GEOLOGICAL SURVEY CIRCULAR 101

February 1951

SURVEYING AND MAPPING IN ALASKA

by
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UNITED STATES DEPARTMENT OF THE INTERIOR
OSCAR L. CHAPMAN, SECRETARY
GEOLOGICAL SURVEY
W. E. Wrather, Director

WASHINGTON, D. C.

Free on application to the Geological Survey, Washington 25, D. C.

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INTRODUCTION

As the story of surveying and mapping in Alaska has never been written before, the following account is based on fragmentary published and unpublished material, principally from the files of the various Federal departments. Alfred H. Brooks, Chief Alaskan Geologist of the U. S. Geological Survey, in Professional Paper No. 45, published in 1906, summarized the early exploration of Alaska and described the first systematic topographic mapping undertaken by the Survey between 1895 and 1902. Other publications on the subject are for the most part confined to reports of the Federal Government or to popular magazine articles.

Hydrographic, geodetic, and topographic surveying in Alaska has been carried on chiefly by three or four Federal agencies since the turn of the century. The writer has abstracted and compiled information from various official reports for the preparation of this sketch for the period from 1900 to the present time. It would be impossible in a single article to describe completely even the major surveying and mapping expeditions conducted by the Federal Government. An attempt has been made, therefore, to select only those considered of outstanding importance or those which have made some real and lasting contribution to the geographic knowledge of the Territory.

Partly because of its remoteness and partly because of the unusually difficult conditions encountered in conducting surveying operations in Alaska, the Territory has been the proving ground for many important developments in the art of surveying and mapping. Terrestrial photogrammetry was used successfully as early as 1893 by the Canadian Government and the U. S. Coast and Geodetic Survey on the International Boundary Surveys in southeastern Alaska. A panoramic camera was developed by members of the Geological Survey in 1905 and used successfully for many years on topographic mapping of Alaska. The first American trilens aerial mapping camera and transforming printer were developed before World War I by J. W. Bagley and F. H. Moffit, members of the Geological Survey engaged in Alaskan work. The Navy Department, at the request of the Geological Survey, completed aerial photographic coverage of more than 20,000 square miles in southeastern Alaska during the period between the first and second world wars.

During World War II "trimetrogon" mapping was developed, largely by Geological Survey personnel engaged in Alaskan mapping and by members of the Army Air Forces, to meet the urgent need for aeronautical charts of this vast area. Naval photographic squadrons returned to Alaska after the war and rephotographed the area of southeastern Alaska with new precision-mapping cameras. Still more recently the Department of the Air Force accomplished a successful photographic coverage of the principal transportation routes leading into the interior of Alaska. This photography was controlled by "shoran", an electronic method used to determine geographic positions within the area photographed. The airplane, helicopter, truck, and tractor have, to a considerable extent, replaced the canoe, dog team, and pack train, and solved the transportation problems connected with surveying in Alaska. Because of the Territory's recognized strategic position in the modern

[1]This paper was originally prepared for the Encyclopedia Arctica.

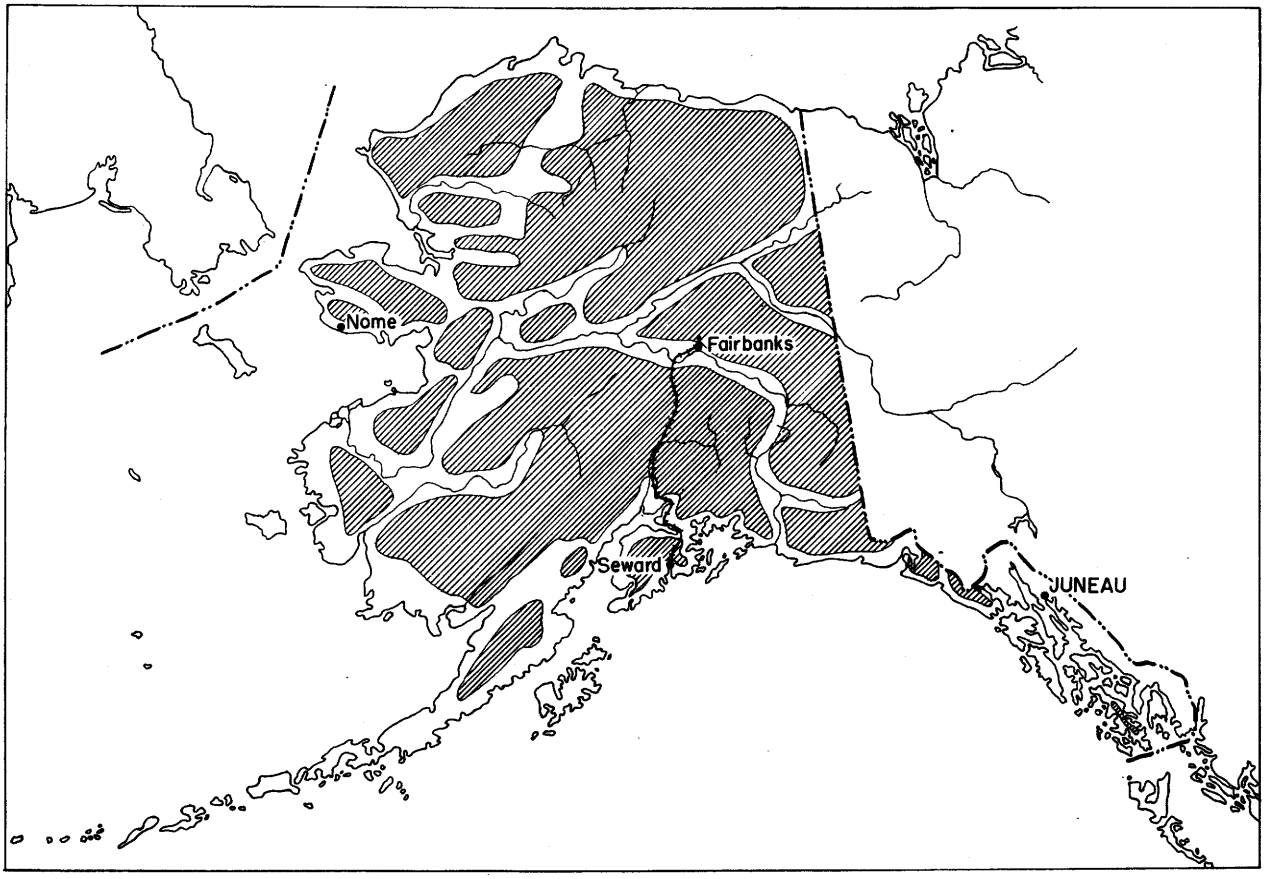

Figure 1.--Unexplored areas in 1895.

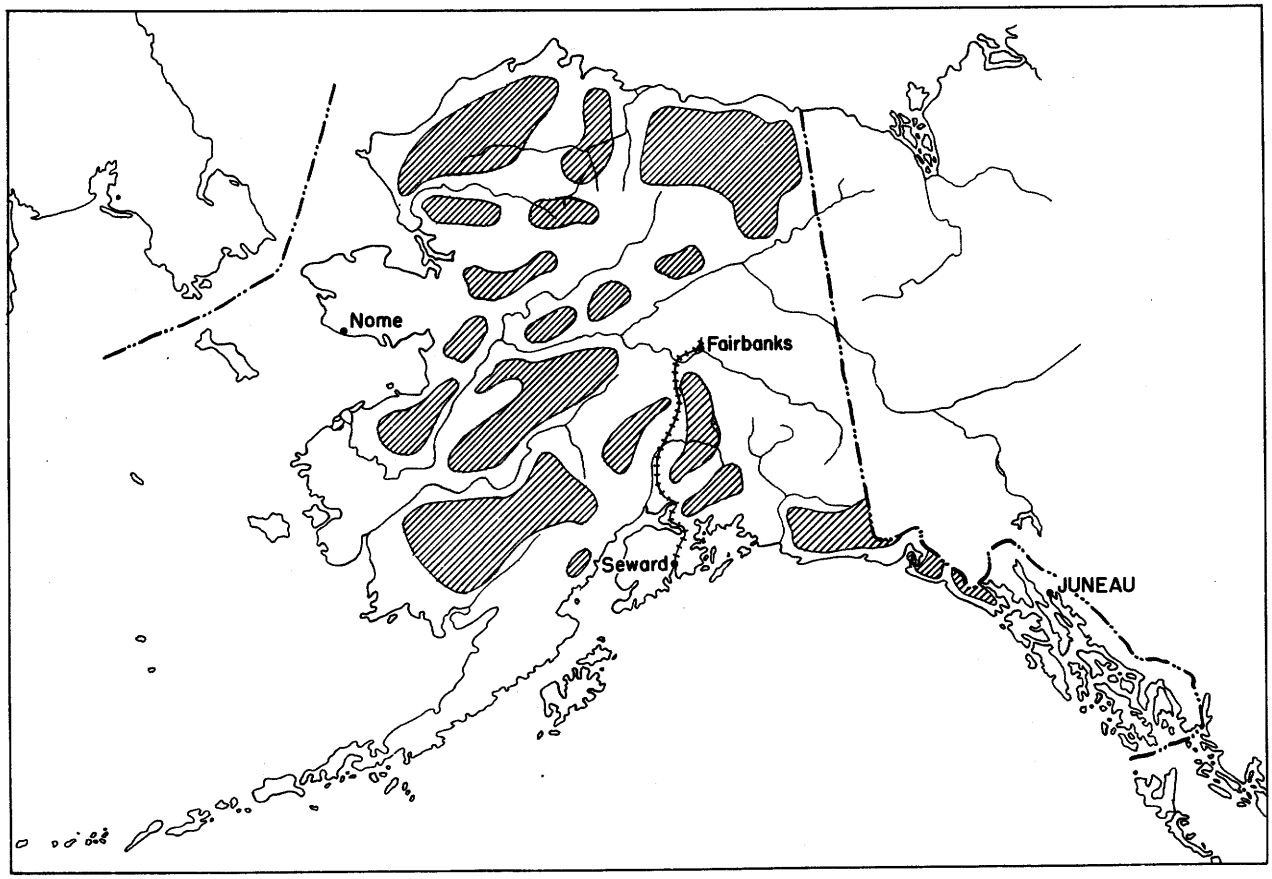

Figure 2.--Unexplored areas in 1905.

