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REPORT OF THE PRELIMINARY RESULTS OF THE AEROARCTIC EXPEDITION WITH "GRAF ZEPPELIN," 1931

Lincoln Ellsworth and Edward H. Smith

IT was a magical journey, this Arctic cruise of 8000 miles in 136 hours! In the kaleidoscope of swiftly moving scenes the high lights of our voyage seemed like flashes upon the screen, so quickly was one impression replaced by the next. The Franz Josef group covered in seven hours—Cape Flora at 5 p. m., Cape Fligely at midnight—six hours to Northern Land, another five hours to Cape Chelyuskin, and in two hours more Lake Taimyr below us! The old explorers who "did it on foot" must have given thought to the airway as they gazed from the encumbered ground to the freedom of the sky. Middendorff in 1843 spent a painful month on the journey from Lake Taimyr to the sea. Nansen sighted the northern shores of Franz Josef Land on July 24, 1895; it took him eleven months to reach Cape Flora!

The conception of the *Graf Zeppelin's* Arctic cruise of 1931 dates back to 1926 and the foundation of the Aeroarctic Society. In its first form the plan was for a crossing of the Arctic from the European to the American side under the leadership of Nansen.¹ The plan failed to mature, largely on account of the extremely high rates of insurance expected for a dirigible navigating so far north. Nansen's sudden death in 1930 brought a further postponement until the election of Dr. Hugo Eckener to the presidency of Aeroarctic later in the same year. Now in 1931 with a modified program the so-called preliminary flight has been successfully accomplished under the leadership of Dr. Eckener supported by a large scientific staff.²

¹ Nansen briefly outlined his plans in his address before the American Geographical Society on May 14, 1928; see *Geogr. Rev.*, Vol. 18, 1928, p. 495. For a note on Aeroarctic see *ibid.*, p. 512. For the plans for 1930 see "Die bevorstehenden ersten Erkundungs- und Forschungsfahrten der Aeroarctic im Frühjahr 1930 mit dem 'Graf Zeppelin,'" *Arktis*, Vol. 2, 1929, pp. 26-28.

² In addition to Dr. Eckener and Captain Walther Bruns, assistant to the leader and general secretary of Aeroarctic, and thirty odd members of the crew, the personnel included: Professor R. L. Samoilovich, senior scientist of the Arctic Institute, Leningrad, chairman of the investigating council for geographical studies, Aeroarctic, and leader of the scientific staff; Professor L. Weickmann, director of the Geophysical Institute, University of Leipzig, and chief of the meteorological investigations on the expedition; Professor P. A. Molchanov, director of the Aerological Observatory at Slutsk and co-worker on the meteorological investigations; Professor A. Carolus, of the University of Leipzig, assistant to the meteorologists; Dr. W. Basse, engineer, aerogeodist, photographer for Carl Zeiss Co.; Dr. C. Aschenbrenner, engineer, aerogeodist, photographer for Munich Surveying Co.; Dr. E. Kohl-Larsen, biologist and physician; Mr. Lincoln Ellsworth, civil engineer and representative of the American Geographical Society, Arctic expert for navigation; Lieutenant Commander Edward H. Smith, of the U. S. Coast Guard, representative of the International Ice Patrol, for ice and oceanographic observations; Dr. G. Ljungdahl, of the Swedish Hydrographic Office, in charge of earth magnetic observations.

Narrative of the Voyage

At 8.35 a. m.,³ the morning of July 24, the monstrous bulk of the *Graf Zeppelin* began to move slowly out of its Friedrichshafen hangar; and a few minutes later we were headed northward towards Berlin, where a landing was made at 6 p. m. Early next morning we were off. Our course lay northward for Helsingfors, thence east for Leningrad, where we landed at 5.30 p. m. At 8.00 a. m., July 26, we were in the air again. In less than an hour out of Leningrad the country grew desolate, with few scattered settlements in marked contrast to the cultivated landscape to the south over which we had been flying. The country was a vast muskeg. At 4 p. m. we were over Archangel, the world's biggest lumberyard. Lumber hides the dwellings of the city of 10,000, and logs choke the waterways. From Archangel we headed northward. The Arctic Circle was crossed at 7 p. m. The wind, which had been light from the northeast all day, suddenly shifted to east-northeast and increased to a fresh breeze almost coincident with our reaching the Arctic Sea. The air temperature also dropped from 14° C. to 9° C., and it was quite apparent that we had left the warm atmosphere of Europe to enter much colder polar air. For a few hours we skirted the coast at altitudes from 200 to 500 meters. Much log wood lay scattered, in places very thickly, along the beaches. A few circular fish weirs, probably for salmon catching, were observed along these stretches of the coast.

OVER THE BARENTS SEA

Before we reached Cape Kanin at 10.53 p. m., the wind backed to north-northwest and freshened to a force of 5 or 6, Beaufort Scale. Our own course, now 6° true, for Cape Flora, Franz Josef Land, had to be corrected about 25° to the left in order to counteract this amount of wind drift to the right. To conserve fuel Dr. Eckener ordered two of the five motors stopped, and so the remainder of the night we bucked the wind towards Franz Josef Land at a speed of 37 miles an hour.

At 9 o'clock in the morning, latitude 74° 40' N., a few drift logs were to be seen, and small birds skimmed the waves. The ship began passing through the first scattered patches of fog at an altitude of 200 meters. Then fog banks became more frequent and soon completely enveloped us. The air temperature of 4° C. had been more or less constant ever since we left Cape Kanin. In the latter part of the morning, however, as the dirigible progressed farther north, the thermometer dropped to 2° C., and the ship gradually emerged into clear atmosphere and bright sunshine. The blue sky overhead was in marked contrast to the white sea of fog over which we skimmed

³ All time references are Greenwich Civil Time.

