The British Arctic Air Route Expedition.

By H. G. Watkins.

The object of the British Arctic Air Route Expedition was to investigate the possibilities of an air route between England and Canada accross the Arctic via the Faeroes, Iceland, Greenland, Baffin Island, and Hudson Bay. The advantage of this route over the direct crossing of the Atlantic would be that a long and dangerous sea crossing would be avoided and the distance would be less, since the Arctic Route would practically follow the Great Circle route between Scotland and Winnipeg.

The least-known part of the proposed route was the east coast and central Ice Cap of Greenland.

It will be best to start with a brief summary of the work and journeys done by the expedition in Greenland. This list will make the narrative easier to follow.

The base was on the east coast of Greenland, about 40 miles west of the island of Angmagssalik.

1 s t J o u r n e y.—Survey af the coast from Angmagsalik to Kangerdlugsuak.

This was done in the summer of 1930. The Q u e s t, motor boats, and a seaplane were used. About 200 miles of coast-line were mapped and a strip of air photographs of this whole coast-line was taken. These photographs are oblique and take in most of the mountain country between the sea and the Ice Cap. A high range of mountains was discovered just north of Kangerdlugsuak. Apart from the mapping, a careful geological and ornithological survey was made on this journey.

2 n d J o u r n e y.—A journey was made in September and October 1930 on the Ice Cap. The party went 125 miles inland in a

*) The Royal Danish Geographical Society takes this opportunity of thanking the Royal Geographical Society for favours shown in connection with the present article by H. G. Watkins.

north-west direction from the base. From here the party turned south and followed the highest part of the Ice Cap for 100 miles, then turned out to the coast and back to the base. A careful record of the height of the Ice Cap was kept and meteorological observations were made throughout the journey. Total length of journey, about 370 miles.

3rd Journey.—An attempt to reach Kangerdlugsuak by sledge in the early spring, 1931. This failed owing to the bad blizzard.

Fig. 1. H. G. Watkins in kayak.

4th Journey.—To the Mount Forel district (about 100 miles north of the base) in late spring. This journey resulted in the survey of the mountain region surrounding Mount Forel, an accurate determination of its height, and an attempt to climb it. The party did not reach the top, but succeeded in reaching the highest point ever attained in the Arctic. A geological study was made in this region and meteorological observations were kept on the whole journey. Total length of journey, about 360 miles.

5th Journey.—The crossing of the Ice Cap from the base to Ivigtut on the south-west coast, July 1931. The journey was made down the eastern edge of the Ice Cap as far as Umivik, and thence across to Ivigtut. Height observations were kept the whole time, also meteorological observations. Several new nunataks were discovered. Total length of journey, about 500 miles.

6th Journey.—Across the Ice Cap from the base to Holsteinsborg on the west coast, late summer, 1931. Height observations and meteorological observations were kept the whole time. The journey

also demonstrated the possibility of a new form of travel, as Eskimo kayaks were carried across the Ice Cap on the sledges so that the party could reach the settlement (a journey of about 90 miles by sea from the edge of the Ice Cap). Total length of journey, about 470 miles.

7th Journey.—From the base round the south-east coast of Greenland to Julianehaab on the west coast. Detailed mapping was done on the first 140 miles of the journey (as far as Umivik). A strip of air photographs had already been taken from the base to Umivik. These photographs were used for filling in detail on the ground survey. An island about 40 miles long was discovered. A new method of arctic summer travel was used. The journey was done in two 18-foot boats fitted with outboard engines. Since petrol for 600 miles had to be carried, very little food could be taken. Instead of food kayaks were taken and food for the journey was secured by hunting seals with the kayaks and harpoons. Total length of journey, about 560 miles.

Apart from these journeys, a careful survey was made of the district round the base and also the southern part of Sermilik Fjord, and air photographs were taken of all this country. Detailed geological and ornithological work was also done round the base and Angmagssalik. Meteorological observations were kept at the base for the whole year.

A station was established on the highest part of the Ice Cap between the base and the west coast. This was about 125 miles from the base. Continous meteorological observations were kept at this station for seven months.

Flying was carried out during the summer and winter, for the purpose of reconnaissance, air photography, and transport of supplies.

The expedition consisted of fourteen men: H. G. Watkins, leader; J. M. Scott, in charge of sledge dogs; A. Courtauld, surveyor; Captain P. Lemon, R.E., wireless officer; Flight-Lieut. N. H. D'Aeth, R.A.F., chief pilot; Surgeon Lieut. Bingham, R.N., medical officer; A. Stephenson, chief surveyor; L. R. Wager, geologist; J. R. Rymill, surveyor; F. S. Chapman, ornithologist; Q. Riley, meteorologist; W. E. Hampton, engineer and second pilot; Flight-Lieut. I. Cozens, R.A.F., photographer; Lieut. M. Lindsay, Royal Scots Fusiliers, surveyor.

Survey

A. Stephenson.

The surveys of the expedition can be divided into three branches:

1. A coastal survey from Kangerdlugsuak to Umivik.

2. An inland survey of the coastal mountains.
3. A survey of the general features of the Ice Cap, wherever possible.

1. The Coastal Survey.—This was the most important section of the survey. We intended to re-map the coast from Kangerdlugsuak in lat. 68° 02' N. to Umivik in 65°, using the existing maps of Gustav Holm and G. C. Amdrup as a basis. Owing to the steep and rocky nature of this coast it was difficult to decide on the best method. Finally, we adopted, on the suggestion of Professor Debenham, a small artillery range-finder for measuring the base, and carried on with a planetable triangulation, using the range-finder wherever triangulation was impossible. Further detail was to be inserted from air photographs.