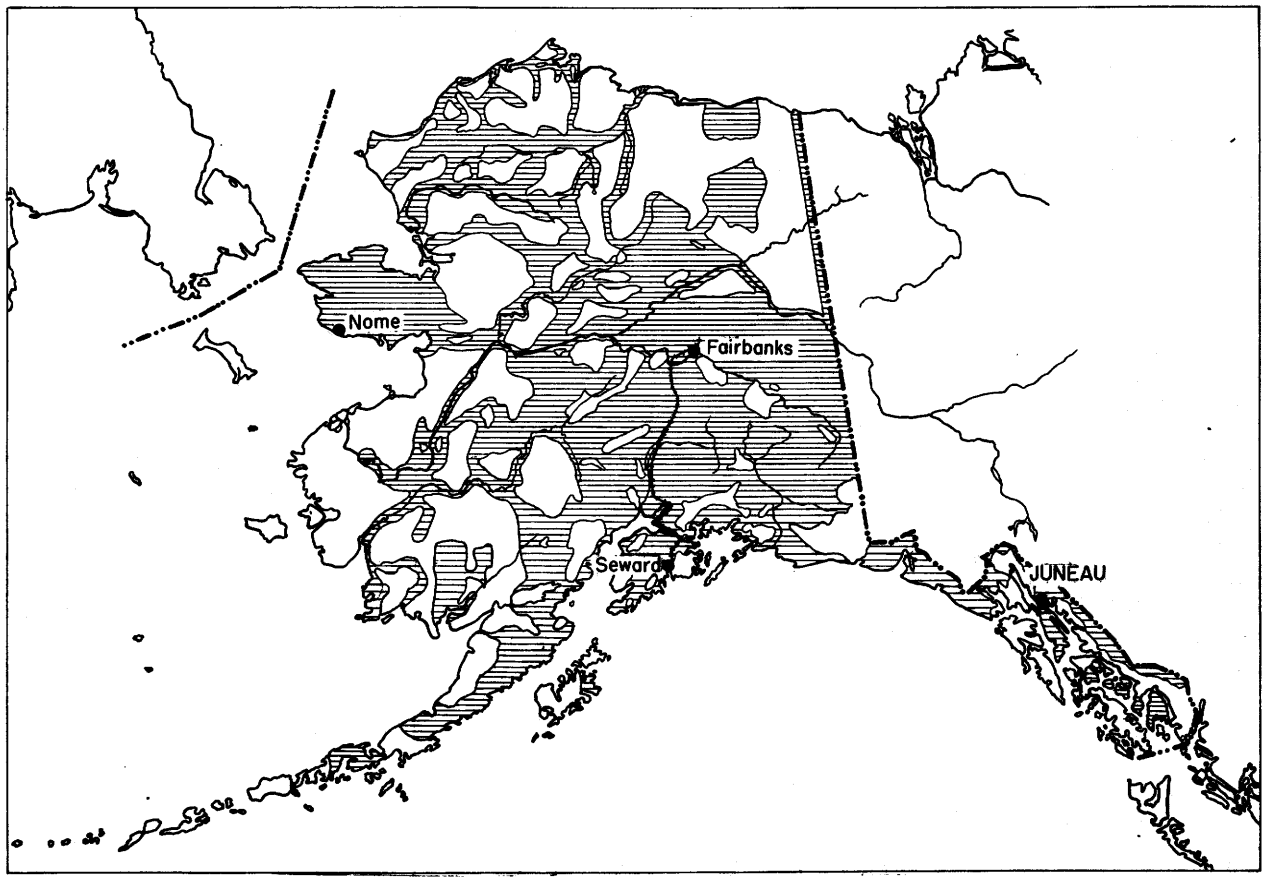

Figure 3.--Exploratory and reconnaissance mapping completed by 1940.

defense plans of the Nation, surveying and mapping activities have greatly increased since World War II.

In order to achieve simplicity of arrangement and to avoid overlapping of narrative, this sketch has been arbitrarily divided into four periods between 1728 and 1950. Each of these divisions represents a significant phase in the history of the exploration, surveying, and mapping of Alaska. (See figs. 1, 2, and 3.)

The Russian occupation was mainly a period of maritime exploration of Alaskan coastal areas by expeditions sent out by the principal nations of the world. Stimulated by the fabulously rich fur trade developed and controlled by the Russians for more than 100 years, expeditions from England, France, Spain, Italy, and Portugal explored and charted in some manner most of Alaska's 26,000-mile coast line before the purchase of Alaska by the United States in 1867.

The second period covers the American occupation from the date of transfer in 1867 to 1895, and was marked by considerable activity in coastal charting and further exploration. The U. S. Army sent several parties into the new territory to explore the great river basins and to determine at least an approximate position for the international boundary between Canada and Alaska. The Navy Department and the Coast Guard conducted several important exploratory expeditions along the coast of Alaska and into the Arctic. The Coast and Geodetic Survey began coastal surveying and charting operations immediately after the purchase of Alaska and undertook triangulation and the establishment of astronomical positions for the International Boundary Commission.

The third period marks the beginning of organized and systematic mapping and charting in the vast unfamiliar interior of the new Territory, and for the purpose of this report, includes the 45 years between 1895 and 1940. The increased activity in surveying and mapping during this period was due principally to the "gold rush" of 1898, which focused national attention on the almost-neglected Territory, and resulted in increased Congressional appropriations for Alaskan work.

With this renewed interest and with additional funds, the Coast and Geodetic Survey expanded its triangulation arcs and its charting operations of hydrographic conditions along the coast. The Geological Survey was able to send geologic and topographic field parties into many of the remote areas of Alaska. The survey of the International Boundary Commission was completed from Dixon Entrance to Demarcation Point. The General Land Office began field work in Alaska in 1899 to establish a rectangular network of surveys necessary for the administration and disposal of public lands. Many private organizations and Federal agencies contributed materially to the geographic knowledge of the Territory. In this category should be included the work of the National Geographic Society, the Harriman Expedition, the Alaska Road Commission, the Army Air Corps, the Coast Guard, the Biological Survey, the Bureau of Fisheries, and many others.

The fourth period, while embracing only ten years, from 1940 to 1950, has been the most important in the history of surveying and mapping in Alaska. Defense plans for Alaska and the Pacific coast required modern maps and charts. In order to provide a more accurate framework for detailed surveying and mapping, the Coast and Geodetic Survey greatly increased its geodetic survey operations, as well as its coastal charting program. During World War II the Aeronautical Chart Service of the Air Force prepared small scale aeronautical charts of the entire Territory. The Corps of Engineers mapped, by modern methods, a number of quadrangles in the vicinity of Anchorage, and part of Unalaska Island.

Postwar work involved the preparation of military maps of strategic areas in western Alaska. During this ten-year period the Geological Survey compiled trimetrogon photographs into maps and charts for the Aeronautical Chart Service, covering 80 percent of the area of the Territory, and expanded its own standard quadrangle-mapping program to include extensive areas in southeastern, central, and northern Alaska. To further the latter program the Department of the Navy cooperated by photographing all of southeastern Alaska, extensive areas in northern Alaska, Seward Peninsula, and Kodiak Island. Photographic units of the Air Force, in addition to providing trimetrogon coverage of nearly all of Alaska, completed shoran-controlled photography for nearly 30,000 square miles in central Alaska. The Bureau of Land Management and the Forest Service each made some contribution to the surveying and mapping of Alaska's 589,870 square miles.

The following account of these four periods, outlined briefly in the preceding pages, presents a fairly comprehensive picture of the major surveying and mapping activities in Alaska for the past 200 years.

RUSSIAN OCCUPATION (1728-1867)

Although little information was available with which to compile a map of Alaska at the time the United States purchased the Territory from Russia in 1867, a brief review of early explorations is necessary to evaluate properly the slow progress made in surveying and mapping following the American acquisition.

Beginning with the voyages of Vitus Bering in 1728 and 1729, Russian exploration of Alaska was principally from the west, across Siberia and the Bering Sea. Navigators and explorers of several nations approached Alaska from the south, across the Gulf of Alaska or through the meandering fiords of southeastern Alaska. These early navigators included the English, who also entered Alaska from the east through the Mackenzie River Valley.

Vitus Bering, a captain in the Russian Navy, was sent by Peter the Great to determine the extent of land east of Siberia. His voyages were made in the period between 1728 and 1741, and, while not greatly productive, they established beyond any doubt that a great land mass existed east of Siberia, connected or nearly connected with Russia by a long chain of islands. The reports of Bering's voyages stimulated the development of the fur trade on the Aleutian Islands. As the supply there became depleted, the fur trade spread gradually to the mainland of Alaska. One of the principal headquarters for this trade was established at Kodiak in 1783

under Alexander Baranof, general manager of the Russian-American Company. A grant from the Russian Government placed Alaska in the hands of this company for a period of 60 years.

While the Russians were developing the valuable fur trade of the Aleutian Islands, the Alaska Peninsula, and western Alaska, the Spanish sent several expeditions to explore southeastern Alaska. During this same period, Captain James Cook and Captain George Vancouver also sailed north to explore southern Alaska. Commander Jean Francois LaPerouse was sent by the French to explore southeastern Alaska in 1786, but he covered much of the area seen by earlier Spanish and English explorers. England, in search of the Northwest Passage, sent several well-equipped expeditions farther north. Captain Cook made his famous voyage into the Arctic Ocean in 1778 and Captain F. W. Beechey charted the north coast of Alaska to Point Barrow in 1826. Vancouver, who had sailed with Cook in 1778, returned to Alaska in 1791 and spent much time preparing a chart of the complicated shorelines and fiords of southeastern Alaska.

In the meantime, the Russians under Baranof had expanded in western, southern, and southeastern Alaska where, in addition to the earlier posts in the Aleutian Islands, the Russians established settlements on Cook Inlet, Sitka Sound, and Prince William Sound. The whole of known Alaska was now in the hands of the Russians. This was formally recognized by England in a treaty signed with Russia in 1825. After this time, exploratory expeditions of other nations to Alaska were limited.

Baranof, who was not interested in exploration, was removed and Russian naval officers placed in charge of the Russian-American colony. Scientific work under the Navy was given more support and considerable progress was made in coastal exploration. Captain Michael Tebenkof of the Russian Navy prepared an atlas of the northwestern coast of America in which he compiled the results of all previous explorations. This atlas is considered the most important contribution to the geography of Alaska made during the Russian occupation.

Before 1826 the Russians had confined most of their activities to the coastal areas of Alaska, but as interest grew in the possibility of extending the fur trade into the interior, expeditions were authorized to continue surveys along the northern coast and as far inland as possible. The Bristol Bay and Kuskokwim River regions were visited in 1818 and 1832, and the Susitna River Basin explored by a Russian group in 1834. The Yukon River was reached from the portage of St. Michael on Norton Bay by another small party, which then portaged to the Kuskokwim River.

One of the most important of the Russian inland explorations was made by Lieutenant Zagoskin of the Imperial Navy in 1842-1843. This party ascended the Yukon River as far as the mouth of the Tanana River, and also explored the lower stretches of the Koyukuk River. On his return Zagoskin traversed the Innoko River, a tributary of the lower Yukon, and then portaged east to the Kuskokwim River.