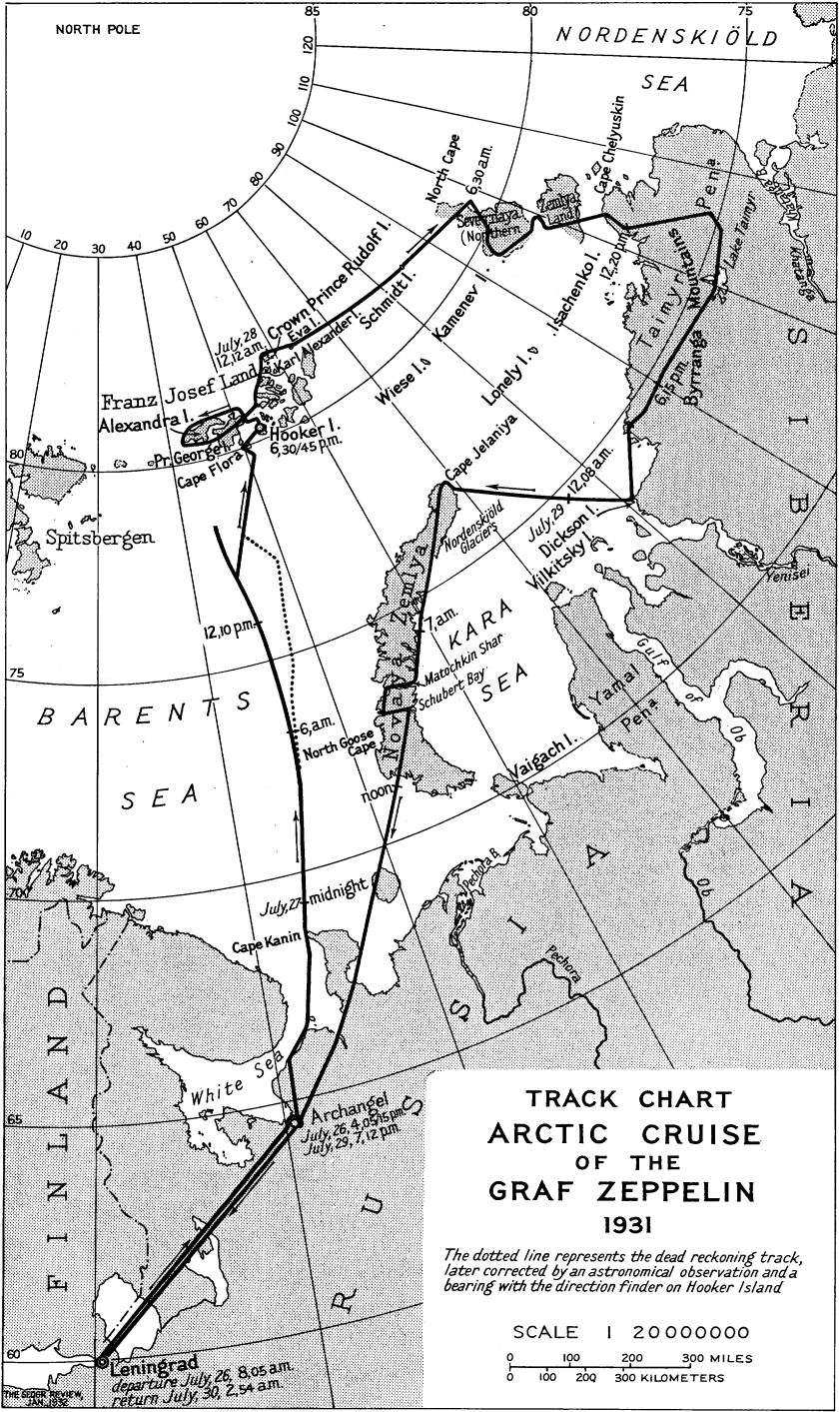


FIG. 1

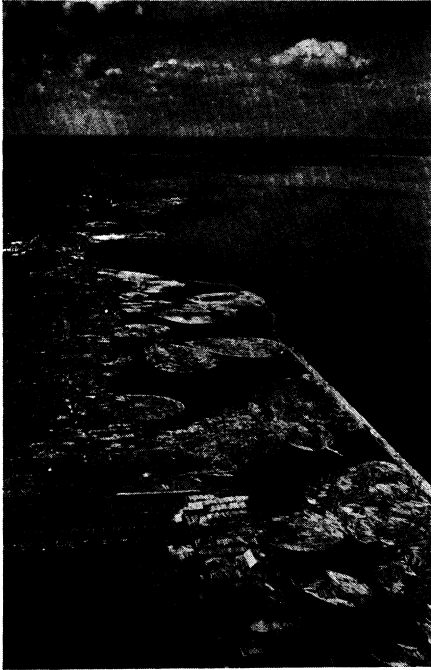


FIG. 2—Logs ready for the sawmill at Petrozavodsk on Lake Onega. (Photograph by W. Basse.)

at a height of 600 feet. About this time radio communication was established with the Russian ice breaker *Malygin*, 250 miles away at Hooker Island radio station, Franz Josef Land. She reported the first ice at 78° N. and also gentle northeast winds and foggy weather.

At 2.50 p. m., however, the stratus sheet beneath us was drawn aside, and far below, scattered here and there, lay the first of the sea ice, in long strips and strings, with much open water around. Then followed intermittent patches of fog, and finally at 3.30 p. m. we came out into clear air again and an unobstructed view of the horizon. The pack ice was composed of *glaçons* ranging in width from two or

three feet to 75 and 100 feet. The ice appeared to be less than three feet in thickness; it was also quite flat, indicating a production sometime during the previous winter. As we proceeded farther north the polynyas and leads grew smaller and fewer. There was no such heavy ice as had been seen by Ellsworth on his flights of 1925 and 1926 fifty miles north of Spitsbergen.

FRANZ JOSEF LAND

During the afternoon the wind dropped to light airs, and the weather became beautiful. The southern islands of the Franz Josef Land group were sighted about 4.30 p. m., at a distance of thirty-five to forty miles. Black and forbidding, Cape Flora was ahead of us, a spot memorable in the annals of Arctic travel, for it was here that Nansen and Johanssen on their long trek from the *Fram* found succor from the Jackson-Harmsworth Expedition. Closer approach brought out more detail, but the main features remained predominant—bare basalt, table-topped headlands, outcropping here and there from the more general, overflowing glaciers. A belt of open water and scattered *glaçons* of sea ice surrounded Franz Josef Land on the south; and British Channel, except for an occasional ice cake, was perfectly navi-

gable for sea craft. This was an open season for Franz Josef Land, a condition that varies greatly from year to year.⁴

Flying up British Channel we soon could make out Hooker Island in the distance, and at 5.45 p. m. we were circling the radio and meteorological station located there on a raised rocky shelf. This lonely post established by the Russians in 1929⁵ is the most northerly meteorological observatory in the world. The *Malygin*, anchored about a quarter of a mile off the shore, had been full dressed in honor of the dirigible's visit. The sea was now perfectly calm, and its surface, interrupted here and there by ice cakes, was like an upturned mirror. Conditions were ideal, and Dr. Eckener

was ready to test a water landing on the air-inflated rubber pontoons, a method tried out at Friedrichshafen. Slowly and uniformly we began to descend. About 100 feet above the water a sea anchor was cast down and also several canvas dip buckets. The buckets, filled with water and drawn upwards a few feet, added just the right amount of extra weight to pull us down where we rode like a ship at anchor.

A boat immediately put out from the *Malygin*. Post bags were hastily exchanged between the side door of the gondola and the bow of the *Malygin's* boat. In the stern stood Nobile, he having taken passage on the *Malygin* in the hope of finding some record of the ill-fated *Italia*. Ellsworth and Nobile exchanged brief greetings. A hurried take-off was made just as a large ice cake was swept dangerously close by the current. The Zeppelin now rose to an altitude of 1000 meters and heading westward flew across British Channel to the northeastern part of Prince George Island.

The automatically recording cameras were started from a known fixed departure point, the Hooker Island Radio Station. Hence the

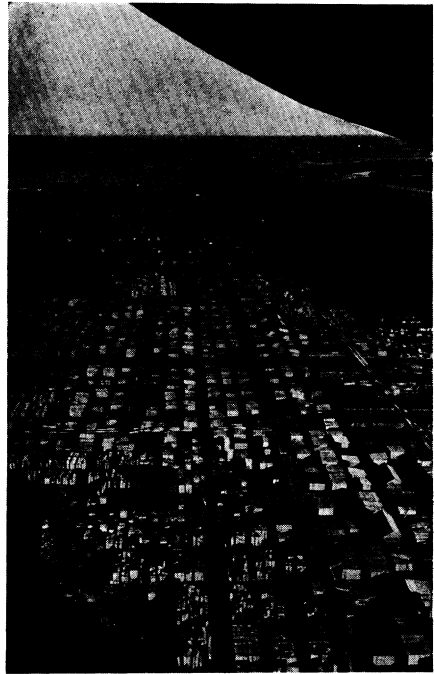


FIG. 3.—Huge piles of sawn lumber ready for shipment at Archangel. (Photograph by Basse.)

⁴ Notes on ice conditions are given in Gunnar Horn: Franz Josef Land; Natural History, Discovery, Exploration, and Hunting, *Skrifter om Svalbard og Ishavet* No. 29, Oslo, 1930.

