the Bureau's BC-4 data acquisition system, but the feasibility of the whole concept of geometrical satellite triangulation. The accuracy obtained is at least three times better than expected. The results clearly demonstrate the capability of the method to improve the basic first-order triangulation and for the establishment of a worldwide geodetic reference frame. Furthermore, these results indicate that significant conclusions can be drawn about the validity of the theorems in theoretical geodesy when the method is applied over a large number of triangles. In collaboration with the manufacturer, a new lens has been designed to further enhance the metric quality of the data acquisition system.

Preliminary studies of general Gravity Instrumentation and Sea Gravity Measurement Systems were conducted as an initial step towards fulfilling the objective of the Special Geodetic Gravimetric Investigations Project. The capabilities of presently available air and land based gravity measuring systems were investigated to determine their utility in an integrated program to collect gravity data. The design of special test equipment and instruments for monitoring additional parameters involved in the reduction of the gravity data collected at sea was initiated. An automatic data recording system was developed and installed aboard ship for two LaCoste-Romberg meters. Contracts were let for the fabrication of two LaCoste-Romberg meters to be operated on stable platforms and for two Askania-type meters. Two meters were operationally tested over the San Francisco Gravity Range. Corrections for high frequency accelerations were found to be inadequate, and special instruments to detect these accelerations are being designed. Library research and project planning for the special geodetic gravimetric investigations were initiated to coordinate these studies with the Bureau's Satellite Geodesy Project.

In conducting Precise Distance-Measurement Research, working agreements were made with the National Bureau of Standards, White Sands Missile Range, and various industrial organizations to acquire theoretical and experimental knowledge necessary to improve methods of determining the refractive index used in computations of light measured distances. A prototype sonic thermometer was developed. The field tests indicated that atmospheric variables were greater than anticipated. Therefore, as

the accuracy of this method has been proved insufficient, development work was discontinued. A method to optically measure the index of refraction along a 10-mile path was discussed and plans for developing instrumentation for this method were prepared.

As part of the study of the Crustal Movements Project, interpretation of data for the determination of shear and stress displacement of the earth's crust surrounding an earth fault near Salt Lake City, Utah, was continued. Investigations, in cooperation with the University of Utah, in this fiscal year have proved that photogrammetric methods can be used to detect earth crustal movement of a magnitude less than 2 inches in horizontal position or height of areas less than 1 mile square. In cooperation with the State of California to detect relative crustal movements along a proposed aqueduct route, 17 control positions on either side of the San Andreas Fault were established and measured. Four additional sites were selected. Work was then suspended for 6 months. The network will be resurveyed to determine deformations of the original survey network and the relative movements of the earth's crust.

Fundamental research was initiated in the Reduction of Geodetic Measurements to examine the reliability of existing theories, which were conceived well over a century ago, for the reduction of geodetic observations in the light of the tremendous technological advances taking place in geodesy. Formulation for simultaneous reduction and adjustment of linear, angular, and astronomical measures in three-dimensions has been completed, but needs further simplification. Current methods of reducing satellite orbital data have been reviewed. Newtonian dynamics do not appear to have been tested to a high degree of accuracy in the unsymmetrical near-earth field, although indications are that the Newtonian theory may be inadequate in such conditions. Einstein's equations of motion offer no solution. They are not computable in a complex field and in any case reduce to Newtonian for satellite velocities.

As part of the Numerical Photogrammetry Research Project, the design of a complex mathematical model dealing with a single camera was completed. The detailed mathematical presentation is being organized into a program for electronic computing. This work will provide, for the first time, a sufficiently powerful tool for detailed calibration of photogrammetric cameras and decisive improvement in the basic computations in satellite geodesy.

A project was initiated to develop New Concepts in Multimedia Photogrammetry applicable to detailed mapping of the ocean floor and to air-sea interface studies. Bureau goals for the detailed mapping of the underwater continental shelf and for the extension of geodetic control on to the sea floor were defined. Arrangments were made for joint sponsorship by the Office of Naval Research and the Coast and Geodetic Survey of underwater radiance research being conducted by the Scripps Institution of Oceanography. The Survey arranged to test the deep-sea artificial light radiance transmissivity meter of the Naval Ordnance Test Station, China Lake, Calif., aboard the ship SURVEYOR. Discussions were held for cooperation in the test of the Navy's airborne pulse light system applicable to the study of the air-sea interface.

Research on the Special Photogrammetry Applications Project continued during the year. The design, building, and testing in deep water of the deep-sea camera system was completed. Increasing the range using the visible portion of the spectrum and conventional photography was accomplished. An important development in the measurement of tidal currents using photogrammetric techniques was reached when a new target material was tested and found to have an excellent image on high altitude photographs. The new material can be air dropped which eliminates the need for surface support for such measurements when only surface currents are of interest.

In the Photogrammetry Systems Development Project in order to obtain the minimization of precision comparator-operator bias errors, a series of tests was conducted which resulted in the development of an qualification test for personnel to be used in the measurement of satellite triangulation photographs. The same studies resulted in the design of a new comparator pointing reticule and exposure format for stellar plates which also reduce errors in obtaining data from satellite triangulation photographs. The capabilities of aerotriangulation were further enhanced with the development of a mathematical model for correcting for film distortion. This model was incorporated in the routine treatment of aerial photographs. Instrument development for use in photogrammetric mapping from color photography advanced with a new illuminator system for the B-8 stereoplotter. Tests of various emulsions and dimensionally stable plates continued in cooperation with the Color Committee of the American Society of Photogrammetry.

Seismology Program.--The Bureau's entire research and development effort relating to the seismology program was given new direction under the guidance of the senior scientists who joined the staff during the fiscal year. The principle goals of the research and development effort were defined as: (1) obtaining a greater understanding of the causes of earthquakes; (2) developing fundamental knowledge of the structure of the earth; and (3) making more effective the dissemination of seismic data. Cooperative studies were initiated with Southern Methodist University, the University of Hawaii, the Lamont Geological Observatory of Columbia University, and Georgia Tech Research Institute.

The Earthquake Mechanism and Predictions Study Project was initiated. Plans were developed to monitor active faults to detect changes in any measurable physical property of the earth (electrical, magnetic, elastic, thermal, or other) which may be diagnostic of the impending occurrence of an earthquake. The first will be conducted somewhere along the San Andreas Fault in California. Methods to automatically record changes in length of two digital lines 100 to 1,000 meters in length with sufficient accuracy to detect underground movements across the fault line are being developed.