While the Russian treaty of 1825 with England considerably curtailed foreign exploration, particularly of southeastern and southern Alaska, English navigators continued their explorations of the northwest coast. Alexander Mackenzie had explored the great river that now bears his name to the Arctic coast from the mouth of the Mackenzie westward. Captain Beechey, cooperating with Franklin, charted the southern coast of Seward Peninsula to Cape Prince of Wales and added much information to the earlier surveys of Kotzebue Sound. In 1834 the Hudson's Bay Company made several attempts to establish itself in southeastern Alaska, finally securing a 10-year lease from the Russians in 1837. In the meantime, this company had established posts on the upper Yukon River and was rapidly controlling the fur trade of that area.

In the period between 1843 and 1853, the British Government sent out several expeditions to bring relief to the ill-fated expedition of Sir John Franklin on the Arctic coast. These expeditions resulted in maps and charts of the Arctic that have been superseded only by aerial photography taken during World War II.

The Western Union Telegraph Company in 1863 undertook preliminary explorations to establish a telegraph route from the west coast of the United States through British Columbia and Alaska to the Bering Strait, where a cable connection with a trans-Siberian line was planned to establish communications between America and Europe. The exploration work in connection with the establishment of this telegraph line contributed much to the knowledge of the interior of Alaska. William H. Dall, one of the leaders of the scientific corps of the expedition, continued his work after the telegraph-survey party was disbanded, and published the results of his investigations in several of the best-known earlier reports on Alaska.

AMERICAN OCCUPATION (1867-95)

After several years of negotiations, Alaska was purchased from Russia in 1867 for $7,200,000. However, for the next 30 years exploration and surveying work were carried on in a small way with little coordination.

During the Russian occupation much of the 26,000-mile coast line of Alaska had been explored and charted by expeditions of several nations. The most important work, however, was done by the English expeditions under Captain James Cook and the relief expeditions sent to the aid of the Franklin party on the Arctic coast.

The Coast and Geodetic Survey, soon after the transfer of Alaska, began the first systematic survey work in the new Territory, and, between 1867 and 1882, compiled and published numerous charts of Alaskan waters. As these charts were based principally on the earlier surveys by English, Russian, French, and Portugese explorers and by the U. S. Navy, much of the early field work was done to control and piece together the fragmentary material already available. The Revenue Service, the Fishing Commission, and the Navy assisted in this work and each contributed in part to the charts and Coast Pilots published by the Coast and Geodetic Survey.

In the summer of 1867, George Davidson and others made an extensive cruise of Alaskan waters in the Revenue Cutter Lincoln, and as a result prepared cruise charts of Sitka Harbor, Saint Paul Harbor, Kodiak Island, and Captain's Bay on Unalaska Island. The first two Coast Pilots of Alaska were published between 1869 and 1883, based on the work of George Davidson, William H. Dall, and Marcus Baker. A third was prepared by Lieutenant Commander H. E. Nichols, U.S.N. in 1891.

The first continuous survey work by the Coast Survey was started in 1882 when the Steamer Hassler was sent north under the command of Lieutenant Commander H. E. Nichols, U.S.N. and later under Lieutenant Commander A. S. Snow in 1884. The Steamer Patterson was assigned to Alaskan waters in 1885 under the command of Lieutenant Commander Richard Clover, U.S.N., and for the next 15 years field work consisted mainly of charting only those channels and harbors used by the Navy and for the very limited commercial shipping.

One of the first inland explorations after the acquisition of Alaska was undertaken by a small party under Captain V. W. Raymond, sent by the Army to Fort Yukon in 1869 to determine the position of the international boundary between Canada and Alaska. As a result of Captain Raymond's astronomical observations at Fort Yukon, the Hudson's Bay Company was forced to move its important Fort Yukon post to a point more than 50 miles up the Porcupine River, where it remained for 15 years. In 1889 the post was relocated farther up the Porcupine, at Rampart House, which was located on the 141st meridian, or the Alaska-Canada boundary.

About 1880 prospectors began to enter Alaska and the Yukon Territories. This activity renewed interest in the geography of southeastern Alaska and the territory between the coast and the headwaters of the Yukon River. Glacier Bay, one of the outstanding scenic areas in Alaska, was explored by John Muir and the Reverend S. Hall Young in 1879. Ivan Petrof, a census agent, in 1880 stated in his report that Alaska needed "a gradual but systematic exploration of the interior, and an immediate survey of the coast and harbors of the region now constantly frequented by trading and fishing vessels, in order to prevent the alarmingly

frequent occurrences of wrecks upon unknown rocks and shoals." Petrof, a resident of Alaska, spent two years traveling along the southern coast of the Territory and on the lower Yukon and Kuskokwim Rivers. His map of Alaska, published with the Tenth Census report, was one of the best general maps of the Territory that had been compiled at that time.

In 1883 Lieutenant Frederick Schwatka, accompanied by Charles W. Homan, followed the prospectors' trail from the coast over Chilkoot Pass and descended the Lewes River through Lake Laberge down the main Yukon River through Canada and Alaska to its mouth at Norton Sound. Homan mapped the entire route by sketch traverses and latitude observations. This was the first actual survey of the Yukon River.

The U. S. Signal Service established a meteorological and magnetic station in 1881 at Point Barrow where observations were made for latitude and longitude. During this same year a German geographer, Dr. Arthur Krause visited southeastern Alaska and the headwaters of the Yukon River and prepared a map of the area.

During the period between 1883 and 1886 several exploratory expeditions of note were made in Alaska by officers of the Army and Navy. In 1883 Lieutenant George M. Stoney of the Navy Department explored parts of Kotzebue Sound at the mouth of the Kobuk River. As a result of this work the Department became more interested in northern exploration, and Lieutenant Stoney was returned to Alaska the next year to explore the Kobuk River. In 1886 he established headquarters on the upper Kobuk River and from this base explored the headwaters of the Noatak and Koyukuk Rivers. One of his officers, Ensign W. L. Howard, led a party of four men from the Noatak River northward through what now is known as Howard Pass, down the Etivuluk River to the Colville River, and to a point near the present site of Umiat. From this spot he portaged to the headwaters of the Chipp River, and arrived at Point Barrow in midsummer. He thus became the first white man to cross Arctic Alaska. The results of the Stoney expedition were sketch maps and some instrumental surveys of parts of the Kobuk Valley, Selawik Lake, the Colville, the upper Noatak River, and the Alatna, a tributary of the Koyukuk River.

In 1884 a U. S. Army expedition, under the command of Lieutenant W. R. Abercrombie, was ordered to make an exploration of the Copper River area. This expedition was not entirely successful, and was undertaken again the following year by Lieutenant Henry T. Allen, who landed near the mouth of the Copper River in March 1885, and ascended that stream for several hundred miles. A portage was made through Suslota Pass to the Tanana River where he obtained a boat and finally reached the mouth of the river near the end of June. Allen then portaged to the Koyukuk River and reached a point near the mouth of the Melozi River. He next explored the Koyukuk River from its headwaters to its confluence with the Yukon River. Continuing down the Yukon River, he crossed the Kaltag portage to St. Michael on Norton Sound. Lieutenant Allen's journey is generally conceded to be one of the most outstanding exploratory trips ever made in the Territory of Alaska. Under extremely trying conditions, subsisting almost entirely on the country, he nevertheless made a careful record of his entire journey, and from his observations and sketches was able to compile an exploratory sketch map of the entire area traversed.

During 1884 and 1885 Lieutenant John C. Cantwell and S. B. McLenigan of the U. S. Revenue Cutter Service explored the headwaters of the Kobuk and the lower Noatak and made sketch maps of both these important northern rivers.

Surveys to locate and mark the international boundary between Alaska and Canada were begun in 1888 by the Canadian Government, which started work in southeastern Alaska. In the years 1891 and 1895 the Coast and Geodetic Survey completed triangulation and astronomical work for the geodetic control, and Canadian surveyors introduced photo-topographic surveying for the preparation of boundary maps. During 1889 J. H. Turner and J. E. McGrath had ascended the Yukon River to Fort Yukon where the party separated. Turner continued up the Porcupine to the Alaska-Canada boundary, where he established an astronomical observatory

and then went north to the Arctic coast by dog team. McGrath, accompanied by Professor I. C. Russel of the Geological Survey, continued up the Yukon River to a point near Eagle, where he also established an astronomical position for the boundary.

The discovery of gold was largely responsible for the greatly increased interest in Alaska and subsequent inauguration of the international boundary survey, and expansion of the Coast and Geodetic Survey's coastal charting program. In 1898 this increased interest resulted in appropriations to the Geological Survey that permitted the undertaking of a systematic program of geologic and topographic surveys of the interior of Alaska. Appropriations to the Geological Survey continued at a more or less uniform rate for the next 40 years.

SYSTEMATIC MAPPING AND CHARTING IN ALASKA (1895-1940)

The turn of the century was the beginning of a period in Alaska in which organized coastal surveys were continued at an accelerated pace to provide for water-borne navigation, and topographic maps of the interior at reconnaissance scales were made to keep pace with the development that followed the discovery of gold. Because of the climate and remoteness of Alaska, surveying and mapping were often carried on under extremely difficult conditions. Transportation and supplies, of course, presented the major problems and, owing to the shortness of the field season, the great variation in topography, and other factors, the surveyor and mapper were called upon to devise and develop new and ingenious methods for accomplishing their work. Terrestrial photogrammetry was employed on Alaskan surveys as early as 1893. The necessity of mapping large areas rapidly on a reconnaissance scale stimulated interest which resulted in the designing of the first American-made multiple-lens camera by J. W. Bagley and his associates of the Geological Survey before World War I. It was only natural, therefore, that the Navy Department, under cooperative agreement with the Geological Survey, photographed 20,000 square miles in southeastern Alaska with the multiple-lens Bagley camera in 1926 and 1929.

New and advanced methods and equipment were developed and used by the Coast and Geodetic Survey to prepare both general and detailed navigation charts of the coastal waters and the principal harbors of Alaska. The hand lead was superseded by the wire drag and the sonic depth finder. The Radio Acoustic Ranging, or "R.A.R." permitted more accurate positioning of ships on deep-water offshore sounding, and permitted operations even with land points obscured. Alaska became an ideal proving ground for the development of reconnaissance mapping by photogrammetric methods and it was here, in 1940, that "trimetrogon mapping" was first used.

Work of the Geological Survey (1895-1940)

1895-1902

Annual appropriations by Congress for the work of the Geological Survey in Alaska, which included topographic mapping, fluctuated widely from $5,000 in 1895 to a peak of $100,000 during the years 1913 to 1917. The appropriation for 1940 was $60,000. This amount was for all of the Survey's operations in Alaska, and, consequently, less than half of it was available for topographic mapping.