⁵ W. Wiese: Die Expedition des Eisbrechers "Sedow" nach Franz-Josefs-Land zwecks Aufbau einer meteorologischen Radiostation, *Arktis*, Vol. 2, 1929, pp. 126-128.

course skirted along the northern coast of Armitage Island and Alexandra Island. Inaccuracies in the map were immediately apparent; Armitage Island, for example, should be charted as a peninsula of Prince George Island; Albert Edward and Harmsworth Islands, recorded on existing maps⁶ about fifteen miles north of Prince George



FIG. 4—Hooker Island, Franz Josef Land, rendezvous of the ice breaker *Malygin* with the *Graf Zeppelin*, July 27, 1931. The radio station lies on the low point of land on the left. (Photograph by Basse.)

Island, do not now exist—at least there were no traces of land in that direction as far as the horizon. The visibility was excellent too, and from our altitude we could plainly see forty miles or perhaps more.

Alexandra Island, except for a small part of its eastern half and three of its southern headlands, is completely covered with island ice. Thirty miles of its more or less regular northern coast line meet the sea in a vertical ice wall from ten to thirty feet in height. A slow movement of the ice cap, moreover, is indicated by the several small-sized growlers that were floating in the water near by. While we made a complete circuit of the island, one of the largest of the Franz Josef Land group, the photographers collected in about three hours enough material for the map. The geographical survey accomplished in this short period, so stated Professor Samoilovich, represented the equivalent of four summers' hard work for a ground party.

At 6.45 p. m. Ellsworth radioed a message to the American Geographical Society:

Met first ice in loose fields 120 miles south of British Channel. Now circling Alexandra Island. Present chart not correct. Albert Edward Island and Harmsworth Island do not exist.

⁶ See the recently compiled map of Franz Josef Land on a scale of 1:750,000 accompanying "Franz Josef Land," *Trans. Inst. for Exploration of the North*, No. 47, Moscow, 1930, reviewed elsewhere in this number of the *Geographical Review*.

The camera survey of Alexandra Island and Prince George Island being completed, the airship was headed northeastward toward Crown Prince Rudolf Island, 85 miles away; the northernmost island in Franz Josef Land. Several rocky islets were observed in the offing of Rhodes Channel, although they are not recorded on present-day

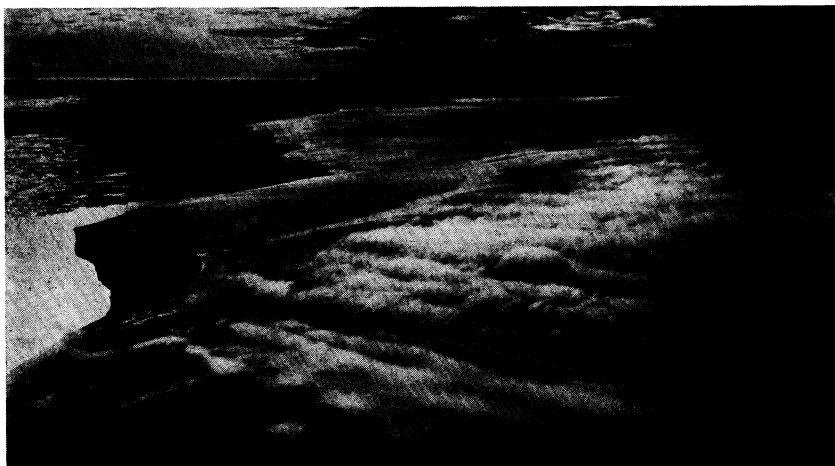


FIG. 5.—Cape Brorok, Crown Prince Rudolf Island, the most northerly member of the Franz Josef Land group. The land is completely covered with a low ice sheet. Even here a shore lane of open water was observed. (Photograph by Basse.)

maps. After we had passed Jackson Island the amount of open water appreciably decreased, and soon there was little or none to be seen. Along the coasts of Karl Alexander Island and Crown Prince Rudolf Island sea ice lay far up on the land, showing plainly that pack ice must often press in there from the northward. The most northerly point in the cruise was attained at midnight on rounding Cape Fligely, latitude $81^{\circ} 50'$, 490 nautical miles from the pole. Here was one of the most beautiful scenes of the trip, looking northward towards the midnight sun, then just below the horizon. All objects appeared to be bathed in the soft and mellow light except where a golden reflection shone brightly along a glittering, icy path between us and the pole.

We had gradually descended to the usual cruising altitude of 250 meters, and now the ship's head was kept off toward North Cape, the northern extremity of Severnaya Zemlya, Northern Land, 300 miles distant.⁷ A half hour past midnight we passed over two very curious overlapping disks of ice, smoothly polished and one to three miles in diameter. This was Eva Island, low, double-mushroom-shaped, completely glaciated, and often probably overridden by sea ice. Another interesting feature in the solid pack, over which we were

⁷ The former Nicholas II Land. For an account of the discovery see N. A. Transehe: *The Siberian Sea Road: The Work of the Russian Hydrographical Expedition to the Arctic 1910-1915*, *Geogr. Rev.*, Vol. 15, 1925, pp. 367-398.

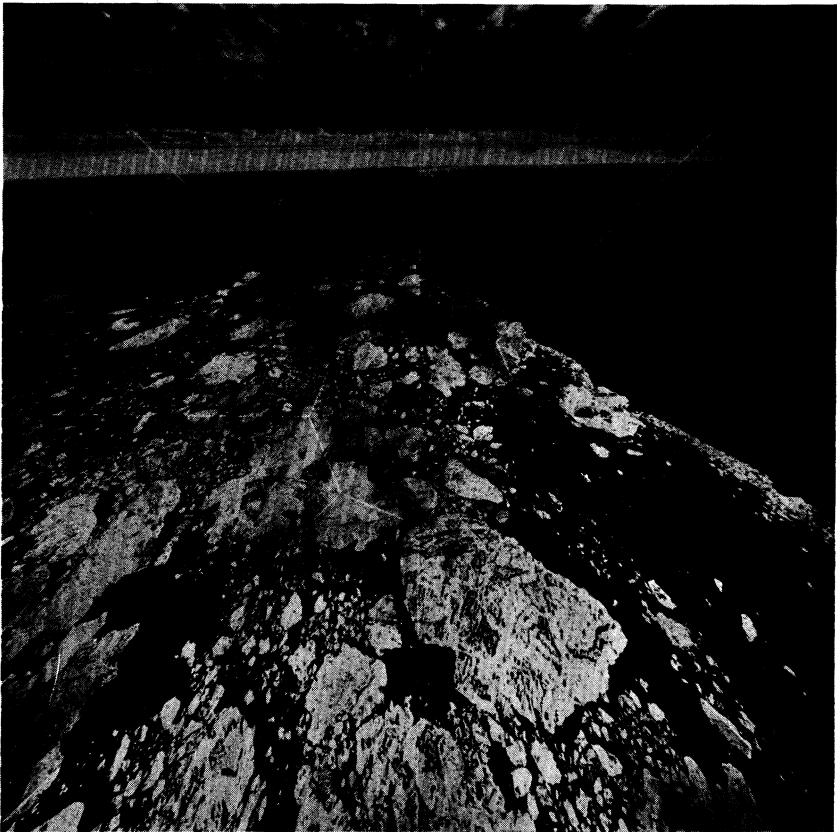


FIG. 6—Example of the aerial surveying work over the north coast of Alexandra Island, Franz Josef Land. (Photograph by C. Aschenbrenner.)

now flying, was patches of color ranging from dark muddy browns to greenish browns and yellows. These areas became so large and so numerous along the course between Franz Josef Land and Severnaya Zemlya that they neutralized the flat whiteness usually observed over ice fields in the north. Undoubtedly this color was the chlorophyll of algae and planktonic life that had blossomed and multiplied in the pools of thaw water. The upper surface of nearly all of the ice fields plainly showed the effects of much summer melting.