Late in the fiscal year the Tsunami Research Project was established. Cooperative studies with the Lamont Geological Observatory on the applicability of certain seismic techniques to the Seismic Sea-Wave Warning System were conducted. Three-component mantle wave recorders were installed at Palisades, N. Y., and Honolulu, Hawaii. They have been operating for several months and have made excellent records of Love and Rayleigh waves from a large number of earthquakes, including those of the recent Alaskan shocks. To support the Bureau's commitment to the IUGG to prepare a bibliography on tsunamis and storm surges, a contract was made with the University of Hawaii.

Under the Studies of Seismic Waves and Earth Structures Project a cooperative investigation of the upper mantle and crustal structure was initiated. Southern Methodist University and the Coast and Geodetic Survey participated in this investigation. The first map of apparent Pn velocities for the U. S. was published. A revised map of Pn velocities in the U. S. was presented at the annual meeting of the American Geophysical Union. A table of Pn velocities at latitudinal and longitudinal grid points for the U. S. was stored in the HYLO computer. Methods of precisely determining focal depth of earthquakes, a new technique developed by Lamont scientists for

determining S Wave traveltimes to a greater precision than was possible before, were made available. This method allows direct comparison of both traveltimes and higher normal mode dispersion with theoretical values and hence determination of the shear strength of the mantle of the earth as a function of depth.

The principle research and development effort on Improved Seismic Systems was devoted to the study of advanced array techniques. An array test was made in Mississippi to monitor a nuclear explosion in fiscal year 1963, and the resulting data were analyzed and interpreted this year. The test, using 36 two-cycle geophones, achieved more than 10 to 1 reduction in surface wave noise. In addition, the surface wave noise in the array possesses such a character that it is possible to determine velocities and azimuths of the noise propagation. For proper control of this surface wave seismic noise, it is necessary to place more than two geophones per wavelength at the highest frequency noise existing within the seismic signal bandwidth to avoid the aliasing of high wave number seismic noise energy into the low wave number seismic signal. Results indicated that other investigations may be using improper spacing for noise control, and, as a result, obtain poor signal to noise ratio improvement. This may limit the efficiency of their systems in distinguishing earthquakes from explosions when using reflected phases. As part of the analysis of the test data, digital filters were devised which, when convolved with the digital tape or oscillograph records, cut unwanted aliasing frequencies by a factor of more than a 100 to 1, thereby reducing the corresponding aliasing wave numbers by the same amount. Plans were prepared to establish a specially designed array in southern Canada to monitor the 5-kiloton Salmon Nuclear Explosion. This experiment will further test this technique.

Initial work on the Operational Improvements in Seismological Services Project determined that in order to optimize the dissemination of data, it would be necessary to process raw seismic data on a scale never before achieved. Therefore, the first step was to develop a computer system capable of processing a large volume of seismic data with great speed and accuracy, and yet maintain a flexibility for positive results. By using the Weather Bureau's STRETCH Computer, this almost completely automatic system the routine hypocenter determinations are currently being made at a speed sixty times faster than previously attained. This expanded computer capability has made possible more accurate hypocenter determinations through magnitude studies, use of local traveltimes, new location techniques, and analysis of station residual towards the development of a refined traveltime curve.

Five MK-II strong motion seismographs procured for the Seismological Engineering Project were received. These units were complete with electrical system, controls, timing system, camera, starter pendulum, accelerometers, and displacement meters. Development effort to improve these instruments and further adapt them to the needs of the Bureau's strong motion activities were initiated, but the project was delayed due the the aftershock investigations in Alaska following the earthquake.

A VELA UNIFORM Experiment in the Aleutian Islands was initiated. A comprehensive plan of the experiment to investigate the crust and upper mantle in a portion of the Aleutian Islands to gain detailed information on the accuracy of hypocenter determinations in island-arc regions, was prepared. This experiment is being conducted in cooperation with the Air Force and various commercial geophysical firms. Phase I of the operation, system engineering and operations planning, included: the development and procurement of five unmanned seismic system stations; and the logistic support plans. This phase of the test was completed. Phase II, system assembling and testing, was delayed beyond the end of the fiscal year due to nonreceipt of components from the vendors and unexpected difficulties with the tape recorders. Phase III, site selection and preparation, included reconnaissance surveys on five of the Aleutian Islands to select the installation sites and construct suitable seismometer tanks. This phase was 75 percent complete.

At the request of the Advanced Research Projects Agency, the Survey agreed to supervise a research contract titled "Studies of the Seismicity of the State of Georgia," being done by the Georgia Tech Research Institute of the Georgia Institute of Technology.

Aeronautical Chart Program.--The ever increasing speeds of commercial aircraft, the tremendous complexity of the airspace control system, and the continuously shrinking schedules for the revision and reproduction of existing aeronautical charts, require the effort under this program to be principally developmental in nature.

The New and Improved Concepts of Data Presentation - Aeronautical Project was almost exclusively devoted to determine the requirements for specific chart series and for the design of chart standards to meet these requirements. Federal Aviation Agency's new standard for Terminal Instrument Approach Procedures were analyzed and our interpretation converted to graphic form for the

charts. Two prototype charts were developed. Survey personnel participated in a comprehensive flight test to evaluate the design in an operational environment. The prototypes were then distributed to FAA for further test and evaluation. The actual physical development of the IFR-VFR Planning chart was completed. Printed prototype charts were distributed for user evaluation. Four prototype Alaskan Visual charts were developed and submitted for printing. On charts containing visual flight information, terrain data must be clearly and simply portrayed while remaining sufficiently subdued for the aeronautical information to have maximum legibility. Current printing methods cannot, without an intolerable number of press runs, reproduce both the terrain and aeronautical data with sufficient clarity, in an effort to solve this problem a grant was made to the University of Washington to study the feasibility of applying four-color process printing to the reproduction of aeronautical charts.

As an initial step in the Automation of the Cartographic Processes - Aeronautical Project work was conducted to establish the necessary procedures for centralized compilation of data that is applied to several series of charts. Development to produce graphics which will tolerate the photographic changes when applied to charts at several scales was conducted. In addition, meetings were held with representatives of various organizations on the feasibility of applying operations research and systems analysis techniques to improving the overall performance of the aeronautical charting operation and of applying automatic data processing. Plans were made to conduct such a study in fiscal year 1965.

Nautical Charting Program.--Research and development under this program was directed toward the improvement of current charts and services, and 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.