The extent of areas mapped in Alaska by the Geological Survey to January 1940 is shown in the following table:

	Contour interval	Square miles
Exploratory mapping on scale of 1:500,000	200 feet	8,952
Reconnaissance mapping on scale of 1:250,000	200 feet	185,586
Planimetric mapping on reconnaissance scale	None	10,894
Detailed mapping, commonly on scale of 1:62,500	50 feet	4,552
Total		209,984

Members of the Geological Survey were sent to Alaska prior to 1895 in connection with scientific expeditions. Professor I. C. Russel was assigned to a Coast and Geodetic Survey party

in 1889 under J. E. McGrath who was ordered to the upper Yukon River to determine by astronomical observations the position of the boundary line between Alaska and Canada. In 1891, Dr. C. Willard Hayes of the Survey accompanied Lieutenant Frederick Schwatka to the headwaters of the Yukon River, via Taku River and Teslin Lake. This party portaged from Fort Selkirk on the Yukon to the White River which they ascended to Skolai Pass and, by portaging again to the Nizina River, they finally descended the Copper River. Dr. Hayes prepared an excellent exploratory map of the trip from his notes and observations.

Prospectors for gold who entered Alaska through southeastern Alaska and from the Yukon Territory during the early 90's demanded information about the interior, and Congress in 1895 appropriated $5,000 to the Geological Survey for the "Investigation of the mineral resources of Alaska." Three Survey geologists, G. F. Becker, William H. Dall, and J. E. Spurr, were sent north to study the coal and gold deposits. Spurr returned to the Klondike in 1898 when gold was discovered there. New discoveries in the Yukon Territory and the great influx of prospectors to Alaska caused Congress to increase appropriations to the Geological Survey for work in Alaska in 1898. From this date organized and systematic topographic mapping became an integral part of the Geological Survey's Alaskan mineral resources program.

An attempt was made during the first years of this survey work to explore the main river valleys of the interior of Alaska since these were then the principal routes of transportation. In planning the 1898 field season it was decided, therefore, to make exploratory surveys of the Kuskokwim, the Susitna, and the Copper Rivers. One of these expeditions, headed by J. E. Spurr, geologist, with W. S. Post, topographer, arrived at the upper end of Cook Inlet in the spring of 1898. The party ascended the Yentna River, a tributary of the Susitna River, portaged through the Alaska Range to the headwaters of the Kuskokwim River, and descended that great river to its mouth. They then turned eastward and, traveling inland parallel to the coast, finally reached Bristol Bay. Using native skin boats the party crossed the bay and reached Naknek on the Alaska Peninsula. Continuing overland they at last reached Shelikof Strait and Kodiak Island. This was a remarkable trip considering the great distance traveled, the difficult portages, and the fact that almost the entire route was unexplored. Post prepared the map of the entire route which accompanied Spurr's report.

During this same year the Susitna River was mapped by George H. Eldredge and Robert Muldrow, who, with a small party traveling by boat and backpack, reached the Cantwell or Nenana River, a tributary of the Tanana River. They returned to the coast via the Susitna River. Exploratory topographic maps were made of the route of this expedition, which included the first determination of the position and height of the continent's highest mountain, Mt. McKinley, 20,300 feet above sea level.

A third party in 1898 explored and mapped the Tanana and White Rivers, headwater tributaries of the Yukon. This party was under the charge of Alfred H. Brooks and W. J. Peters. It made exploratory surveys of about 10,000 square miles. In addition, E. C. Barnard made a survey of about 2,000 square miles of the Forty-Mile River basin, a tributary of the Tanana.

The War Department sent two expeditions into Alaska during 1898. The first, under Captain Edwin F. Glenn, which left the coast at Cook Inlet, traversed the Matanuska Valley, crossed the Copper River Plateau, and drifted down the Delta River to the Tanana River. W. C. Mendenhall, of the Geological Survey, accompanied Captain Glenn and prepared an exploratory traverse map of the journey.

The second expedition, under Captain W. R. Abercrombie, landed at Valdez and with the aid of pack horses traveled inland to the Copper River valley by the Valdez Glacier route. F. C. Schrader of the Geological Survey was attached to this expedition and conducted both geologic and exploratory surveys of the lower Copper River basin. The result of the work of 1898 was exploratory surveys of about 3,000 square miles based on instrumental traverses and, in addition, more accurate reconnaissance maps of approximately 2,000 square miles.

The experiences of the 1898 parties set a pattern that was to be followed for a great many years in the conducting of exploratory and reconnaissance surveys in Alaska by the Geological Survey. In the interest of economy most expeditions of the Survey consisted of a combined topographic and geologic party, with the man senior in length of experience generally in command. Additional members of the party were recorders, boatmen, cooks, horse packers, and dog-mushers.

For river work, Peterborough-type canoes were often used for transportation. These light cedar-strip canoes could carry a load of one-half ton and were, without much difficulty, portaged many miles by the parties. Pack horses used for cross-country work were usually purchased in the western United States and shipped north with the field parties in the spring. "Wintering" a pack train in Alaska was often attempted in the interest of economy, but was not always successful. Dog teams were purchased in Alaska. On many of the expeditions dogs were used to haul sleds in winter and for packing during the summer months.

Camp equipment consisted of small, light mosquito-proof tents, sleeping bags, cooking utensils, axes, guns, and ammunition. The equipment and feed for a party of 6 men, for a period of 4 months, would generally weigh between 1,800 and 2,000 pounds. Great care was used in outfitting a survey party for work in Alaska, either for winter or summer work. In addition to food, tents, beds, and cooking gear, medical supplies and carefully selected personal clothing were of importance, since most of the parties were "on their own" during the field season. During recent years, however, the airplane, helicopter, and radio have greatly changed all this.

Topographic work was carried on by standard Geological Survey plane-table methods accepted for reconnaissance mapping. The equipment consisted of a plane table, telescopic alidade, and a light mountain-transit theodolite. A micrometer eyepiece attachment for the alidade was often used in determining traverse distances. Graphic plane-table triangulation, checked by latitude and azimuth observations, was generally used in conducting reconnaissance plane-table surveys, which in most cases originated from bases measured at the starting point of field work. (See fig. 4.) Elevations at the initial point were sometimes determined by aneroid barometers and carried throughout the survey by vertical angles. Special insulation was used on instruments where work in sub-zero weather was required, and most of the plane-table work was done on sheets of celluloid or painted zinc to prevent damage by rain or snow.

Each of the early topographic parties was issued the following instructions: "An attempt will be made to carry a continuous instrumental survey line over the whole route traversed, starting from a position in latitude and longitude at sea level as nearly as may be determined and closing in the same way. The routes traversed will be critically inspected with a view to ascertaining the most practicable location for trails, wagon roads, or railroads; the character and extent of the timber will be noted and the rivers or streams will be examined as to the possibilities of navigation and the height of falls or rapids; and the rise and fall of tides will be reported." In general, the field scale for exploratory and reconnaissance surveys was 1:180,000 or about 3 miles to the inch, with a 200-foot contour interval.

In 1899 two major survey expeditions were outfitted for Alaska. Peters and Brooks continued their previous year's work by extending a survey westward from Lynn Canal along the northern base of the St. Elias Range to the headwaters of the White and Tanana Rivers and thence northward to the Yukon at the Forty-Mile River. This was a pack-train expedition. During the same year F. C. Schrader, geologist, and T. G. Gerdine, topographer, started work at Fort Yukon. They ascended the very swift Chandalar River, and from its headwaters, portaged about 15 miles to the headwaters of the Koyukuk River, which they followed and mapped to its mouth. Eight thousand five hundred square miles were mapped during 1899.

In 1900, eleven thousand square miles were mapped on a reconnaissance scale in the Copper River basin and on Seward Peninsula by Gerdine, Barnard, and Peters. In 1901 Schrader and

Figure 4.--The plane-table method was employed by the Geological Survey for many years for Alaskan mapping, both reconnaissance and large scale.

Peters left White Horse in the early spring and arrived at Alatna on the Koyukuk River with dog teams. After the break-up of the ice, they ascended John River, crossed the Anaktuvuk Pass, and descended Anaktuvuk River to the Colville River, which they traversed to its mouth. Here they obtained native skin boats for the coastal trip west to Point Barrow and then south to Cape Lisburne. Alfred H. Brooks considered this to be one of the most notable exploration trips by the Geological Survey to that date.

During this same year W. C. Mendenhall, geologist, and D. L. Rayburn, topographer, started work at the mouth of Dall River on the Yukon and, with the aid of canoes, ascended the Dall and portaged from its headwaters to a headwater tributary of the Koyukuk River. They descended the Koyukuk to the mouth of the Alatna River, which they ascended for nearly 100 miles, making another portage to the headwaters of the Kobuk River, which they followed to its mouth on Kotzebue Sound. Topographic mapping on this trip was started at Fort Yukon, where an elevation of 500 feet was assumed for the river. (This elevation is still used.) A continuous traverse was made down the Yukon River, up the Dall River, down a portion of the Koyukuk River, up the Alatna River, and down the Kobuk River to Kotzebue Sound. During the 1901 season T. G. Gerdine and D. C. Witherspoon made a topographic map of a large part of Seward Peninsula, which was then becoming of great importance because of the gold stampede to Nome, located on the southern side of the Peninsula.

The field work for the season of 1902 included an exploratory trip, led by Brooks and Rayburn, from Cook Inlet through the Alaska Range and along its northwest flank through what is now Mount McKinley National Park to the Nenana River, and from there across the Tanana River in a northwesterly direction to Rampart on the Yukon. During this same year Gerdine and Witherspoon continued topographic mapping in the Copper River basin area, while Peters began a detailed topographic survey of the mining district near Juneau.

1902-1910

During this period there was a departure from exploratory surveys and a majority of the field parties were requested to prepare reconnaissance maps for publication at a scale of 1:250,000, with a contour interval of 200 feet. At this time a start was also made toward preparing more or less detailed topographic maps of the major mining districts. Although there was some refinement in the execution of field surveys for mapping during this period, the instruments used were not materially changed. J. W. Bagley began experimental work on a panoramic camera that was to be used successfully for many years in Alaska.

From 1902 until 1907, T. G. Gerdine was in general charge of topographic surveys in Alaska, under Alfred H. Brooks, Chief Alaskan Geologist. Gerdine was succeeded by R. H. Sargent in 1907. In addition to Gerdine and Sargent the following topographers worked in Alaska between 1902 and 1910: J. W. Peters, D. L. Rayburn, D. C. Witherspoon, E. G. Hamilton, J. W. Bagley, C. E. Giffin, R. B. Oliver, G. C. Anderson, J. B. Leavitt, and W. R. Hill.