SEVERNAYA ZEMLYA (NORTHERN LAND)

Our course thence gradually diverged from the track taken by the dirigible *Italia* from Franz Josef Land to Severnaya Zemlya in 1928.⁸ With the exception, therefore, of the drift of the *St. Anna* in longitude 71° 30' E., 1912–1914, we were now blazing a new trail in

⁸ See map accompanying the note "Nobile's Flights in the Arctic on the Airship *Italia*, May, 1928," *Geogr. Rev.*, Vol. 19, 1929, pp. 683–685.

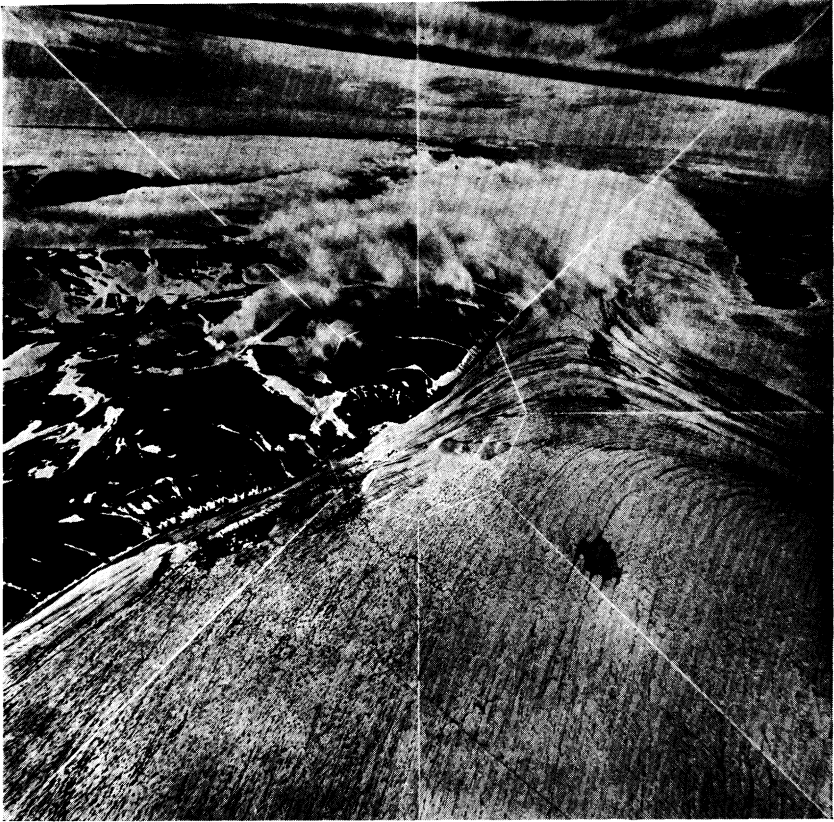


FIG. 7.—A glacier in northern Severnaya Zemlya. This view gives a good impression of the appearance of the land-and-ice-scape of Northern Land. The presence of a ridge in the bed of the glacier in the right foreground is marked by the lines of flow and indicates, furthermore, the relative thinness of the ice here. (Photograph by Aschenbrenner.)

the Arctic. No new island or other land was sighted on this leg of the cruise, however, and the principal object of interest was still the pack ice. As we approached Schmidt Island, discovered by the ice breaker *Sedov* the previous year,⁹ and the western shores of Severnaya Zemlya, the sea ice became heavier, and its upper surface assumed a more rugged character than the ice around Franz Josef Land. From the gondola windows of the *Graf* at an altitude of 250 to 300 meters, the first pressure ridges, disjointed and scattered by previous disruptions of the floes, looked like mole mounds in size. The ice, in a belt about midway between Franz Josef Land and Severnaya Zemlya, appeared to be lighter, and the proportion of openings greater than elsewhere. Could this condition of the pack be traced to the influence of a warm current from the southwest pushing in from the open Barents Sea?

⁹ Cf. B. Isachenko: The Arctic Expedition of 1930 on the Ice Breaker *Sedov*, *Geogr. Rev.*, Vol. 21, 1931, pp. 499-500.

A moderate breeze sprang up from the westward during the early morning of July 28 and, as a tail wind, increased the speed of the *Graf Zeppelin* to 65 miles per hour. About the same time we encountered a light fog. As Schmidt Island was neared the fog became thicker, and it was impossible to see this land at all. Later it cleared



FIG. 8—A glacier in northern Severnaya Zemlya flowing westward from the inland ice. Note the folding along the sides. (Photograph by Basse.)

somewhat, and at 5.30 a. m. the western headlands of Severnaya Zemlya were seen through the clouds. We rose again to about 4000 feet and flew southeastwards over the inland ice to the eastern coast near Cape Vilkitski. Most of this land that we were now exploring had never before been seen by man; at least so far as we know from existing records.

Severnaya Zemlya, in its northern part, is devoid of high mountains or alpine scenery. Its bare basalt headlands, with ice-worn tops and steep slopes, connect it to the same geological formation as Franz Josef Land. But there the similarity ends. Unlike the group of islands to the westward, the northwestern coast of Severnaya Zemlya is ice-locked the entire year. It is deeply entrenched in the polar cold, ice submerging all but the very tops of the uplands. Because of the absence of any great heights in this section of Severnaya Zemlya the glaciers gradually merge into the sea ice, and it is difficult to detect where the one leaves off and the other begins. Few or no icebergs can be produced under such conditions. Motion of the glaciers was well indicated in one place, however, where a projecting

tongue, pushing out into the sea ice, had cracked it apart for a long distance.

The northeastern side of Severnaya Zemlya appeared to be less icebound than the west. Several broad U-shaped valleys in the east were bare of snow, and through them ran streams of water, 50 to 100

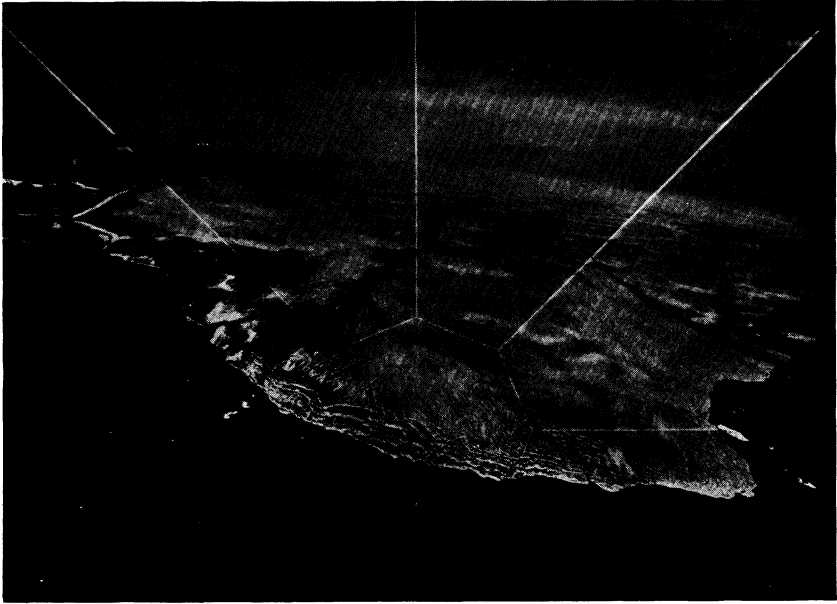


FIG. 9.—Glacier entering the sea on the east coast of Novaya Zemlya. The width of the glacier is about seven kilometers. (Photograph by Aschenbrenner.)

meters wide, draining the inland ice. There was also a slight coloring to the valley bottoms, probably indicating the presence of mosses and lichens; but from our altitude of 3000 feet nothing certain can be stated. No animal life was to be seen. The northwestern slopes of Severnaya Zemlya are skirted in one place by a gently sloping coastal plain, the strandflat of the Norwegians, some 15 or 20 miles in width and in height several feet above the level of the sea ice. This may be evidence of previous transgression and subsequent uplift; such a movement has been recognized in the Taimyr Peninsula to the south.