The work under the New and Improved Concepts of Data Presentation - Nautical Project was principally developmental and directed towards realistic nautical charting plan responsive to user requirements and while assuring the optimum use of resources in disseminating nautical data. A continuing analysis was conducted of correspondence from chart users, technical reports, and planning documents. In addition, a study was performed to determine the chart user requirements on the west

coast, which was a continuation of a contract for the east and gulf coasts. As a result of an effort to automate the collection of hydrographic data aboard ship such data are available in a corrected form on punched paper tapes and punched cards. A method has been developed to semiautomate the chart compilation procedure using these tape and card records. Conversion of chart specifications and projection requirements in "machine language" suitable for automatic plotting on the Bureau's plotter was started. A comparison of the results of the compilation made by this method with one of the same area prepared by conventional methods was started. To respond to the needs of the user for the portrayal of data necessary in the use of electronic positioning systems, two experimental charts were prepared showing Consol Consolan arcs on selected standard charts. Further studies were begun on the Loran A and Loran C navigational systems.

The first area to be investigated under the project, Analysis of Natural Phenomena as they Affect Nautical Charts was in Alaska. Studies were begun to define and areas of uplift and subsidence resulting from recent earthquakes in that area. Steps were taken to coordinate the research under this project with that being conducted by the University of Illinois under the Oceanography Program.

Under the Advanced Cartographic Development Project, production personnel were trained in the preparation of photochemical halftone vignettes. As a result of testing of various paints, new mixtures and formulas, and new methods of mixing and grinding, a photo negative paint has been developed which is considered satisfactory. Tests were conducted on the visibility of certain inks under subdued lighting conditions, deficiencies were identified and some remedial measures were implemented.

OFFICE OF ADMINISTRATION

OPERATIONAL ACTIVITIES

Administrative and Technical Services

As a result of overcrowding in many areas occupied by the Department and the Bureau, the Administrative and Technical Services Division developed a plan to move approximately 50 percent of the Headquarter's employees to a new location within the metropolitan area. To fill the Bureau's requirements, General Services Administration entered into a lease of 139,000 square feet of office and special purpose space in two buildings at the Washington Science Center just south of Rockville, Md. At the end of the fiscal year, the first building containing approximately 91,000 square feet had been occupied.

The Division completed 4,692 procurement actions amounting to \$6,310,749, an increase of approximately \$30,000 over the previous fiscal year. The breakdown of these activities is:

	<u>No.</u>	<u>Amount</u>
Negotiated Contracts	78	\$3,437,696
Advertised Contracts	81	1,192,042
Grants	5	72,376
Open Market and other purchases	<u>4,528</u>	<u>1,608,635</u>
Total	4,692	\$6,310,749

On July 1, 1964, The Bureau's procurement function was transferred to the Department of Commerce and a liaison officer appointed to coordinate the procurement and contracting activities with the Department's Procurement Division.

Excess property which cost about \$1,000,000 was sold or transferred to General Services Administration and other Government agencies, exceeding by \$750,000 the amount reported last year. This increase was largely due to a concerted effort on the part of supply and operating personnel to identify obsolete items for removal from inventory. The Bureau acquired, without cost, surplus property valued at \$173,522 from other government agencies.

Inbound and outbound shipments totaled 1,075 tons. Approximately 75 percent of the shipments were carried by motor freight; the remainder was transported by express, rail, air, and mail.

During the year, 111 vehicles were disposed of, 80 were purchased, and 3 were acquired without charge from other agencies of the Government.

Bureau vehicles traveled a total of 3,862,521 miles at a cost of \$0.080 per mile, a decrease of \$0.005 from last year and \$0.029 less than the national average. Vehicle years traveled totaled 290, a reduction of 8 from 1963. Average mileage per vehicle year was 13,319 or 282 miles less than last year.

Four claims for damages were settled for \$1,383.29.

Requisitions for printing processed by the Division amounted to \$170,241. An estimated expenditure of \$101,689 was required for 251 job orders for housekeeping services. A catalog of forms used by the Bureau was issued.

Through its continuing records disposition program 6,247 cubic feet of records were eliminated from Bureau space. Of this amount, 3,998 cubic feet were disposed of and 2,249 cubic feet were listed, packed, and transferred to the Federal Records Center for future servicing by that facility. This action reduced the Bureau's total records holdings from 34,184 cubic feet to 32,635. A total of 2,162 Survey documents were serviced from the Records Center during the year. An official list of Bureau recurring reports was published July 1963.

The Division processed 1,986 temporary duty travel orders, 172 travel orders involving a permanent change of station, and 516 individual travel requests; and it obtained approval of 159 foreign travel requests, security clearances, and passport clearances.

The Division planned and coordinated the Bureau's publications program. The Chief of the Division, in the capacity of publications officer for the Bureau, expedited final production of all book and pamphlet publication of the Bureau. 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.

On September 9, 1963, a Bureau Safety Officer entered on duty. Several trips were made to the field to review and further develop a sound and progressive safety program for all areas of the Bureau. A shipboard safety checklist was developed and accepted by the Office of Oceanography for distribution to the Commanding Officers of vessels for guidance and assistance for their safety committees.

A draft of a proposed Bureau Safe Practices Guide was also developed. The guide was approved, with modifications by the Bureau Safety Committee and the affected assistant directors and division chiefs, and is now being field tested. This guide has chapters on: (a) explosives, use and handling, (b) compressed gases, (c) electronic equipment, (d) handling flammable materials, (e) general shipboard safety, and (f) pressure vessels.

During the first half of 1964, the time lost in accidents was reduced 48 percent compared to the same period of 1963. The number of motor vehicle accidents was reduced 36 percent during the same period. Significant cooperation is reported from all personnel. This evaluation is based on the number of requests for assistance and response to inquiries regarding accidents and conditions.

With the Bureau's move to the Washington Science Center, a review and updating of the fire and emergency evacuation plans was initiated. Transfer of safety activities from the Personnel Division to the Administrative and Technical Services Division was made during this period.

The Bureau's Emergency Readiness Plan is undergoing necessary revamping in order to correct certain deficiencies and weaknesses found during the Cuban Crisis.

With the assistance of the Office of Emergency Planning and Office of Emergency Transportation, funds are being sought for expanding the security storage program and the emergency chart production program. Both of these programs are far below the minimum requirements anticipated to meet military and civil defense needs. An all-out effort concentrated on gaining budget support for this purpose has been initiated.