An exploratory survey covering more than 10,000 square miles was made along the western front of the Alaska Range from Cook Inlet to the Yukon. Reconnaissance mapping was carried on in the Yukon-Tanana regions, Seward Peninsula, Kenai Peninsula, Cape Lisburne, Copper River, and the Susitna River Basin. Another party mapped the north flank of the Alaska Range between the Delta River and the Nenana valley. Reconnaissance mapping was also undertaken in the Innoko-Iditarod region, the Koyukuk-Kobuk River valley and the Yakutat-Alsek region. More than 100,000 square miles were mapped for publication at a scale of 1:250,000 during this period. It is estimated that this work cost about $3 per square mile.

The detailed mapping of mining districts included the Juneau district, the Kasaan Peninsula in southeastern Alaska, the Kotsina-Chitina on the Copper River, Seward Peninsula near Nome, the Matanuska Coal Fields, the Fairbanks special, and The Rampart quadrangle in the interior. These maps were prepared for publication at a scale of 1:62,500 with contour intervals of 25, 50, or 100 feet, and cost about $30 per square mile. Between 1902 and 1910 nearly 3,000 square miles were mapped at this scale, which is approximately one mile to the inch.

In 1910 Congress appropriated $100,000 for the survey of public lands in Alaska. This subdivision work was carried on in the vicinity of Fairbanks during the field season of 1910 by the Geological Survey under the direction of R. H. Sargent, in cooperation with the General Land Office.

1911-1920

R. H. Sargent supervised the topographic mapping operations of the Geological Survey in Alaska during this 10-year period. Other topographers assigned to the work included D. C. Witherspoon, J. W. Bagley, C. E. Giffin, T. P. Pendleton, and C. P. McKinley.

Exploratory surveys for 1:500,000 scale publication were continued in northern Alaska on the Alatna and Noatak Rivers and on the Koyukuk River. They covered a total area of 16,500 square miles.

Reconnaissance maps were made on a scale of 1:250,000 of areas in the Copper River valley, Kenai Peninsula, the south flank of the Alaska Range near Broad Pass, along the Richardson Highway from Valdez to Thompson Pass, from Lake Clark across the Kuskowim valley to Iditarod, Tanana valley-White River, the Susitna River, from Ruby on the Yukon south to Iditarod, Prince William Sound, Kantishna district, Goodnews Bay area, and Tuxedni Bay. Twenty different field parties, or an average of two parties a year, carried on this reconnaissance mapping program between 1911 and 1920, covering a total of 51,000 square miles.

Detailed mapping at a scale of 1:62,500 was undertaken for the following areas: Kotsina, Matanuska Coal Field, Willow Creek, Juneau, and Prince William Sound. The total area surveyed on this detailed scale was 1,275 square miles, which included 350 square miles in the vicinity of Juneau mapped for publication on a scale of 1:24,000.

Between 1898 and 1920 the Geological Survey completed the following mapping in Alaska: exploratory surveys at 1:500,000 scale, 51,000 square miles; reconnaissance mapping at 1:250,000 scale, 152,000 square miles; detailed mapping at 1:24,000 or 1:62,500 scale, 3,700 square miles. Seventy-five permanent bench marks were established during 500 miles of spirit leveling.

War activity during 1917 and 1918 sharply curtailed mapping operations in Alaska since a majority of the Geological Survey staff were either commissioned in the Army or assigned to more important war work outside of Alaska.

1921-1930

Alfred H. Brooks died in 1923 and Philip S. Smith became Chief Alaskan Geologist directing both geologic and topographic work in Alaska.

R. H. Sargent continued to supervise the topographic mapping in Alaska. Other topographers assigned to the work were C. P. McKinley, Gerald FitzGerald, Richard K. Lynt, E. C. Guerin, H. A. Whitaker, O. Lee Wix, K. W. Trimble, J. O. Kilmartin, and R. M. Wilson. In this decade 4,000 square miles of exploratory surveys were made in Arctic Alaska. Reconnaissance mapping of more than 60,000 square miles was completed for such areas as Naval Petroleum Reserve No. 4 in northwestern Alaska, the Alaska Peninsula, Nixon Fork of the Kuskokwim, the Skwentna River, the Porcupine River, the Mount Spurr region of the Alaska Range, Lake Clark-Mulchatna, Goodnews Bay, and southeastern Alaska.

Two hundred and seventy miles of detailed mapping were completed for several widely-separated areas, including Juneau, Wrangell Narrows, the Hyder district, Iniskin Peninsula, and the lower Matanuska valley.

Mapping of Naval Petroleum Reserve No. 4 was started in 1923 in cooperation with the Navy Department and continued through the 1926 field season. Because of the remoteness of the area and the short summer, field parties were outfitted at Nenana on the Alaska Railroad during the winter months and used dog teams to transport food and equipment across the Brooks Range to the Colville River drainage on the Arctic slope. From 1924 to 1926 a considerable amount of geologic and topographic mapping was done during the winter and early spring months using dog team transportation. After the "break-up" about the first of June, Peterborough canoes were used on the principal rivers of the region and along the Arctic Coast.

In 1928 an airplane was used for the first time by Geological Survey parties in Alaska to transport personnel and equipment to remote field assignments, thus better utilizing the short field season.

In 1926 the Navy Department, in cooperation with and at the request of the Interior Department (Geological Survey), started aerial photographic work in southeastern Alaska. A detail of three amphibian planes, an airplane tender, a housed-over 110-foot barge, photographic personnel and equipment, and five photographic pilots under the command of Lieutenant Ben H. Wyatt were assigned to the project. The results of this expedition were so successful that the work was continued in 1929 with a second outfit, under the command of Lieutenant Commander A. W. Radford.

This project is considered an important milestone since it marked the first attempt to use aerial photography in Alaska as an aid to mapping. Approximately 20,000 square miles were photographed with multiple-lens cameras, covering most of southeastern Alaska. The photographs were used by the Geological Survey to compile planimetric maps of the area. They were also used by the Forest Service, Coast Guard, Coast and Geodetic Survey, and other Federal agencies for special studies and reconnaissance work.

1931-1940

R. H. Sargent continued in charge of Alaskan mapping until 1935 when he became editor of topographic maps for the Geological Survey. Responsibility for the Alaskan work was turned over to Gerald FitzGerald. John Collins,

Philip Erickson, C. F. Fuechsel, J. Mark Holmes, George Jensen, R. H. Lyddan, J. E. Mundine, T. W. Ranta, and Vernon Seward were assigned to Alaskan mapping during this 10-year period.

Reconnaissance mapping was continued in southeastern Alaska, and included areas on Admiralty, Chichagof, Baranof, Kupreanof, Kuiu, Prince of Wales, and Revillagigedo Islands. New projects were undertaken in the Copper River valley near the Nabesna district, Slana, Mentasta Pass, and Copper Center, using pack trains for transportation. River boats were used by survey parties in mapping the Goodnews Bay area, Nushagak River, Porcupine River, and the Holitna River. A pack train was used by a party mapping the north base of the Alaska Range east of the Richardson Highway to the Tok River.

Detailed surveys were made of Adak Island in the Aleutians, Chichagof, and Annette Islands in southeastern Alaska, the area near Yakutat on the Gulf of Alaska, and the Goodnews Mining District in western Alaska. Most of this large-scale mapping was done by the Geological Survey for the War and Navy Departments, for use in locating sites for possible air bases.

In addition, trilens aerial photography was obtained for the area between Nenana, Lake Minchumina, and a section of the upper Tanana valley in the Tetlin Lake area.

After completion of the 1940 field season the Geological Survey had mapped a total of 210,000 square miles, or about 46 percent of the total area of Alaska. Most of this work was published at a scale of 1:250,000 since much of the exploratory mapping, as well as all of the reconnaissance mapping, was published at this scale. The older exploratory surveys were published at a scale of 1:500,000 in Survey bulletins with the exceptions of the Seward Peninsula sheet and the northwestern Alaska map, which were published as separate maps at the scale of 1:500,000.

The detailed maps were at scales of 1:12,000, 1:24,000, and 1:31,680 for special mining maps and 1:62,500 for coverage of most of the important mining districts. By 1940, about 50 separate maps at the above scales had been published by the Geological Survey for general distribution, in addition to several small scale maps which had been compiled of the entire Territory. The best known and most popular of these general-purpose maps are Map A, at 1:5,000,000; Map E, at 1:250,000; and Map B (in 2 sheets) at 1:500,000.

Work of the Coast and Geodetic Survey (1895-1940)

As outlined in a preceding section, the work of the Coast and Geodetic Survey for the first twenty-odd years of the American occupation consisted chiefly of revising and completing much earlier surveys of Alaska in order to provide coastal charts so urgently needed during this period of development. However, with the preliminary work on the international boundary undertaken in cooperation with Canada, and with increased charting and geodetic control activity as a result of the discovery of gold, the work of the Coast Survey was greatly accelerated during the nineties. From that time on, increased congressional appropriations made possible a continued program of new charting and refinement of earlier charts and Coast Pilots, as well as the expansion of a control network.

Among the early vessels used to perform this new work was the Steamer Patterson which saw service in Alaska from Dixon's Entrance to Norton Sound between 1885 and 1904, and was commanded by Lieutenant Commanders H. E. Nichols, C. M. Thomas, W. S. Moore, E. K. Moore, and Mr. J. F. Pratt. Under the command of Pratt, the Patterson (see fig. 5) was used in making surveys between 1899 and 1904, in Norton Sound off Nunivak and St. Lawrence Islands, and at other points in the Bering Sea and in the Aleutian Islands. During this period, Pratt also conducted triangulation and hydrographic and topographic surveys in southeastern Alaska and along the north shore of the Gulf of Alaska.

In 1897, triangulation and topographic and astronomical surveys were made of the Pribilof Islands by W. W. Diffield. As a result of these detailed surveys, the Coast Survey published charts at a scale of 1:20,000, with a

contour interval of 20 feet, and at a scale of 1:2,000, with a contour interval of 10 feet.

The Survey Ship Pathfinder was built in 1898 for Alaskan duty and was assigned to survey work in western Alaska during 1900 and 1901 under the command of J. J. Gilbert. In 1940, the name of this vessel was changed to the Research and should not be confused with the new Pathfinder.

Hydrographic surveys of Prince William Sound, areas in the Aleutian Islands, and southeastern Alaska were made by Ferdinand Wesdahl, in command of the Coast Survey Steamer McArthur during the field seasons of 1900, 1901, and 1902.

H. P. Ritter was in charge of a triangulation and hydrographic survey party which worked in the Copper River delta area and in the eastern portion of Prince William Sound during the field seasons from 1898 to 1903.

From 1899 to 1905 the Steamer Gedney, under the command of E. F. Dickins, was engaged in various surveying operations in southeastern Alaskan waters. This work included triangulation, hydrography, and topography.

The discovery of gold in Alaska and the rush to the Klondike region in 1897 created new interest in the long-neglected Territory of Alaska, and the Coast Survey, like the Geological Survey, was given increased appropriations with which to carry on and expand its Alaskan work.