About 7 a. m. the course was swung to the left, and it was announced we would pay a visit to Kamenev Island. This little island, located in latitude $79^{\circ} 6' N.$, longitude $97^{\circ} 12' E.$, about 15 miles off the western coast of Severnaya Zemlya, was discovered in 1930 by the Russian ice breaker *Sedov*. A radio and meteorological station has been established there, and it was an exploring party from Kamenev Island this spring that succeeded in making the first astronomical determination of the northernmost extremity of Severnaya Zemlya: latitude $81^{\circ} 16' N.$, longitude $95^{\circ} 38' E.$ On our approach to the

western coast, however, fog was encountered, and as it would be useless to attempt locating Kamenev Island under such conditions the dirigible was headed southward along the western coast line of Severnaya Zemlya.

The strandflat in this section, like that in the northwest, extends back as a broad, flat, raised shelf, some 10 or 20 miles in width. Many glacial streams in a myriad of tortuous patterns drain across it from the inland ice. At 9.50 a. m. we swung to the eastward and followed the western coast line where it forms a reëntrant opposite Schokalsky Bay on the east. No land could be seen bridging this gap, and from our altitude and position in the *Graf Zeppelin* the sea ice could be seen for several miles to the eastward without interruption. It is believed, therefore, that Schokalsky Bay is in reality a sound that transversely divides Severnaya Zemlya into two islands, oddly resembling the way in which Novaya Zemlya is cut midway of its longitudinal axis.

We proceeded southward to the southern extremity of Northern Land and Vilkitski Strait. Ellsworth radioed the following message to the American Geographical Society:

Surveyed southwest coast of Nicholas II Land this morning and find that Schokalsky Channel divides this ice-locked land into two large islands.

THE TAIMYR PENINSULA

It took us one hour to cross the strait to Cape Chelyuskin, and because of fog we were unable to observe ice conditions therein. At 1 p. m. both the fog and the coast were left behind as we flew inland to clear atmosphere, approaching Taimyr Lake. It was astonishing to see the great change wrought by an hour's flight. The ice and snow of Severnaya Zemlya were now replaced by the dark browns, greens, and reds of the tundra country. Far to the eastward near the horizon could be discerned the rounded summits of an unmapped range of mountains. At 2 p. m. we began a camera survey of Taimyr Lake, heading westward parallel with its longest axis. Here on the tundra some of the first animal life of the cruise was seen. In several of the lakes birds as large as geese were feeding, and for many miles along our course to Dickson Harbor we flew over hundreds of reindeer. They were distributed either singly or in herds of as many as 30 or 40. Unfailingly they would scatter in every direction badly frightened by the approach of the airship. No signs of human life were perceived, and it is stated that the country north of the Byrranga Range, in these longitudes, is practically uninhabited by man and virtually unknown. The Taimyr Expedition of the Russian Academy of Sciences crossed farther south in 1928 on a route from Dudinka on the Yenisei River to the Khatanga and, striking north to Taimyr Lake, followed the southern shore of the lake to its eastern extrem-

ity.¹⁰ As A. Tolmachev, leader of the expedition, points out, no exploration had been made in this interior country since Middendorff's expedition of 1843.

At 10 p. m., July 28, we arrived over the Russian trading post of Dickson. This place marks the normal navigational limit for ordinary trading steamers from the westward during the short sum-

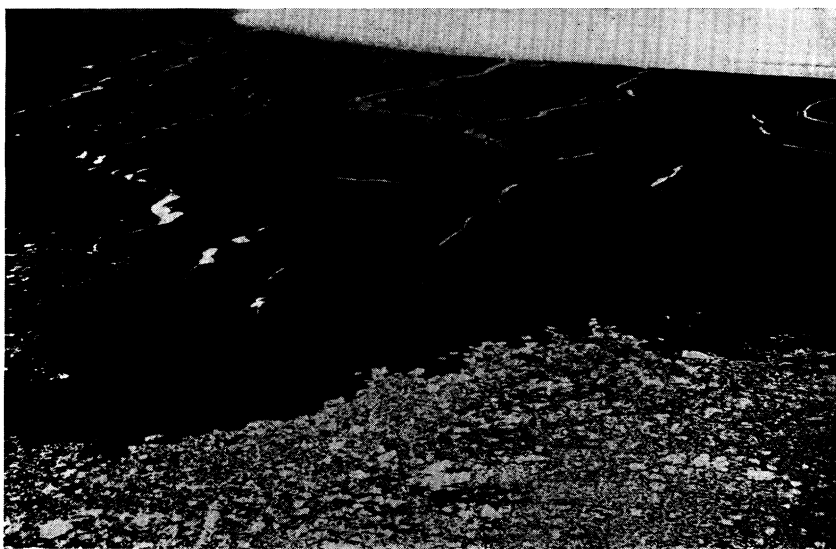


FIG. 10—The northern end of Novaya Zemlya showing inland ice, the bare land belt, lanes of open water, the sea ice in the foreground. (Photograph by Basse.)

mer season. Three ships of the trawler type were moored to a small pier near the station, and a Dornier-Wahl seaplane was hauled up on the bank close by. The Soviet government maintains three of these planes on a summer patrol between Dickson and Vaigach for the safety of life and property. After dropping some sacks of potatoes and mail by parachute that had been intended for Kamenev Island station, we headed northwestward across Kara Sea for the northern end of Novaya Zemlya. A fifty-mile-wide belt of open water was traversed off Dickson before we came over loose and scattered *glaçons* of pack ice. The character of the ice was similar to that met south of Franz Josef Land two days previously—flat, free from pressure ridges, and also probably dating from last winter's freezing. Much of the ice, even 100 miles out from land, was covered with a deposit of dark brown mud; some of the *glaçons* seeming to be composed of as much mud as ice. Obviously this was ice formed either in the shallow bays or large rivers, or both, along the Russian coast. As we neared the Novaya Zemlya side of Kara Sea the ice became whiter and free

¹⁰ A. Tolmachev: Die Taimyrexpedition der Akademie der Wissenschaften von U. S. S. R. im Jahre 1928, *Arktis*, Vol. 2, 1929, pp. 33-38.

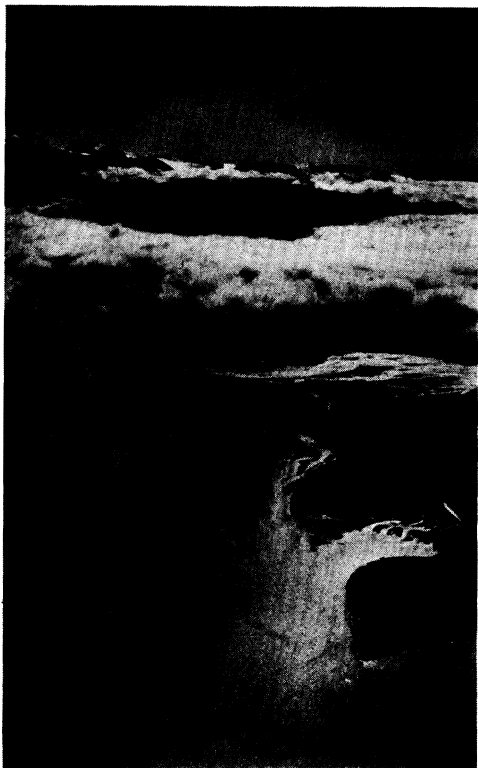


FIG. 11—A small river delta on the east coast of Novaya Zemlya. Melting snow and drainage from the near-by inland ice form these tortuous streams across the bare strandflat. (Photograph by Basse.)

of mud, as well as more tightly packed together. A belt of open water five to ten miles in width separated the pack ice from the Novaya Zemlya coast.