Further development included the designing and printing of a relocation assignment card for relocatees. This card contains pertinent information and instructions for relocatees and will be issued to all personnel having an emergency assignment together with a copy of the relocation instructions. Further planning included the organization of a communications corps to operate the teletype equipment and radio station at the headquarters site.

Approximately 132,000 new maps were received and processed in the maintenance of the Bureau's collection of map source material. More than 77,000 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 600 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.

Among those receiving maps and map information outside the Bureau were various state highway departments, Florida Development Commission, National Geographic Society, Pan American Airways, and Texaco Co. Among those within the Government were the Army Map Service, Beach Erosion Board, Bureau of Land Management, Bureau of Public Roads, various agencies of the Department of State, Federal Aviation Agency, Federal Power Commission, Geological Survey, the Navy Research Laboratory, Oceanographic Data Center, and Soil Conservation Service.

Approximately 260 nautical charts and 130 aeronautical charts, together with 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 64 new hydrographic survey sheets and 180 planimetric maps. As a result of names research in the division and field reports, more than 150 cases of name conflict were submitted to and decided upon by the Board on Geographic Names. In addition, about 150 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 in the Division and other sources, over 300 name changes were made on nautical charts during the year, and more than 200 such changes were effected on aeronautical charts. In reply to requests for names information

from the public and other sources, most of which required considerable research, approximately 160 letters were written during the year.

Special sheets for the field investigation of geographic names were prepared for 28 different project areas. In response to this, 25 geographic names field reports were received and processed in the Division. In keeping with the Division's 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 1,000 items were added to the Division's card file of Board on Geographic Names decisions, alphabetically by states, during the year. About 3,000 location cards were prepared and placed in the alphabetical file of Atlantic coast place-name locations.

Some 60 solicitations for geographic names information were made by mail to local sources. The responses, in many instances, provided information utilized in the preparation of cases submitted to the Board on Geographic Names and the respondents felt that they were a part of an interesting and important undertaking.

In response to various requests, a great deal of geographic research was conducted in the Division. The results of much of this work were contained in the more than 2,000 letters issued on various geographic subjects.

Long term research was accomplished on map and geographic names source material for specific purposes and in connection with congressional requests. Special geographic names research was done on numerous locations both for governmental and outside sources, the latter in the interest of good public relations. Research on geographic names in Delaware, relative to projects coordinated with the Board on Geographic Names, represented one such effort. Research into the coastal geography of portions of the coast of Alaska, Washington, Oregon, California, Florida, Texas, and Mississippi was done at the request of the Department of Commerce.

A file on source material and indexes for the compilation of aeronautical charts was continuously maintained. Approximately 1,800 aerial photographs were received and processed. Source material was provided for the revision of 312 aeronautical charts, in keeping with the Bureau's aeronautical chart revision program.

More than 2,000 photographs and slides depicting Bureau subjects were accessioned and placed in the files. The Division issued over 11,000 photographic prints and slides and loaned more than 450 reels of motion picture films portraying Bureau activities. The Bureau's 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; 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 Company of Canada, Ltd., Toronto, Canada.

Numerous exhibits and display panels were constructed and placed at various regional and international boat shows and conferences throughout the country.

The Division prepared 556 special maps, graphs, and charts for a variety of Bureau and departmental needs. This illustrative and cartographic work included graphs and maps for budget presentation, and special drawings illustrating Bureau activities. In addition to scenic paintings for Bureau exhibits, 259 art illustrations for publication covers and texts, slides, and hand-lettered signs were completed. More than 330 certificates were lettered, including those for departmental awards and officer appointments.

Approximately 3,600 books and pamphlets were added to the permanent collection of the Bureau library, and about 435 volumes were eliminated. Slightly less than 6,000 books and pamphlets were circulated and more than 1,100 books were loaned.

Budget and Finance Division

The Bureau's budget formulation, presentation, and execution processes and procedures were modified as required during the year to place proper emphasis on the Regional Office concept of operations and budgeting from a zero base rather than on an increase basis only. Efforts in this area are continuing in the light of expanded decentralization of activities.

Immediately after the devastating Alaskan earthquake of March 28, 1964, Bureau operating financial plans had to be changed to: provide emergency surveys of the channels and harbors; reestablish tide stations; make seismological investigations; restore geodetic control; and compile and publish revised charts and chartlets covering the stricken area. Such action not only entailed major reprogramming of funds within previously approved financial plans, but also formulation and

presentation of a supplemental appropriation request with all the attendant budgetary back-up data. The dispatch with which this unforeseen workload was organized and approved compliments this Division's efforts in striving for maximum flexibility in financing operating plans with no loss of vital top management control.

One budget analyst attended an advance seminar in automatic data processing and financial management which was sponsored by the Civil Service Commission.

Continued emphasis was placed on improving procedures and on 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 report is quoted in part as follows:

"Systems Modifications.—The Coast and Geodetic Survey modified its accounting system to provide for distributing overhead costs to projects by applying predetermined percentage rates to labor costs. The change has reduced machine processing time and has expedited preparation of mechanized reports. Use of the predetermined rates in calculating estimated reimbursable obligations has resulted in more accurate estimates, which permit better financial planning.

* * * * *

"Procedural Simplifications.—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. About 40,000 customer copies of service station delivery tickets and a like number of vendor copies, with invoices, are processed annually. New desk procedures for processing the tickets and invoices eliminated various steps and records, and have resulted in an annual savings of about \$555.

"2. The practice of assigning individual numbers to each basic voucher was discontinued. This action eliminated typing about 17,000 voucher numbers on schedules and the recording of voucher numbers on various other records. The annual savings were about \$490.

"3. The general ledger, accounts receivable ledger, files, and related billings were reviewed. Action was taken to eliminate the posting of nonessential

information, reduce the number of journal vouchers by posting directly from registers, and reduce the number of reimbursement billings by making certain billings quarterly rather than monthly. These actions resulted in an annual savings of about \$1,645.

"4. The number of payroll controls for commissioned officers was reduced from 65 to 2 by having controls for "office" and "field," rather than controls for each cost center. The method of preparing civilian biweekly payroll schedules was simplified, and the number of schedules was reduced from five to two. The Bureau now furnishes the Treasury Department with a payroll tape (rather than cards) for use in issuing payroll checks. These actions have resulted in an annual savings of approximately \$1,040.