From 1900 until 1940 the Coast and Geodetic Survey continued operations in Alaska to provide navigation charts of the Territory's 26,000 miles of coastline. The survey fleet operating during the early part of this period usually numbered six or more vessels, including the Taku, commanded by R. B. Derickson, and later G. T. Rude, operating in Prince William Sound; the Yukon, commanded by C.G. Quillian, and later F.H. Hardy, operating in the vicinity of Kodiak and in Cook Inlet; the old Explorer, commanded by W. C. Dibrell and others, operating in Bristol Bay; and the vessels previously mentioned.

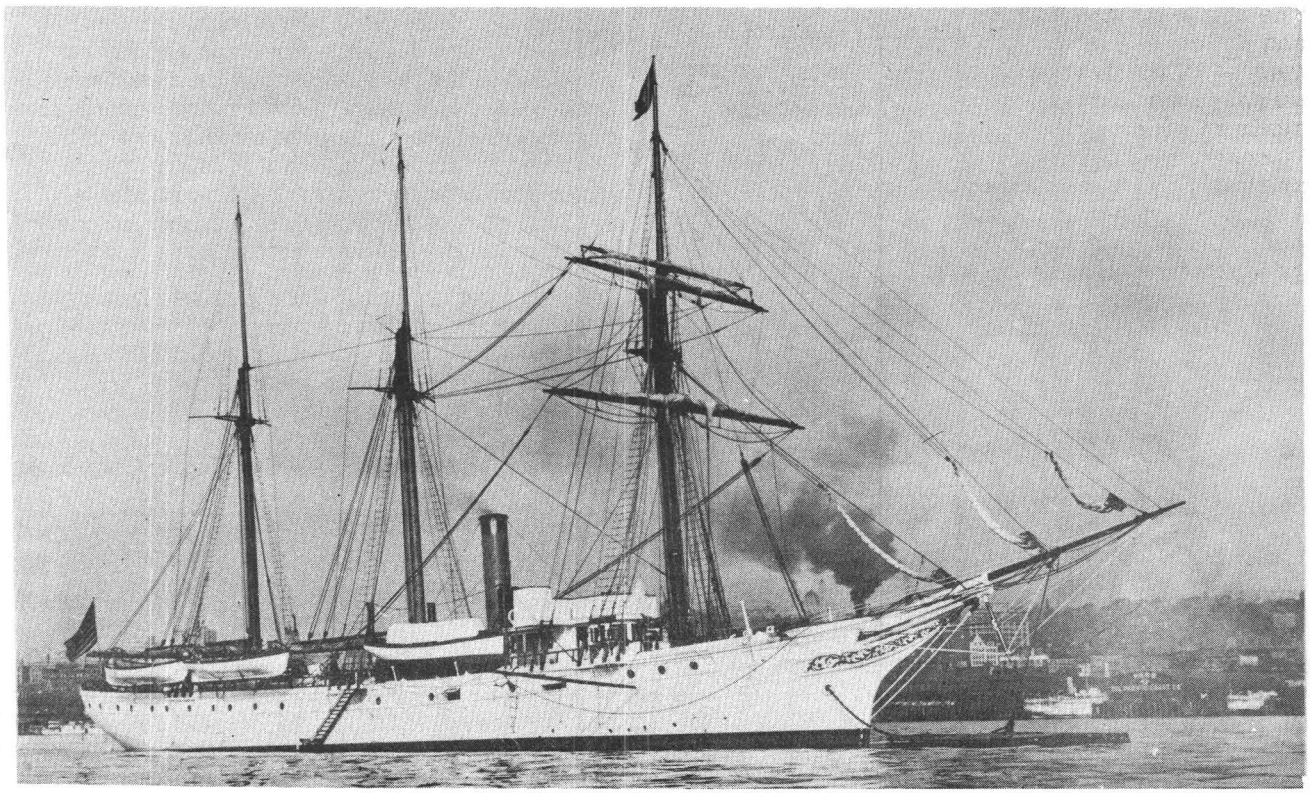

Figure 5.--United States Coast and Geodetic Survey ship Patterson, Seattle, Wash. 1915.

General small scale charts were prepared for practically all of Alaska's coast line, with special attention given to the complicated channels and small bays of southeastern Alaska from Dixon Entrance to Cape Fairweather. Nautical charts were produced from the surveys of Prince William Sound, Cook Inlet, Bristol Bay, and Norton Sound. Both triangulation and hydrographic surveying were undertaken on Kodiak Island and on the south shore of the Alaska Peninsula.

As travel to Alaska increased, surveys by wire drag were made of the main waterways of southeastern Alaska, and of the principal harbors used by ocean-borne shipping. From these surveys, large scale nautical charts were prepared and published for the rapidly expanding maritime traffic in Alaskan waters. Triangulation was extended in a continuous, unbroken line from Dixon Entrance through southeastern Alaska around the north shore of the Gulf of Alaska into Cook Inlet, Shelikof Strait, and around the south shore of the Alaska Peninsula to Unimak.

Modern survey ships were specially designed and built for the Coast and Geodetic Survey fleet. The new ships included the Surveyor, Explorer, and Pathfinder. Echo-sounding equipment, developed by the Coast and Geodetic Survey, revolutionized hydrographic surveying, and became standard equipment for all survey ships and launches. To facilitate position fixing of survey ships engaged in offshore hydrography, Radio Acoustic Ranging was developed for use beyond the limit of visibility of shore objects, and for work where the use of buoys for three-point fix control was impracticable or unwarranted.

Following World War I, combined operations were accelerated in Alaska with the survey fleet consisting of the following vessels: the Surveyor, commanded by F. H. Hardy; the Explorer, commanded by N. H. Heck; the Wenonah, commanded by T. J. Maher and J. H. Hawley; the Lydonia, commanded by E. H. Pagenhart; the Discoverer, commanded by H. A. Seran; and the Pioneer, commanded by R. R. Lukens. Surveys were extended along the southeast coast, supplementary examinations were made in various parts of the main ship channels, and, in 1926, the preliminary reconnaissance of the Alaska Peninsula was completed.

Before World War II there was little opportunity for the Coast and Geodetic Survey to extend its geodetic operations into the interior of Alaska. Precise levels were now run from the coast to Fairbanks along the Alaska Railroad and the Richardson Highway. An arc of second-order triangulation was carried from the head of Cook Inlet along the Alaska Railroad to the vicinity of Broad Pass. Although reconnaissance work was completed to tie this line to Fairbanks, and eventually to the international boundary, work was not undertaken until after World War II.

The new Explorer and the motor vessel Lester Jones were commissioned in the spring of 1940 and assigned to Aleutian Island surveys. Surveys in the Aleutians by the ships Guide, Discoverer, and Pioneer were interrupted when the vessels were transferred to the Navy early in World War II.

The early published charts of the Coast and Geodetic Survey, like the topographic maps of the Geological Survey, were rapidly compiled to meet urgent demands for maps and charts required in the development of the new Territory. Most of these exploratory reconnaissance charts either have been replaced or are to be replaced by modern up-to-date charts based on more accurate survey work. The strategic position of Alaska during the last war strongly emphasized the need for better maps and charts.

The International Boundary Survey

The generalized boundary definitions used in the Convention of 1825 between Great Britain and Russia had resulted in much confusion, and finally caused a serious controversy between Great Britain and the United States after the purchase of the Territory from Russia. At the time of the "gold rush" the location of the boundary line between southeastern Alaska and Canada became the subject of an international dispute that was finally settled by a Tribunal in London in 1903. In accordance with the

decision of this Tribunal the boundary was to be surveyed and monumented between Dixon Entrance and Mount St. Elias. A large amount of preliminary work had been accomplished along this portion of the boundary in the years 1891 to 1895 by both the Canadian and the United States Governments. Field parties of the Coast and Geodetic Survey did triangulation and astronomical work along the inlets and up the rivers, and the Canadian Survey used terrestrial photogrammetry in the preparation of preliminary maps of the area between the coast and the vicinity of the boundary.

The demarcation of this part of the boundary called for by the Tribunal of 1903 was undertaken during the years from 1904 to 1914, and was under the direction of two commissioners, Dr. O. H. Tittmann, Superintendent of the Coast and Geodetic Survey, for the United States, and Dr. W. H. King, Chief Astronomer of Canada, for the Canadian Government.

During the period of actual survey each country had an average of two field parties working independently to determine the geographic positions of principal peaks along the boundary, and to complete topographic maps along the boundary line. A 20-foot vista was cleared through all timber across the river valleys and on the mountain sides; this slash is still visible along the greater part of the line. Permanent monuments were established to mark the line in the valleys and on those mountain tops that were accessible. The total length of the boundary line was approximately 900 miles, of which about 700 miles was surveyed on land and approximately 200 miles across the water.

The Boundary Commission published 11 topographic maps, Nos. 3 to 13, covering the section of the boundary from Portland Canal to Mount St. Elias. Sheets Nos. 1 and 2, which cover the area of Dixon Entrance and most of Portland Canal, have finally been completed, and are ready for printing. All the topographic maps are on a scale of 1:250,000, with a contour interval of 250 feet.

The engineers in charge of field work on the southeastern Alaska boundary were: for the United States, J. A. Flemer and Fremont Morse of the Coast and Geodetic Survey, and O. M. Leland, formerly of the Coast and Geodetic Survey, and later Dean of Engineering of the University of Minnesota; for Canada, C. A. Bigger, D.L.S., and N. J. Ogilvie, D.L.S., later Director of the Geodetic Survey of Canada, and Boundary Commissioner.

The boundary line from Mount St. Elias to the Arctic Ocean, along the 141st meridian, became the subject of considerable interest after the Klondike gold rush in 1898, although positions had been established for the line at the Yukon River crossing and on the Porcupine River ten years earlier. In 1887 William Ogilvie of the Canadian Survey carried a micrometer traverse from the head of Lynn Canal in southeastern Alaska down the Yukon to the vicinity of the boundary. There he built an observatory and made astronomical observations for a determination of the 141st meridian. This work was started in September 1887 and completed in March 1888, and the line was marked across the river.

In 1889, J. H. Turner and J. E. McGrath, of the U. S. Coast and Geodetic Survey, arrived at Fort Yukon from St. Michael. Turner ascended the Porcupine to Rampart House on the boundary and established an astronomical station to determine the position of the boundary at that point. During the winter he made a dog-team trip from the Porcupine River to the Arctic Ocean along the 141st meridian. McGrath went to the boundary crossing of the Yukon River and made astronomical observations for the determination of the location of the boundary. The final location of the 141st meridian at the Yukon River was made in 1906 by the use of telegraphic time determination for the differences of longitude, and this result differed but little from those previously made. The observers participating in this work were Edwin Smith and J. E. McGrath of the U. S. Coast and Geodetic Survey, and Dr. Otto J. Klotz and F. A. McDiarmid of the Dominion of Canada Observatory.