NOVAYA ZEMLYA

At 4.30 a. m., July 29, we reached Cape Jelaniya, the northern tip of Novaya Zemlya; and, rising to 4000 feet, the *Graf* headed southwestwards along the longitudinal axis of the island to carry out a camera mapping survey en route. The northern end of Novaya Zemlya displays a bare coastal fringe five miles or more in width before the edge of the inland ice is met. Somewhat farther south, on the eastern coast, the inland ice extends directly to the sea as the four Norden-

skiöld glaciers, in latitude $75^{\circ} 30' N$. About fifty small bergs were scattered in the offing of the southernmost glacier of this group.¹¹ Directly inland from the Nordenskiöld glaciers the inland ice slopes rapidly upward towards a high ridge where only scattered summits here and there protrude above the surface. This was the first alpine scenery met on the voyage.

From the Nordenskiöld glaciers to Matochkin Shar, a distance of 200 miles, we skirted the eastern coast of Novaya Zemlya. It is estimated that ten glaciers were observed, and about two hundred icebergs that had calved were drifting in the coastal waters. Practically all of the icebergs were of small size, probably none over fifty to seventy-five feet in height, and most of them, considering their position with relation to the glaciers, appeared to be drifting southward more or less parallel to the coast.

¹¹ Compare R. Samoilovich: Explorations in Novaya Zemlya and the Barents Sea Executed by the Institute for the Exploration of the North, *Arktis*, Vol. 1, 1928, pp. 2-11. A full account in Russian is given in Novaya Zemlya, *Trans. Inst. for Exploration of the North*, No. 40, Moscow, 1929, reviewed elsewhere in this number of the *Geographical Review*.

At 8.30 a. m. we arrived off the entrance to Matochkin Shar and passed through to the Barents Sea end of the strait at 9.15. The channel presents beautiful scenery and affords a magnificent cross section of the folded rocks of this continuation of the Urals.¹² Our course from here doubled back to Schubert Bay on the east coast, and from there we headed southwestward for the southern cape of Goose-land, which we passed at noon. By this means the southern boundary of the inland ice was determined. It is interesting to compare these crossings with the ski crossing of Dr. Holtedahl's party at a very favorable location from Mashingi Fjord to Zwolke Fjord and

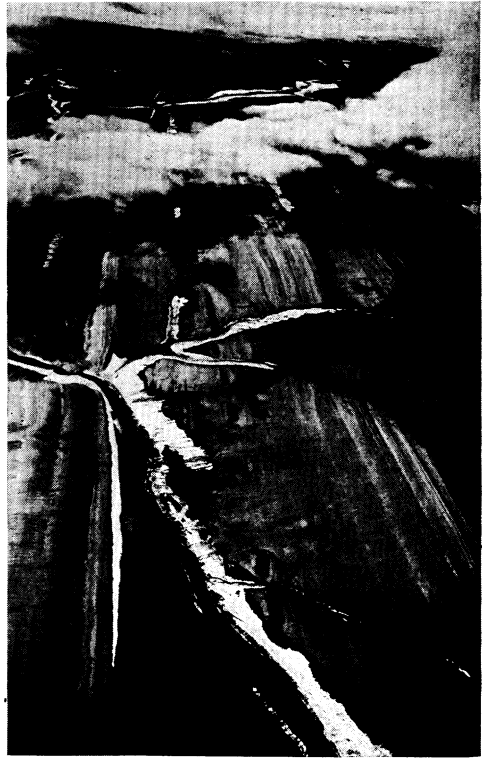


FIG. 12—An old glacier bed in the northern extremity of Novaya Zemlya. (Photograph by Basse.)

back, which was accomplished in six days in the summer of 1921.¹³

The ship was now placed on 215° true, and with quartering winds from the north-northwest the speed was such that at 7 p. m. this same day we were passing over Archangel. Leningrad wished to greet us again; but at the last moment a stop was considered inadvisable, and we continued directly to Berlin. The *Graf Zeppelin* stopped at Templehof field for a half hour, then left for Friedrichshafen, the final destination, which was reached at 5 a. m., July 31, 1931.

Results of the Expedition¹⁴

CONTRIBUTIONS TO THE MAP

One of the most important contributions of the *Graf Zeppelin* expedition was the correction of existing maps. The installation of

¹² See O. T. Grønlie: Contributions to the Quaternary Geology of Novaya Zemlya, *Rept. of the Scientific Results of the Norwegian Expedition to Novaya Zemlya 1921*, No. 21, Oslo, 1924; Olaf Holtedahl: On the Rock Formations of Novaya Zemlya, *ibid.*, No. 22, Oslo, 1928.

¹³ Olaf Holtedahl: A Crossing of Novaya Zemlya, *Geogr. Journ.*, Vol. 59, 1922, pp. 370-375.

¹⁴ Preliminary statements of results are the subject of several articles now appearing in appropriate scientific journals. The more detailed reports with data worked out will be published later in *Arktis*.



FIG. 13—The mountains of Novaya Zemlya. These tops protruded through the inland ice along the meridional ridge of the island. Note the shadow of the *Graf Zeppelin* on the ice. (Photograph by Basse.)

two of the latest approved German mapping cameras was one of the most important features of our equipment and marks, moreover, a great advance over previous aircraft expeditions to the Arctic.¹⁵ Reference has already been made to the fact that Albert Edward and Harmsworth Islands, in the northwestern sector of Franz Josef Land, could not be found. A bare possibility, suggested by Eva Island, is that these islands, if similarly low and ice-covered, might likewise be screened by pack ice. Several small islets not recorded on present-day charts were discovered off the entrance to Rhodes Channel, but for that matter similar unknown islets undoubtedly lie scattered quite

plentifully throughout the Franz Josef Land group. The subject of photogrammatic survey in Franz Josef Land was, particularly, Alexandra Land and a portion of Prince George Land.

The photogrammatic material secured by the *Graf Zeppelin* in Severnaya Zemlya consists of exposures from the northwest coast to Matusevich Bay, on the east coast, thence westward towards Kamenev Island, and then southward past Schokalsky Strait to Taimyr Lake. Fog was encountered along various parts of this track, so that it is not definitely known how much of this material is usable. No statement can yet be made regarding the location or the form of the unknown western half of Severnaya Zemlya. Only one navigational line of position was obtained in this region, and since it runs more or less normal to the general trend of the western coast it alone furnished little information. If the mosaic map of photographs can be referred to an astronomically known point, such as Matusevich Bay, then an

¹⁵ A discussion of the method by Dr. Aschenbrenner will appear in a succeeding number of the *Geographical Review*.