"5. A detailed study of the procedures used in accounting for travel and travel advances, and in processing cashiers' reimbursement vouchers and refunds for unused transportation led to procedural improvements. The actions taken have resulted in an annual savings of approximately \$1,440.

"6. Emphasis was placed on eliminating unnecessary records and on the control and flow of paper work. Several important improvements were made; for example, it is estimated that new instructions for routing and filing about 4,000 "locator file copies" of purchase orders saves \$500 annually."

A Capitalized Personnel Property Transaction Register was established as a means of reducing the time required to reconcile the accounts with Bureau property records.

Problems being encountered in reconciling accounts payable were studied. As a result the use of accounts payable punch cards was discontinued and improved procedures were implemented.

Three new chapters of the Bureau Finance Manual were issued which covered the following subjects: uniform allowances, vouchers for cash purchases and payments, and distribution of certain costs among projects. In addition, nine revisions were issued on previously issued chapters.

The following funds, from sources indicated, were made available to the Bureau during the fiscal year 1964.

Available Funds

Appropriations:	
Salaries and Expenses	\$26,120,000
Transfers from:	
Commerce - Office of the Secretary	<u>600,000</u>
Total Salaries and Expenses	<u>26,720,000</u>
Construction of Surveying Ships	
(Includes unobligated balance of \$5,498,010 brought forward from fiscal year 1963.)	18,498,010
Construction and Equipment, Seismological Laboratory, (Unobligated balance brought forward from fiscal year 1963.)	
Total Appropriations	<u>889</u> <u>45,218,899</u>
Reimbursements from Other Agencies	<u>8,398,919</u>
Total Funds Available	<u>\$53,617,818</u>

Collections covering all miscellaneous receipts, including sales of nautical and aeronautical charts and related publications totaled \$1,221,232. Of this amount, the sum of \$654,565 was collected by the Department and deposited into the GPO fund. Similar collections during the fiscal year 1963 amounted to \$1,027,553.

Management and Audit Division

During the fiscal year major activities of the Management Branch involved the following: conducting management studies, surveys, evaluations, reviews, and analyses; planning and effecting organizational improvements; developing and monitoring a production measurement program; and disseminating information and instructions to Bureau units.

Studies, surveys, evaluations, reviews, and analyses were made as follows: (1) an evaluation of proposals to conduct a study of the Bureau's aeronautical chart distribution system and liaison with the management consulting firm selected to do the study; (2) a study of the problem of storage, retrieval, and distribution of geodetic data, which included the following aspects: (a) a review of the entire geodetic data operation as now conducted; (b) a study of anticipated Bureau operation of a modern depository and distribution center for geodetic data from both domestic and foreign sources;

and (c) a recommendation of methods and systems to be retained or adopted in the interests of efficiency and economy, including possible new reproduction systems for geodetic data sales material; (3) a review and written analysis of a proposed policy on use and authorization of overtime; (4) a study of postage costs involved in the sales of charts and miscellaneous services; (5) a review of a property management study conducted by a private management consulting company and assistance in implementing the recommendations received; (6) a study for the Assistant Director for Research and Development concerning other agencies' and universities' practices regarding scientific research personnel, which included information collected from National Aeronautics and Space Administration, National Institutes of Health, National Science Foundation, Geological Survey, and several local universities; (7) a review of prices charged for miscellaneous services furnished by the Bureau, which included the initiation of a new form and new procedures for reporting costs from the divisions which provide miscellaneous services. Preliminary work was also accomplished for preparation, at a future date, of a handbook for distribution to the general public listing special services provided by the Bureau; (8) review of Chapters 16, 17, 18, of the Bureau Personnel Manual concerning Employees' Compensation for Disability and Death, Within-Grade Step Increases, and Quality Step Increases; and (9) review of Chapters 12, 14, 16, 22, of the Bureau Finance Manual concerning Travel Regulations, Bonding Requirements, Uniform Allowances, and Distribution of Certain Costs Among Projects.

Organization planning was concerned with the following: (1) functional alignment, delegation of authority, and proposed staffing in connection with the implementation of the Bureau's regional plan. The following specific actions were taken: (a) The Seattle, Norfolk, Kansas City, and San Francisco District Offices were reorganized and redesignated as Regional Offices; (b) functional statements and/or organization-function charts were prepared for the Seattle, Norfolk, Kansas City, and San Francisco Regional Offices; (c) a Bureau field office was established at Anchorage, Alaska; (d) the Ft. Worth District Office was closed with its functions transferred to the Kansas City Regional Office; (e) the Baltimore and Tampa District Offices were closed with their functions transferred to the Norfolk Regional Office; (f) the Geodetic Computing Unit of the New York District Office was consolidated with similar functions at Bureau headquarters; and (g) all remaining district offices were redesignated field offices and placed under the control of the respective regional offices.

Organizational planning for the following was done during the fiscal year and submitted to the Department for approval: (1) the redesignation of the Personnel and Safety Division as the Personnel Division, with the Safety function to be transferred to the Administrative and Technical Services Division; (2) the transfer of Emergency Planning coordination from the Director's Staff to the Administrative and Technical Services Division; (3) the realignment of the Management and Audit Division as follows: (a) the Internal Audit Branch to become the Internal Audit Staff in the office of the Director; and (b) the Management Branch to become the Management and Organization Division; and (4) an Operations Research and Systems Analysis Staff to be established in the office of the Director.

Other organizational changes at Bureau headquarters included the following: (1) transfer of the Hydrographic Verification Section from the Office of Oceanography to the Office of Cartography; (2) abolishment of the Wood-working Section, Administrative and Technical Service Division, with its functions absorbed by the Visual Aids Section; (3) the reorganization of the Instrument Division and redesignation as the Engineering Division; and (4) organizational realignment in the Negative Engraving Branch of the Reproduction Division.

In line with emphasis on work measurement, manpower utilization, and increased productivity throughout the Federal Government, a production measurement program was initiated. Principal actions taken were the following: (1) a feasibility study by the Management Systems Corporation of Cambridge, Mass.; (2) designation of responsibility for the program to a three-man staff from this Division; (3) attendance at production measurement courses; and (4) preparation for a study in one major work area to begin in the first quarter of the next fiscal year.

Information and instructions were disseminated to Bureau activities in memorandums on the following subjects: (1) corrective procedures and instructions to field units concerning administrative malpractices discovered in field audits; (2) policy for the procurement and utilization of executive-type furniture; (3) the President's program for improving productivity and efficiency in the Federal Government; (4) disposition of funds derived from sales of reproducible positives and negatives; and (5) clarification of Bureau policy relating to costs chargeable to reimbursable projects conducted on Bureau ships.