In 1907 field parties started work on the actual surveying and monumenting of the boundary

along the 141st meridian. During this survey the United States and Canada conducted joint survey operations and, in the six years between 1907 and 1913, the combined parties accomplished 750 linear miles of triangulation covering an area of nearly 8,000 square miles. The parties also ran 500 miles of leveling and mapped topographically, on a scale of approximately 1 mile to the inch, 3,700 square miles along the boundary limits. In addition, 2,500 square miles of rugged, mountainous terrain was mapped by phototopographic methods. Two hundred permanent monuments were on the boundary line between Mount St. Elias and Demarcation Point on the Arctic Ocean. Topographic maps of this part of the boundary were published in atlas form, on sheets 1 to 38, at a scale of 1:62,500, with a contour interval of 100 feet.

The engineers in charge of the work on the 141st meridian were Thomas Riggs, later Governor of Alaska and Boundary Commissioner, for the United States; and J. D. Craig, D.L.S., who was later Surveyor General of Canada and Boundary Commissioner.

The General Land Office in Alaska (1899-1940)

The office of Surveyor General for the District of Alaska was created by the Act of July 24, 1897. The first man appointed to this post was Wm. L. Distin. His office was first located at Sitka, but was moved to Juneau in 1907.

An Act of March 3, 1899, made provision for the beginning of a rectangular system of surveys in Alaska. The first contract, for the survey of the Copper River base line and meridian, was dated March 22, 1904, but not executed until 1905. On August 11, 1914 John P. Walker was appointed to take charge of surveys in Alaska and directed this work until 1924, except for military service during the first World War. He was succeeded by George A. Parks who remained in charge until his retirement in 1948, except for his period of service as Governor of Alaska from June 15, 1925 to April 19, 1933.

In 1910 Congress appropriated $100,000 for subdivision surveys of public lands in Alaska, and the Geological Survey was requested to cooperate in carrying out the program called for under this special appropriation. Work was started on subdivision surveys in the vicinity of Fairbanks during the field season of 1910 by four parties, under the direction of R. H. Sargent of the Geological Survey. Precise astronomical observations for latitude, longitude, and azimuth were made by a member of the Coast and Geodetic Survey at Fairbanks, Tanana, and Copper Center.

Following the passage of the Act of October 20, 1914, to provide for the leasing of coal lands in Alaska, the extension of the rectangular system of cadastral surveys to the Bering River, Matanuska and Nenana coal fields was undertaken. Fifteen field parties were organized for these surveys in 1915. The Bering River surveys near Katalla were based on the Copper River meridian; the Matanuska fields near Knik Arm were surveyed under the Seward base line and meridian; and the Nenana surveys were surveyed under the Fairbanks base line and meridian.

In 1916 and subsequent years, the rectangular surveys were extended to include agricultural lands in the Cook Inlet district, the Susitna valley, and other areas adjacent to the Alaska Railroad, Kachemak Bay on the Kenai Peninsula, and the Chilkat valley near Haines.

In this period the townsites of Haines, Douglas, Fairbanks, Eska, and Sitka, as well as additions to the townsites of Seward, Nenana, Fairbanks, Anchorage, and Juneau were surveyed.

By 1922, 1,550,000 acres had been surveyed under the rectangular system. In 1923 and subsequent years these surveys were extended to additional areas on the Kenai Peninsula, the Chulitna coal fields, and the Chignik oil fields on the Alaska Peninsula. During this period, the survey of Mount McKinley National Park was also completed. In all, nearly two and one-half million acres have been surveyed in Alaska by the General Land Office (Bureau of Land Management).

Other Contributions (1895-1940)

Although most of the mapping, charting, and surveying in Alaska during the period 1895-1940 was accomplished by the U. S. Geological Survey, the Coast and Geodetic Survey, the International Boundary Commission, and the General Land Office, important contributions were made to geographic knowledge of the Territory by other organizations, both governmental and private.

The National Geographic Society sponsored a number of expeditions to Alaska during the past 40 years. Among the most important were the Alaska Glacier Investigations, carried out in 1909, 1910, 1911, and 1913. Also, several parties were sent to the Alaska Peninsula to study volcanoes. Some mapping was accomplished on each of these expeditions. The Society also published the results of a number of expeditions to Alaska sponsored by various other organizations, as well as work prepared by individuals on the subjects of exploration, mountain climbing, archeology, botany, geology, and ethnology.

During the early 1930's the Hydrographic Office of the Navy Department made systematic hydrographic surveys and carried on geodetic work in the Aleutian Islands. These expeditions were organized for the purpose of determining the feasibility of establishing air bases on the various islands, and the locating of adequate ship anchorages at various points along the Aleutian chain. The resulting surveys, maps, and reports were of great value in preparing for the military occupation and defense of Alaska after Pearl Harbor.

The Alaska Road Commission carried on many surveying activities in Alaska, principally in connection with road location. One of the largest expeditions of this kind undertaken by the Commission was a survey of a land route for a mail and pack trail from Fairbanks to Council City and Seward Peninsula. Field work on this project was accomplished during the summer of 1906 by civil engineers working under direction of the president of the Alaska Road Commission, Major W. P. Richardson. Reconnaissance surveys were prepared for this route, and furnished valuable information for map compilation.

The Revenue Cutter Service and the Coast Guard each made contributions to geographic information of Alaska which were utilized by the Coast and Geodetic Survey in compiling nautical charts, and by the Geological Survey in preparing reconnaissance topographic maps.

Numerous newspaper men, adventurers, explorers, and mountain climbers, have made trips into various parts of the Territory of Alaska. Many of these expeditions were widely publicized and conveyed the impression to the public that a large amount of mapping was accomplished in this manner. Actually, the combined result of most of these so-called exploring expeditions was insignificant as far as usable map information was concerned.

One exception to the unimportance of individual exploration in Alaska was the work of Robert Marshall during the summers of 1929, 1930, and 1931, in the headwaters of the Koyukuk River. He prepared drainage maps of the Koyukuk River basin north of the Arctic Circle, from 10,000 to 15,000 square miles in area. Many geographic features were discovered and named on these expeditions. The results were published in report and map form by the Geological Survey in 1934.

RECENT MAPPING (1940-50)

From 1940 to 1950 more progress was made in surveying and mapping in Alaska than in any other period in the history of the Territory.

Even before our entry into World War II it became increasingly apparent that the strategic position of Alaska would make the area important in a global war. Mapping and charting of the Territory, therefore, received attention by those responsible for national defense as early as 1940. Both reconnaissance and detailed surveys were necessary to determine suitable locations for military airports, as well as to determine problems connected with their construction. The Army Air Forces required navigation charts at different scales to facilitate air travel across the Territory. The Army, concerned with the defense of strategic areas in Alaska, particularly the land transportation routes, needed maps of both coastal and interior areas,

and the Navy could not operate effectively in Alaskan waters without hydrographic charts.

Surveying and mapping operations were continued by the Coast and Geodetic Survey and the Geological Survey throughout the war, principally to assist the military services which were at that time rapidly expanding their own facilities for producing military maps and charts. Much was accomplished during this war-time period, particularly in control and mapping at reconnaissance scales. Post-war defense plans, combined with a large scale program designed to develop the economy of Alaska, called for continued surveying and mapping. This work has been continued in a coordinated effort by the U. S. Geological Survey, the Coast and Geodetic Survey, the Corps of Engineers, the Bureau of Land Management, and the Aeronautical Chart Service.

Work of the Coast and Geodetic Survey (1940-50)

Most of the normal operations of the Coast and Geodetic Survey in Alaska were sharply curtailed during the war. Survey ships were assigned to naval operations and personnel were either transferred to the armed services or were used directly on war mapping and charting activities.

One of the first postwar operations undertaken by the Coast and Geodetic Survey was the connection by triangulation of control surveys of the Pacific Coast with those of Alaska, thus establishing a coordinated network of continental triangulation based on the North American Datum for 1927. This work required continuous arcs of triangulation from Puget Sound through British Columbia and southeastern Alaska, and thence along the Alaska Highway through the Yukon Territory and the Tanana valley to Fairbanks. From there a connection was made with the earlier arc that extended from Cook Inlet to Broad Pass along the Alaska Railroad. A new arc was established along the Richardson Highway between Big Delta and Valdez, with a cross-tie between Gulkana on the highway to Tok Junction on the Tanana River. Another major arc was run from Nenana down the Tanana and Yukon Rivers to Norton Sound, via the Kaltag-Unalakleet portage. A tie was made to Little Diomede Island in Bering Strait by an arc along the south coast of Seward Peninsula. This work is now being extended north and east along the Arctic Coast to Demarcation Point, the north end of the Alaska-Canada boundary on the 141st meridian.

In southern Alaska another major arc was extended along the south side of the Alaska Peninsula through the Aleutian Islands to Attu Island. This arc is, in turn, connected with the northern work by a network from Iliamna Bay across the base of the Alaska Peninsula to Bristol Bay, thence northward along the coast and up the Kuskokwim River, where a tie is made between Aniak and Holy Cross.

Concurrent with the expanded postwar geodetic work, the Coast and Geodetic Survey also increased hydrographic survey operations, particularly in the Aleutian Islands, Prince William Sound, along the south shore of the Alaska Peninsula, in Bristol Bay, and in the Bering Sea. Modern survey ships assigned to the Alaskan work since the war include the Explorer, Pathfinder, Lester Jones, Pioneer, Patton, Derickson, and the Westdahl. Offshore hydrographic work has been greatly expedited by the use of the electronic position indicator, an adaptation of the war-developed shoran.

Coast and Geodetic Survey operations include the maintenance of existing stations and the establishment of many new tidal stations in the coastal waters of Alaska. Magnetic surveys, which were begun by Professor Davidson in 1867, are being expanded to provide isogonic information for use on aeronautical charts.

Under a joint agreement among the Department of the Army, the Geological Survey, and the Coast and Geodetic Survey, topographic mapping of the Aleutian Islands west of 165 degrees, will be carried on by the Coast and Geodetic Survey in conjunction with nautical charting and geodetic work. These maps are required for military use, and will be published first by the Army Map Service at a scale of

1:25,000, and later by the Geological Survey for civil use at a scale of 1:63,360, as an integral part of the National Topographic Map Series.