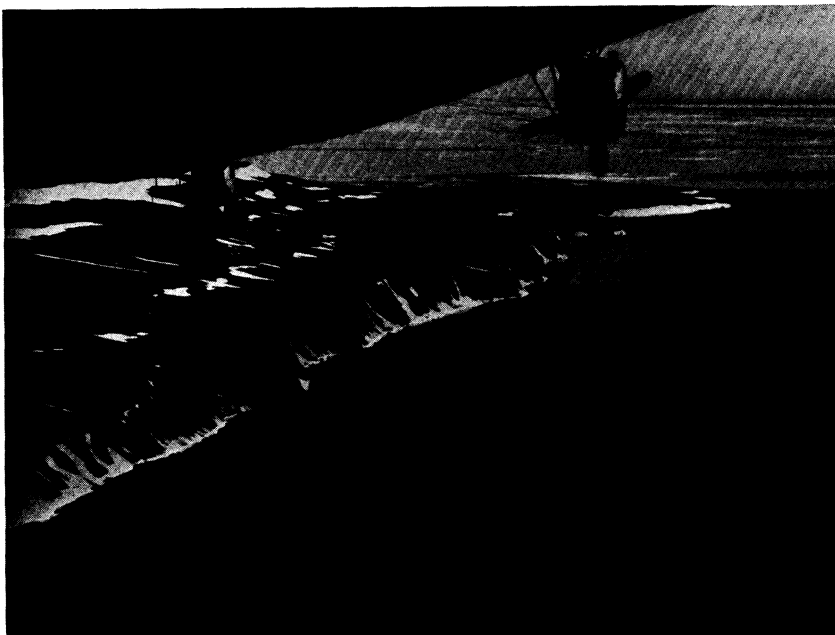


FIG. 14

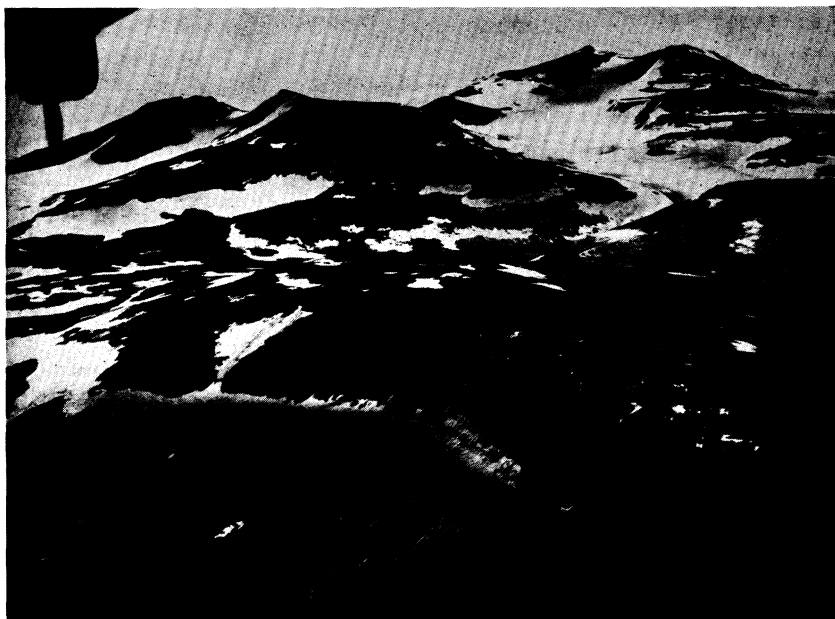


FIG. 15

FIGS. 14 and 15—Matochkin Shar (Matthew Strait), Novaya Zemlya. Figure 14 shows the eastern entrance, Figure 15 the northern side, of the strait. Figure 15, taken about halfway through the strait at an altitude of about 1000 meters, shows the height to which the meridional ridge of Novaya Zemlya rises. (Photographs by Aschenbrenner.)

area of considerable extent can safely be added to our existing maps. Naturally the results of this particular survey, covering one of the "blind spots" of the Arctic, will be awaited with particular interest.

Mountains about 1200 meters in elevation, unrecorded on our charts of Taimyr Peninsula, were sighted in the vicinity of latitude $75^{\circ} 40' N.$, longitude $101^{\circ} 30' E.$ The contour of Taimyr Lake on existing maps also will be modified somewhat by the photographs made from the *Graf Zeppelin*.

In Novaya Zemlya the northern and southern limits of the inland ice were photographed with the mapping cameras, as also were unrecorded mountain peaks that protrude through the ice along the meridional ridge of the island in its northern part. The unexplored section of the eastern coast of Novaya Zemlya for a distance of 120 miles from Rusanov Bay southward to Matochkin Shar was also the subject of survey.

METEOROLOGICAL DATA

The *Graf Zeppelin* expedition, unlike all other aircraft explorations of the Arctic, was made during midsummer, a season usually attended with much fog and low visibility. However, it seemed that given certain winds and pressure conditions this handicap could be avoided: and we were fortunate in being able to take advantage of favorable meteorological conditions.

Our start from Leningrad on the morning of July 26 was purposely delayed until the receipt of the morning observations. A disturbance of considerable intensity had been centered over Novaya Zemlya, giving Franz Josef Land a strong northeast gale. The morning's map showed an area of high pressure over the White Sea, while to the westward pressure was low from Norway towards Iceland. The fact that the disturbance in the Kara Sea was moving off to the eastward allowed us to begin the northward flight. Moreover, the sooner we started the better, for the easterly advance of another low from the direction of the Gulf Stream Drift would, it was predicted, bring low visibility and fog all too soon. Fortunately, such a development failed to materialize, and instead a large mass of polar air invaded southeastwards, forming a ridge of high pressure with the anticyclone previously noted near Archangel. The slow eastward movement of the pressure system during the following three days resulted in a high barometer and an unusually clear atmosphere for the region in which we worked. The winds were relatively light and always had a northerly component. Some restricted areas of fog were encountered, but they were always of small altitude, not much over 600 feet, with the top well defined. The construction of isobaric maps three times daily on the *Graf Zeppelin* is of the utmost importance: to take advantage

of the knowledge thus gained of the continually varying atmospheric conditions spells successful navigation with lighter-than-air craft.

The air temperatures at our altitudes in the Arctic varied from a minimum of 2.2° C., recorded somewhat south of Franz Josef Land to a maximum of 11° in the southern part of Novaya Zemlya. Considerable inversions were recorded by the thermometers, one of which was suspended at various distances below the dirigible, in a stream line metallic case. A routine meteorological record was maintained throughout the cruise.¹⁶

One of the most interesting instruments with which the *Graf* was equipped for this flight was the so-called Molchanov balloon, invented by Professor P. A. Molchanov.¹⁷ Briefly, it consists of a large sounding balloon from which is suspended a case containing a small radio transmitter, thermometers, and a barometer. Connecting an electric battery circuit causes the changes in the temperature, the humidity, and the pressure to be communicated to the transmitter, which in turn broadcasts by radio a coded sequence of signals. Although such balloons with their apparatus have previously made several ascents, it was quite another matter to launch one successfully from the *Graf Zeppelin* with her five motor appendages. This problem was finally solved by weighting the Molchanov balloon and releasing it through a trapdoor near the keel of the mid-section of the ship. After dropping clear of the hull one hundred feet or so the weight was automatically loosed, and the balloon was free to begin its ascent. Of course, after the balloon is once released there is slight possibility that either the balloon or its instruments, costing at least two hundred dollars, will be recovered. Three successful ascents were made with Molchanov balloons during the Aeroarctic expedition: one east of Franz Josef Land, one over Severnaya Zemlya, and one in the vicinity of Vaigach Island.

OBSERVATIONS ON EARTH MAGNETISM

Throughout the flight frequent observations (every four hours north of Leningrad) were taken of the intensity of the horizontal force of the earth's magnetism. These determinations were made by means of the "double compass," loaned for use on the *Graf Zeppelin* Expedition by the Carnegie Institution of Terrestrial Magnetism of Washington, D. C.¹⁸ The *Italia* had a similar instrument which was lost when the dirigible was destroyed in the Arctic in May, 1928. The double compass, in order to record accurate determinations of

¹⁶ See *Fahrtbericht des "Graf Zeppelin," Arktis*, Vol. 4, 1931, pp. 39-41.