Memorandums and letters for the Director's signature were prepared in response to requests for information from private parties, business concerns, and members of Congress concerning the following subjects:

(1) the discontinuance of sales of charts and geodetic control data by Coast and Geodetic Survey field offices, and (2) a reply to a questionnaire from the Consulting Engineers Council concerning the use of consulting engineers by the Bureau.

Forty-eight special reports, continuing reports, and evaluations were submitted. These reports and evaluations covered the following subjects: (1) significant actions taken by the Office of Administration (submitted monthly); (2) manpower utilization (submitted quarterly); (3) semiannual records report; (4) financial management improvement report; (5) report of any legislative requirements concerning the Office of Administration, for consideration of the 89th Congress; (6) report on estimated publications printing requirements for fiscal year 1965; (7) inventory report of continuing services provided to other Federal agencies; (8) annual report on organization of Federal Executive Departments; (9) report to Office of Management and Organization on the effects of automation on Federal employment; (10) special accomplishment reports covering Survey accomplishments in various states and regions of the country; (11) annual report on scientific research grants; and (12) a report on the Bureau's administrative dealings with the Canadian Government.

Branch personnel attended 19 meetings, demonstrations, and special training classes held outside the Bureau. Training was received in the following areas: (1) Program evaluation and review technique (PERT); (2) current management principles and practices; (3) work measurement; (4) files improvement; (5) operations research; (6) automatic data processing systems; and (7) systems and procedures analysis.

The Branch issued 8 new or revised organization-function charts. The Branch also issued 6 General Circulars or amendments, 1 Office Circular, 4 Information Bulletins, 1 Commissioned Personnel Circular, and 41 additional or revised pages to the Bureau Regulations. Rescinded items included 11 General Circulars or amendments, 1 Office Circular, and 1 Commissioned Personnel Circular.

In September 1963, two staff members of the Internal Audit Branch returned from a 13-month detail with the Office of Audits of the Department. Several comprehensive audits were undertaken during the year and copies of reports on completed audits were issued to the Department of Commerce and the General Accounting Office.

Audits completed during the year were concerned with (1) management controls, practices, and procedures, Field Party 624, Cape Kennedy, Fla.; (2) activities of the Albuquerque Seismological Laboratory, Albuquerque, N. Mex.; and (3) management and financial controls over ship construction activities. The reports of these audits contained recommendations designed to assure greater adherence to established regulations, policies, and procedures; improve the effectiveness of management controls; and increase the efficiency of the Bureau's operations.

Considerable follow-up work was performed after completion of the audits to ascertain the adequacy of the corrective action taken on deficiencies and to furnish advice and assistance to operating units in implementing the report recommendations. In one instance a memorandum report was submitted to the Director which summarized the corrective action taken and pointed out areas where the desired results of report recommendations had not been fully realized.

In process at the end of the fiscal year were comprehensive reviews of (1) Bureauwide overtime practices and procedures, (2) nautical chart distribution activities, and (3) reimbursable activities. Audit work performed on the latter review related to the activities of the International Technical Cooperation Staff in training foreign nationals, and to the work performed for the National Aeronautics and Space Administration at the Fredericksburg Magnetic Observatory.

Numerous requests for information from other divisions were answered on an informal basis throughout the year after researching applicable laws, regulations, and Comptroller General Decisions. Other miscellaneous projects performed included a cost analysis of the geodetic data user-charge activity to determine whether the data should be sold or issued free; and a study of the mailing lists maintained by the various Bureau divisions, in answer to a report submitted by the Office of Audits of the Department.

Outservice training of staff members consisted of attendance at the following: (1) Institute of Internal Auditor's Seminar on New Concepts, Trends, and Plans in Contracting and Contract Auditing; (2) Department of Agriculture Graduate School courses on Federal Purchasing and Contracting Procedures; (3) Civil Service Commission's Institute on "Finance in Agency Management," and (4) IBM's Basic Programing Course for a 1401 ADP System.

PERSONNEL DIVISION

Office of the Chief.--On September 27, 1963, the Bureau signed an agreement with Local 98 of the Amalgamated Lithographers of America (ALA), giving them exclusive recognition to represent approximately 200 wage board employees in the Office of Cartography. This was the first agreement between the Department of Commerce and a Labor Union. On October 16, 1963, exclusive recognition was granted to the National Maritime (NMU) to represent all unlicensed, nonsupervisory personnel, with certain exclusions, aboard the PEIRCE and HYDROGRAPHER. Exclusive recognition was also awarded NMU to represent all unlicensed, nonsupervisory personnel, with certain exclusions, aboard the PIONEER in San Francisco, and the ships based in Seattle, Washington.

The four Bureau programs of great benefit in the recruitment and retention of quality personnel were: Earth Scientist, Quartermaster Surveyor, Yeoman, and Cartographic Draftsman. Four trainees are in the Earth Scientist Program at this time and doing excellent work. The urgently needed Quartermaster Surveyor and Yeoman Training Programs are designed to meet the expanding requirements of our fleet and reduce the high ratio of employee turnover in these categories. The two-year Cartographic Draftsman Program has resulted in reducing the rate of turnover in the field of cartographic drafting and accelerating the proficiency of participants in the program. Fifty-seven employees have completed the program since it began last fiscal year.

During this year, all key Bureau officials participated in a conference which resulted in the drafting of short and long range plans for achieving maximum results under the Equal Employment Opportunity Program. To this date, commendable progress has been made in adhering to these plans. The records reflect that during this fiscal year we hired 23 additional negroes making a total of 302 negro employees on June 30, 1964. During this same period, 71 negroes received promotions.

Classification and Wage Administration Branch.--Classification surveys were conducted in the following Bureau areas during the fiscal year. A total of 439 positions were surveyed.

1. Boston District Office
2. New Orleans District Office
3. Seismology Division

4. Geomagnetism Division
5. Office of Division Chief, Administrative and Technical Services Division
6. Property and Supply Branch, Administrative and Technical Services Division
7. Procurement Branch, Administrative and Technical Services Division
8. Aeronautical Chart Division
9. Photogrammetry Division
10. Engineering Division
11. East Coast Tide Party No. 262
12. Airport Survey Parties Nos. 704, 711, 725
13. Triangulation Parties Nos. 603, 607, 613
14. Coastal Survey Party No. 720
15. Geodetic Data & Distribution Section, Geodesy Division
16. Distribution Division

To help reduce paper work in the classification process "checklist" type position descriptions were introduced for clerk-typists, clerical stenographic, and secretarial type positions. The use of the checklists has saved time for both the classification staff and supervisory officials of the Bureau.