Work of the Corps of Engineers (1940-50)

After the early explorations carried on by field parties under the sponsorship of the War Department between 1895 and 1902, little surveying or mapping was accomplished in Alaska by that Department before 1940. The Corps of Engineers requested the Geological Survey to make several detailed surveys in Alaska in connection with the location of proposed Army Air Bases. These included Annette and Yakutat. Early in World War II, the 29th Engineer Battalion, with headquarters in Portland, Oregon, dispatched field parties to Cook Inlet where control surveys were made as part of a training program. These covered several quadrangles which were later compiled by multiplex method from aerial photographs into maps published at a scale of 1:50,000. Several quadrangles were also compiled from photographs of part of Unalaska Island. Numerous other isolated surveying and mapping jobs were performed by the Corps of Engineers during the war, principally in training programs or to assist in construction work.

After the cessation of hostilities plans were formulated for an expanded mapping program in connection with hemispheric defense. Such a program obviously called for greatly expanded activity in Alaska. Although the mapping of Alaska for more than 50 years had been primarily a civilian responsibility under the Geological Survey, priorities established by the General Staff under the postwar defense program required an expansion beyond the capabilities of the Geological Survey. Mapping of extensive areas in western Alaska, including Seward Peninsula, was assigned to the Army Map Service, and work was undertaken during the field season of 1949 to establish control in Seward Peninsula for multiplex mapping of the area at relatively large scales. Upon completion of the Seward Peninsula work Army mapping will be extended to include coastal areas from Norton Sound to Bristol Bay. When completed, this work will be published in a military edition by the Army Map Service, and, as is required, in civilian edition by the Geological Survey at civilian scales.

Work of the Aeronautical Chart Service of the Air Force (1941-50)

The Aeronautical Chart Service, or the Map Chart Division as it was originally called, was organized in 1941 and almost immediately began the preparation of several series of charts for planning and operational use. These charts followed the general outline and specifications recommended by the Federal Board of Surveys and Maps in 1929, when a special committee of the Board had studied the subject of aeronautical charting. However, the United States had declared war before the airlanes through the Northwest Territory of Canada and across Alaska were charted. In order to provide the minimum information necessary to compile aeronautical charts, the Aeronautical Chart Service, the First Photographic Group of the Army Air Forces, and the Alaskan Branch of the Geological Survey began work in 1941 on reconnaissance mapping. A new and then-untested method using aerial photographs was employed. This new method was destined to become one of the most important contributions to mapping and charting developed during World War II. Because of the urgent need for pilotage charts covering northwest Canada and Alaska, it was natural that these vast unmapped areas should be the proving ground for the trimetrogon mapping system. The work carried on in Alaska by the Air Forces and the Geological Survey to develop trimetrogon mapping served not only to perfect a new technique in rapid mapping, but also to supply a vast amount of new geographic information covering the unmapped areas in the Territory.

Between 1941, when the first experimental photographic flights were made in Alaska, and 1946, most of Alaska was covered by trimetrogon photography, and charts had been compiled and published. The Aeronautical Chart Service prepared specifications and edited and published the final charts. The First Photographic Group and its successor, the 311th Wing, accomplished the photography and established astronomical positions for control in remote areas throughout

the Territory. The Geological Survey compiled the base topographic information for the charts, using special techniques and instruments developed for mass production of trimetrogon mapping. Most of the charts of Alaska prepared and published by the Aeronautical Chart Service were at scales of 1:500,000 and 1:1,000,000. The millionth scale series was completed during the war and the half-million series is still being compiled for the lower priority areas. All existing information from earlier surveys by the Geological Survey, the Coast Survey, and others, supplemented by trimetrogon compilation, was used in the preparation of the aeronautical charts. A maintenance program provides for revision of individual charts as new control and topographic information become available.

Much of the original information compiled from aerial photography for the aeronautical charts of Alaska has been used by the Geological Survey to prepare a revised 1:250,000 scale series covering the entire Territory, which will, when completed, become a part of the National Topographic Map Series. The joint cooperative effort of the Aeronautical Chart Service, photographic units of the Air Force, and the Geological Survey has produced the greatest contribution to the surveying and mapping of Alaska made during the 200 years covered by this report. Alaska's strategic position for the effective use of air power in national defense requires accurate maps and charts. It appears certain, therefore, that the Department of the Air Force will continue to take an active part in photographing Alaska from the air, as an indispensable aid to the preparation of topographic maps and aeronautical charts.

Mapping Activities of the Geological Survey (1940-50)

For 45 years the work of the Geological Survey in Alaska has necessarily been connected with the development of the mining industry, and much of the topographic mapping has been undertaken in areas of potential mineral value. By 1940, nearly one-half of the Territory had been mapped in some manner. A large part of this mapping could be classified as "exploratory reconnaissance", at scales ranging from 4 miles to the inch to 8 miles to the inch. Mapping at larger scales, principally 1:62,500, had been accomplished for more than twenty widely separated areas. Most of these surveys covered established mining districts. A considerable portion of the area north of the Brooks Range and east of the Colville River remained unexplored at the beginning of World War II.

In 1941 the Alaskan Branch of the Survey was requested by the Army Air Forces to develop a method for rapid exploratory reconnaissance mapping, for use in compiling aeronautical charts. Alaska, therefore, became a testing laboratory for trimetrogon mapping and a program was started by the Geological Survey, under the auspices of the Army Air Forces (Aeronautical Chart Service), that was ultimately to have a far-reaching effect on the mapping of Alaska and many other unmapped or poorly-mapped areas throughout the world.

After the war the Survey continued to use the trimetrogon photography of Alaska, with some refinement of wartime methods, to produce reconnaissance maps of many areas, but because of a growing demand for maps at large scales, ways and means of obtaining single-lens mapping photography were studied. A relatively small amount of this type of photography had been obtained by units of the Air Force and the Navy in Alaska, and no program covering extensive areas was undertaken until 1948. At that time the Navy Department in cooperation with the Geological Survey and other Federal bureaus returned to southeastern Alaska and, with war-trained photographic squadrons, using the most modern equipment available, photographed more than 20,000 square miles, obtaining high-quality aerial photographs suitable for large scale topographic mapping. During the same summer other photographic units of the Navy covered large areas in the Naval Petroleum Reserve No. 4 in northern Alaska. This coverage was required principally by geologists and geophysicists in the exploration for oil within the Reserve.

One squadron, before returning to its California base in the fall, photographed an area covering the new highway between Anchorage and Tok Junction.

During the war years the Geological Survey sent few topographic field parties to Alaska. Most of the available equipment and personnel were used to prepare maps and aeronautical charts from trimetrogon photography by office-compilation methods. Although this compilation eventually covered most of Alaska, the personnel of the Survey ordinarily engaged in Alaskan mapping devoted much of their effort during the war to preparing charts of foreign areas. After the war the trimetrogon mapping of Alaska was used to compile for republication the standard base map of Alaska, known as "Map E". This map was published in 1947 at a scale of 1:2,500,000 and a comparison with the edition of 1939 reveals the great amount of work accomplished in Alaskan reconnaissance mapping during the war.

For some areas in Alaska the "trimet" coverage is also used to compile and revise maps at a scale of 1:250,000. A program is planned to cover the entire Territory at that scale, with an estimated completion date for the entire series by the end of 1953. Immediately after the war, and before single-lens photography became available for photogrammetric mapping, field parties returned to Alaska and carried on mapping work for both civil and military use. Much of this new work was prepared for publication at a scale of 1:62,500, and photo-topographic methods and trimetrogon photography were used to supplement the plane-table surveys made in the field. The area between Anchorage and Fairbanks was given a high priority because it covered the Territory's principal transportation routes. Therefore, several parties were sent to this area to establish horizontal and vertical control for use in aerial photographic mapping. These parties used helicopters to speed up the field work. This was the first time this unique aircraft had been used for surveying operations and its use by the Geological Survey in Alaska has demonstrated its usefulness in transporting surveyors and equipment to remote stations on high mountains. The rate of progress has been increased to such an extent that a crew of six men and two helicopters can control one quadrangle per day (approximately 200 square miles), and a single engineer has established as many as fifty supplemental control points in one day. Prior to the use of helicopters it took an engineer an entire season to control a quadrangle for standard mile-to-the-inch mapping. Many other surveying organizations throughout the world have followed the Survey's lead and are now using helicopters to expedite survey operations.

During the summer of 1949 photographic units of the Army Air Forces and the Navy continued photographic mapping operations in Alaska. Navy Squadron VP61, based at Nome, photographed additional areas in Naval Petroleum Reserve No. 4, as well as a large part of Seward Peninsula. Air Force Reconnaissance Group 55, of the 311th Air Division based at Fairbanks, in spite of adverse weather conditions during that summer, photographed more than 30,000 square miles, covering much of the area between Anchorage and Fairbanks, including the Richardson Highway and the Alaska Railroad. This coverage was accomplished to rigid mapping specifications and, in addition, was controlled by shoran, an electronic method of measuring distances accurately from fixed ground stations to the aircraft in flight. Signals from ground stations are received in the plane and converted to distance measured in microseconds of time. They can be adjusted and synchronized with vertical mapping photography to compute a geographic position for the optical center of each aerial photograph. If final accuracy tests prove this method satisfactory, it will not only expedite mapping of many areas in Alaska, but will also eliminate the necessity of the very costly arcs of triangulation now being planned for mapping control in Alaska. The Geological Survey has requested the Department of the Air Force to continue this shoran-controlled photography of Alaska in order that standard quadrangle mapping of high priority areas may be completed. In response to this request photographic units of the Air Force covered an additional 20,000 square miles in south central Alaska during the summer season of 1950. A request has also been made for complete photographic coverage of all unmapped areas of Alaska at high altitudes (above 35,000 feet), for use in the preparation and revision of the 1:250,000 scale map series.

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In order to provide elevations for topographic mapping the Geological Survey has investigated several methods being developed by private companies and the military services to provide airborne control. A contract was entered into with a Canadian company with specialized equipment to establish spot elevations over a large area during the summer of 1950. Radar altimetry has been used successfully in Canada to provide spot elevations for the control of aeronautical charts and it is believed if this method is successful it can be used effectively with shoran to provide both horizontal and vertical control for mapping at medium (1:63,360) and small (1:250,000) scales. This combination of airborne control methods should be ideal for reconnaissance mapping over large areas in Alaska, particularly north of the Arctic Circle.

The contract radar altimetry project covering an area of approximately 60,000 square miles in central Alaska was completed late in the summer Preliminary computations indicate that this experimental coverage will provide vertical control of sufficient accuracy for the compilation of medium scale maps with a contour interval of about 100 feet.

Topographic mapping in Alaska accomplished prior to World War II was published in sheets of varying sizes, generally to accomodate the work of one or two seasons or a specific mining area. More than 50 such sheets had been published without an attempt to provide a series of standard-sized quadrangles. After the war a new map-sheet layout was designed for Alaska, including scales of 1:24,000, 1:63,360, and 1:250,000. Alaskan maps now being published are on standard format and are considered part of the National Topographic Map Series. Sheets originally prepared by the military services will later be published by the U. S. Geological Survey as part of this National Series.

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