¹⁷ P. A. Molchanov: *Problems and Methods in the Investigation of the Atmosphere in Arctic Regions*, pp. 51-60 in "Transactions of the Second Polar Conference, Leningrad, June 18-23, 1928," Leningrad, 1930. [In Russian: the original report of the conference, which is less full, was published in German.]

¹⁸ A description of the instrument and the results of earlier observations made on the *Graf Zeppelin* are contained in *Terrestrial Magnetism and Atmospheric Electricity* for December, 1930.

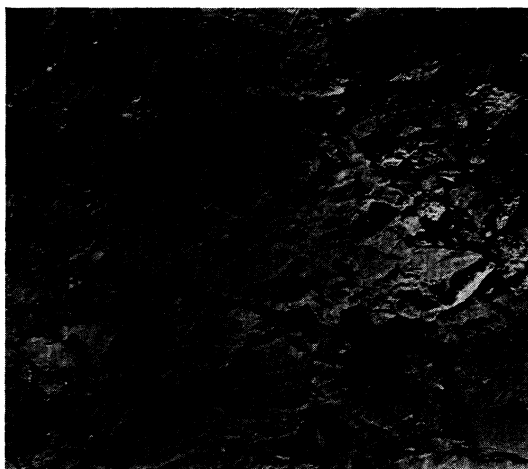


FIG. 16.—Pack ice about 45 miles south of Franz Josef Land. The pools of water on the ice cakes indicate summer melting. (Photograph by Basse.)

the horizontal intensity, requires a steady platform. These conditions were for the most part satisfied on the *Graf Zeppelin* except when the ship was changing course or flying in bumpy air. Over the ice and water in the Arctic the air appeared to be very quiet, and double observations agreed, as a rule, within 0.0020 of the value of H with each other. In the vicinity of Severnaya

Zemlya, where the horizontal intensity is weak, the accuracy of observations necessarily was less. The instrument was secured to the floor of the first cabin on the port side abaft the living-room quarters in the forward gondola of the *Graf*. In order to eliminate all local sources of attraction, aluminum berths were substituted for the iron ones in this room, and all other iron or steel objects were also removed.

A few determinations of the deviation of the total force of earth magnetism were also made, and these indicated a difference in many instances as great as two or three degrees from the values shown on the navigational charts.¹⁹ In one locality a difference of six degrees was noted on the ship's magnetic compass from that which was printed on the chart, while another test in Franz Josef Land showed a close check between compass error and local variation. There was some speculation as to the action of the gyrocompass, with which the *Graf Zeppelin* is equipped, when we approached the northern end of our flight, it being stated that near the pole the gyro would vary considerably from the geographical meridian. Although we did not proceed farther north than latitude 82°, there was no appreciable failure.

OCEANOGRAPHY AND ICE OBSERVATION

Little or nothing could be undertaken in the oceanographical field. The original program of Aeroarctic's airship expedition under the leadership of Nansen reserved a prominent place for oceanography. It was proposed to lower sonic sounding apparatus from the belly of

¹⁹ A letter from Dr. Ljungdahl states that he found errors in the deviation as great as 20° in the eastern part of our area.

the dirigible into open water areas of the polar cap ice and thus while the ship hovered there obtain the depth to the sea bottom. Because of the difficulties inherent in such maneuvering no observations of this nature were attempted in 1931. Subsurface oceanographic observations such as are made by a vessel at sea would, moreover, be quite impractical if not impossible to carry out from a dirigible either in the air or on the water.



FIG. 17—White Islands, Franz Josef Land. Note front of inland (glacial) ice and pack (sea) ice. (Photograph by Basse.)

On the other hand an excellent opportunity was afforded not only for immediate personal observation of the ice from a point of vantage but also for the securing of a permanent camera record for later study with greater care and at more leisure. The photographic material has yet to be arranged and classified under such headings and sub-headings as: character, age, surface features, pattern, distribution, percentage of open water to ice, and drift.

One of the important results of the ice observation was to point out the conditions existing around the northern section of Severnaya Zemlya. Here we found the land completely ice-locked towards the sea, with the pack pushed in against the coast so tightly that it coalesced with the ends of the glaciers. The heaviest sea ice was found in the region adjacent to and northwest of northern Severnaya Zemlya. But even there the ice had not the rugged character belonging to the heavier, older polar cap ice. In fact the relative lightness and flatness of the sea ice over the entire length of our flight classified it as belonging to the pack-ice zone intermediate between the polar cap ice of the central basin and the fast ice of the coastal shelves.²⁰

NAVIGATION

A total of 23 sun sights and one moon sight were taken during the flight. Weather conditions were unusually favorable for good observations except for temporary interruptions from fog. The sextant

²⁰ A more detailed report on the subject of ice observation will be published in this year's annual bulletin of the U. S. Coast Guard entitled "International Ice Observation, Ice Patrol, and Derelict Destruction Service (1931)."

used for measuring the altitudes was the bubble type manufactured by C. Plath of Hamburg, Germany. From experience with the use of a bubble sextant on shipboard it was found that a dirigible airship provides a much steadier platform. A skilled observer under ordinary air conditions on a dirigible is able to control the bubble to errors of altitude not greater than four or five minutes.

The American Geographical Society supplied us before the expedition started with polar projection charts, together with tables, and a celluloid template containing arcs of various altitude circles, all to be used in connection with a short method of polar navigation.²¹ The simplification of this method rests largely on the selection of the geographical pole as the assumed position of the observer. Since we did not approach the pole nearer than latitude $81^{\circ} 50'$, the method was not considered so feasible. The facilities of navigational work on the *Graf Zeppelin* are practically the equal of that of a sea ship, and unlike an airplane there is ample table space for books, charts, and plotting instruments. Good results were obtained with the use of U. S. Hydrographic Office Publication No. 209 entitled "Position Tables for Aerial and Surface Navigation," and the lines of position were drawn in the usual manner on the ordinary plotting sheets embracing the required latitudes. Advantage was taken to cross the astronomical lines of position with isomagnetic lines of horizontal intensity from values determined by the double compass and guided by Fisk's charts,²² but the reliability of the isomagnetic lines is, of course, questionable.

CONCLUSIONS

It is all too early yet to form any definite conclusions regarding the place the work of this expedition will take with other scientific investigations in the Arctic. It was designated as a preliminary cruise to a longer flight to take place either in the summer of 1932 or 1933. The U. S. Coast Guard, with its International Ice Patrol researches, is for one much interested in these airship investigations in the Arctic. It hopes to see a successful flight along the iceberg-glacier fronts of Baffin Bay and to realize a camera study of the iceberg distribution in West Greenland waters. The Aeroarctic Society deserves much praise for what has been accomplished: not only in outlining plans for a systematic study of the Arctic's many problems, but now as a result of patience and persistency, it may point with pride to this, its first expedition.

²¹ This method is described in Sir Hubert Wilkins: *The Flight from Alaska to Spitsbergen*, 1928, and the *Preliminary Flights of 1926 and 1927*, *Geogr. Rev.*, Vol. 18, 1928, pp. 527-555.

²² See Harlan W. Fisk: *Isomagnetic Charts of the Arctic Area*, *Trans. Amer. Geophys. Union*, *Twelfth Ann. Meeting, April 30 and May 1, 1931*, National Research Council, Washington, 1931, pp. 134-139.