A member of the Branch participated in the Annual Lithographic Wage Survey of private firms in the Washington Metropolitan area. New wage rates were approved and made effective on the following dates: lithographic positions, November 7, 1963; regular wage board positions, December 8, 1963; and vessel employees, June 21, 1964.

A comprehensive study of Wage Marine positions and compensation system was started during the fiscal year.

A study of the various pay systems in the Bureau was conducted by the Branch and a series of charts were developed showing the composition of the Bureau's work force with relation to the pay system.

During the year, the tentative proposed Civil Service Commission Classification Standards listed below were reviewed:

1. Grade Evaluation Guide for Supervisors of Work Classifiable in the Two-Grade Interval Pattern
2. Civil Engineering Series
3. Hydrology Series
4. Photography Series
5. Cartographic Technician Series
6. Supply Series
7. Employee Relations Series
8. Guide for Appraisal of Scientific Positions in Grades 16, 17 and 18
9. Office Drafting Series
10. Management Technician and Officer Series
11. Guide for Evaluation of Positions in Basic and Applied Research
12. Payroll Series
13. Personnel Staffing Series
14. Oceanography Series
15. Mail and File Series

The Branch developed a comprehensive field audit schedule which represents an attempt to meet the Bureau requirements for a classification audit of all field positions in a three-year period. The schedule recognizes such factors as Branch staff, time available, geographic location of field personnel, work seasons, classification and wage setting priorities, and other matters.

Considerable time and work was devoted to setting up and aligning positions at the newly designated regional offices.

Training Branch.--During this year, activity in the field of Executive Development was expanded. Thirty executives or potential executives attended courses in Executive Development. This represents an increase in this training area of 50 percent over the previous fiscal year.

Technical and scientific training was increased to meet the most pressing and immediate needs of the Bureau. The number of employees attending full-time training in the fields of Oceanography, Geodesy, Photogrammetry, and Geophysics at graduate schools of universities increased from 7 last year to 13 this year. They were enrolled for one or one and a half years of study under training agreements approved by the U. S. Civil Service Commission.

The number of student trainees under the Bureau's Cooperative Student Trainee Program was increased. Thirty-four coop student trainees received training under this long-range program designed to obtain the best potential engineering and scientific talents available for careers in the Bureau.

The 2½-year Cartographer Program was continued.

The Bureau's Officer Training Program was continued with training conducted for 67 officers in the Washington Office and at Norfolk.

The orientation program for new employees was conducted for 126 employees.

Seventy-six employees enrolled in training courses offered at the Patent Office Training Laboratory. The Coast and Geodetic Survey with several other bureaus of the Department of Commerce sponsor this training on an annual basis. Courses offered at nominal fees were in professional report writing, effective English usage, letter writing, reading improvement, and short-hand review.

Development of a 2-year Electronic Technician Program was begun to provide training for selected vessel employees to meet the Bureau's needs for an adequate number of qualified electronic technicians for bureau ships.

The Bureau has a total of 13 in-bureau training programs. More than 500 employees participated in various programs and courses offered through inter-agency and nongovernmental facilities. These courses and programs varied in duration from one hour to one year; in grade classification of the participants from GS-2 to GS-15; in type of subject matter from clerical and technical to professional; and, in cost from free courses to programs costing more than \$3,000 for one year of full-time study at a university. The purpose of the Bureau's training activities is to develop manpower resources for maximum utilization.

Employment and Employee Relations Branch.--Chapters 17, "Within-Grade Step Increases - General," and 18, "Quality Step Increases," were established in the Bureau Personnel Manual and new procedures were adopted. Four sessions were held to orient 125 supervisors in the implementation of the new standards.

During the 1963-64 academic year, our recruiter visited 10 colleges and universities outside the Washington, D. C., area and 4 local universities to recruit for our professional hard-to-fill positions. The total number of schools visited was reduced from previous years to eliminate those schools where the response did not justify continued recruitment. Two recruiters spent two weeks in West Virginia recruiting typists and stenographers. These combined recruiting efforts resulted in approximately 130 applications from well-qualified applicants.

The summer employment program procedures were changed considerably. This year we were not permitted to hire students for clerical positions, or sons, daughters, or relatives of any Department of Commerce employees. Coast Survey standards for student assistants in engineering, cartography, geophysics, business administration, oceanography, and mathematics were written and used to rate some 400 applications. Of these, 176 were rated eligible and 44 ineligible. The others were for positions not included in our summer program, and they were returned to the senders. Originally, we were authorized to hire 30 summer employees, however, this figure was later reduced to 24. In addition, four youths were hired under the Washington Area for Youth Program (WAY).

The newly established Seattle Regional Office assumed responsibility for personnel records of its Wage Board and Seattle-based vessel employees. Approximately 245 personnel folders were shipped to that office.

With the move of Bureau Headquarters to the Washington Science Center, a massive reassignment and recruitment program was conducted to fill resulting vacancies especially in the clerical fields, grades GS-2 through GS-6. The activities of the New York Computing Office were consolidated with the Norfolk Office. The resulting personnel change involved retirements, reassignments, separations, and movement of personnel from the old to the new locations.

Meritorious Services Awards were presented to Captain Joseph E. Waugh, and Messrs. Harland R. Cravat, Dwight L. Greene, and Wendell V. Mickey.

During the fiscal year, 47 cash awards were granted for sustained superior performance and special acts or services, 268 awards for suggestions, and 217 awards for length of service. The suggestion backlog which resulted from the Commerce Suggestion Campaign of April-May 1963 was reduced from 1,098 to 316.

The Board of Examiners continued to conduct examinations and maintain registers for the positions of geodesist, geophysicist, surveying aid and technician, as well as printing plant and lithographic trainee which was reannounced in May 1964 after a significant revision of the standards. It is hoped that the inclusion of an experience requirement will produce a list of better qualified eligibles. The Board processed 434 applications and issued 228 certificates of eligibles to various agencies on a nationwide basis.

Engineering Division

The Instrument Division was reorganized and named the Engineering Division during the year. Although the major effort of the Division was in systems research and development, maintenance capability continued pending actual transfer of all such responsibility to field units. Except for the maintenance of current meters and tide gages for the west coast, responsibility for which was transferred to Seattle, the following instruments continued to be repaired and serviced by the Division: chronometers, clocks, and other timing devices; theodolites, precise levels, and similar optical instruments; current meters and tide gages; fathometers and associated telemetering systems; electronic distance-measuring instruments; portable radio transmitters and receivers; and electronic navigation systems.

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 was accomplished by the Division.

Preliminary development of the automatic hydro-graphic plotter and its associated data processing equipment was advanced sufficiently to permit transfer of this equipment to the Seattle Ship Base.

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 Department of State and to various Members of Congress.

As mutually beneficial service, all advance quadrangles of the Geological Survey covering coastal areas were reviewed in the Administrative and Technical Services Division for agreement of geographic nomenclature. Of 910 sheets reviewed, some 110 were returned with corrections, effecting consistency in name usage. A similar service was performed for the Shipping Branch of the Census Bureau, and the proof reading of Coast Guard Light Lists for correctness and agreement of geographic names. The Division continued to be represented on the interagency Board on Geographic Names. Through the efforts of this Board, 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 the Department of Justice through an important extension of the responsibilities of the Geographic Branch of the Administrative and Technical Services Division. This Branch assumed the functions and duties of the former Technical Information Staff of the Office of the Director, responsible for analysis and research on coastal geography and interpretation of Bureau works and products for litigation and important industrial purposes. To this end such consultation was extended to the Department of Justice with relation to interpretation of geographic features and the delimitation of jurisdictional areas and seaward boundaries in Yakutat Bay, Alaska; along portions of the coasts of Florida, Oregon, and California; and adjacent to the mouth of the Columbia River. Special cooperation with the Department of Commerce was extended in many ways. In addition to those items already mentioned, various officials of the Department were served through interpretation of coastal geographic phenomena relative 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 100 letters concerning this exchange were prepared, and numerous special services were performed along this line.

APPENDIX

PUBLICATIONS ISSUED

Tides, Tidal Currents, and Oceanography

The following Tide and Tidal Current Tables, prepared by the Prediction Section of the Tides and Currents Branch were published by the Government Printing Office:

Tide Tables, East Coast, North and South America, 1965.
Tide Tables, West Coast, North and South America, 1965.
Tide Tables, Europe and West Coast of Africa, 1965.
Tide Tables, Central and Western Pacific and Indian Ocean, 1964.
Tidal Current Tables, Atlantic Coast of North America, 1964.
Tidal Current Tables, Pacific Coast of North America and Asia, 1964.
Tidal Current Surveys by Photogrammetric Methods by Morton Keller, Technical Bulletin No. 22, October 1963.

Coast Pilots

U. S. Coast Pilot 7, Pacific Coast - California, Oregon, Washington, and Hawaii, Ninth Ed., 1963.

Seismology

Seismological Bulletin, April 1962 through December 1962
Seismological Bulletin, Antarctic, 3rd quarter 1962 through 1st quarter 1964.
United States Earthquakes, 1962, by J. F. Lander and W. K. Cloud.
Abstracts of Earthquake Reports for the Pacific Coast and the Western Mountain Region, 3rd and 4th quarters, 1964.
Quarterly Engineering Seismological Bulletin, 1st, 2nd and 3rd quarters, 1963.
The Annotated Bibliography on Tsunamis.
The Fifth Edition of the Communication Plan for the Seismic Sea Wave Warning System.
Reproduction, Electronic Computing and the Office of Oceanography, published a preliminary report entitled Prince William Sound, Alaska Earthquakes, March-April 1964, April 17, 1964. Copies of the report were distributed to the Office of Emergency Planning, Members of the Senate and House of Representatives, numerous government agencies, colleges and universities, structural engineers, insurance companies, and private individuals.
Seismic Waves from an Underground Nuclear Explosion Under a Desert Valley, Special Report, July 1963. By J. N. Jordon, D. W. Gordon, and D. S. Carder.

- Project 8.1, Operations NOUGAT, STORAX I and STORAX II, Intermediate Range Seismic Measurements for Events BLACK through SANTEE, August 1963. By W. V. Mickey.
- Operation Pre-DRIBBLE, Seismic Effects of 1000-lb Detonations in Salt and Sedimentary Deposits, August 1963. By W. V. Mickey.
- A Comparative Study of Seismic Monitoring of NTS Events and Earthquakes by College and Mould Bay Stations, August 1963. By J. N. Jordon and L. M. Murphy.
- Seismic Noise Survey, Patrick Air Force Base, Florida, November 1963. By W. V. Mickey and T. R. Shugart.
- Equivalent Earthquake Magnitude for Selected Nuclear Detonations at the Nevada Test Site, November 1963. By W. V. Mickey.
- Expected Amplitudes from an Explosion in the Aleutian Islands, Special Report, 1963. By J. N. Jordan and D. W. Gordon.
- Seismic Waves from the Underwater Explosion of May 11, 1962, 1963. By J. N. Jordon and D. W. Gordon.
- Seismic Effects from SHOAL Nuclear Detonation in Granite, Project 1.4, Preliminary Report, December 1963. By M. V. Mickey and T. R. Shugart.
- A Brief Study of Seismic Signal Reception by San Juan, Puerto Rico Station, January 1964. By J. N. Jordon and D. W. Gordon.
- Seismic Data Summary, Nuclear Detonation Program, 1961 through 1963, January 1964. By W. V. Mickey and T. R. Shugart.
- Micro-Earthquake Monitoring at the SHOAL Site, April 1964. By W. V. Mickey.
- Seismological Data from Nueva Concepcion, El Salvador Station, July 1963-February 1964. By L. M. Murphy and J. N. Jordon.

Magnetism

- Magnetograms and Hourly Values: Guam, Mariana Islands, 1959; Guam, Mariana Islands, 1960; College, Alaska, 1960; Sitka, Alaska, 1960; South Pole, 1960; Byrd Station, Antarctica, 1960; Honolulu, Hawaii, 1960; San Juan, Puerto Rico, 1960; San Juan, Puerto Rico, 1961; Tucson, Arizona, 1961; Fredericksburg, Virginia, 1961; Fredericksburg, Virginia, 1962.
- Magnetism of the Earth, by James H. Nelson, Louis Hurwitz, and David G. Knapp, Publication 40-1. Reprint of 1962 edition.
- Magnetic Results, Antarctic Peninsula Traverse, 1961-1962, by P. J. Wasilewski.

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