For an explanatory survey on 1/250,000 this proved very satisfactory. The range-finder was a Barr and Stroud 80 cm. artillery pattern, which gave results within plottable error at distances between 2000 and 3000 yards, and very good approximate results up to 6000 yards. Frequently we made intersections of points previously fixed by the range-finder, and the two agreed.

The coast from Kangerdlugsuak to the base was surveyed in the summer of 1930 by Courtauld, Chapman, and Stephenson. On the way north, while the Quest remained in Lake Fjord and the aeroplane party were taking photographs, the survey party mapped from Kangerdlugsuak to Cape Gustav Holm, travelling in a 16-foot whaleboat with an outboard engine. On this journey we were working to our own time, the ice conditions were favourable, and the coast was well indented with bays which facilitated fixing detail. The fjords were also straightforward to map, since only one measurement was made across the head and then a triangulation was carried down the length of the fjord. Occasional islands off the coast facilitated triangulation and decreased dependence upon the range-finder. We consider our map of the first strip of coast accurate to 500 yards. In the Kangerdlugsuak section conditions were similar, and a like order of accuracy can be expected.

Working south from Kangerdlugsuak conditions were different. We were travelling with the Quest and speed was essential. For the first 50 miles, as far south as Aggas Island, the ice conditions were bad, and even when the coast was accessible it was unsuitable for landing. Hence we had to work from islands off the coast, using the range-finder to determine longer distances than usual. This meant that our scale was unreliable, but the detail relatively accurate. The map has been adjusted to the astronomical positions. Amdrup had

made frequent observations, and his latitudes agreed very well with ours. The longitudes however did not agree. All our longitudes proved to be farther west than those of Amdrup, on the coast journey, at Angmagssalik, and at the base. All our longitudes depend on W/T signals.

South of Aggas Island the many islands assist triangulation. We were driven in behind Kialinek Island by bad weather, so we mapped the hitherto uncharted mainland and neglected the seaward side of the islands mapped by Amdrup.

From Poulsen's Fjord to Cape Gustav Holm we had to leave a gap, since we were forced to travel after dusk to seek shelter from more bad weather. The coast here however is very plain, and aeroplane photographs show it to agree very well with Amdrup's map. The final map of the coast from Kangerdlugsuak to Cape Gustav Holm, after being adjusted to the astronomically determined positions, should have an accuracy within 1000 yards.

South of Kangerdlugsuak we were hindered rather than helped by the islands. We concentrated on the mainland as far as possible, fixing only prominent points on the islands with detail from the air photographs.

From Leif's Island, south to Cape Dan, we were content with mapping the seaward islands only, as with our limited time and personnel we could not improve on the map made by the native schoolmaster, based on Gustav Holm's original with greatly improved detail.

The coast south of the base to Umivik was mapped in the summer of 1931 by Lemon and Courtauld when travelling south with Watkins to Julianehaab.

Captain Lemon's account says that the preliminary aeroplane reconnaissance had shown that the coast between the base and Pikiutdlek was fairly well surveyed by Gustav Holm's 1884—85 Expedition. Lemon used the same methods as the northern party and the same scale (1/250,000). The first section mapped was from the south side of Kivdlak to Ikermiut, the terminal bases being Kajartalik and Pikiutdliuta. This section was the most satisfactory, and the accuracy should be within 500 yards, except in Pikiutdlip-Ikera and outside the islands of Tasitsek.

The second section between Ikermiut and Kulusuk was the least satisfactory. Triangulation was possible as far as Kangek, but between Kangek and Kulusuk a patent-log traverse and an azimuth only was possible. The inaccuracy in this section may be as much as 2000 yards in places.

The third section, Umivik Bay, was mapped separately on fresh bases and was joined up to the second section by a range-finder and azimuth traverse in the channel between Kulusuk and the mainland. The accuracy of this section should be of the order of 1000 yards.

Oblique aeroplane photographs were taken by Watkins of the whole coast from Kangerdlugsuak to Umivik from a height of 10,000 feet. No mechanical charge was used in taking these plates, so the field of view is not constant, nor the angle at which they were taken. Along the coast there are sufficient fixed points to fill in detail from the photographs with very little loss of accuracy. Inland, detail can only be interpolated approximately. Nevertheless, the complete set of photos gives a very good idea of the extent inland which the mountains reach, and of their approximate area.

During the autumn a survey of the base fjord was done on the scale of 1/63,360. For this a base of 1000 yards was measured by sub-tense methods, and heights were determined with an Indian clinometer. The range-finder was little used in this survey, detail being fixed by plane-table.

The chief survey inland was of the region around Mount Forel, an area quite unknown apart from a few peaks fixed from a distance of 70 to 100 miles by De Quervain in 1912. Unfortunately we had no plane-table with us and we had to make rounds of angles with the theodolite from as many mountains and nunataks as we could. From sketch-maps made at the same time and our photographs we were able to fill in the detail, within the rough thedolite triangulation. The base was measured along a straight ski track, by a sledge-meter, reading to one-tenth of a mile, the mean of a number of runs being taken.

The map was drawn on a scale of 1/63,360, with heights by theodolite, based on datum by the aneroid and hypsometer, reduced by Mr. Mirrlees of the Meteorological Office.

Both on the Forel journey and the journey towards Forel in March and April an attempt was made to map the inland border of the coastal mountains. This was done by taking rounds of angles to the prominent peaks from points 15 to 30 miles apart. Unfortunately the number of peaks that can be distinguished for certain, from two points so far apart, were very limited, and what points we did fix coincided with those fixed by De Quervain. The actual edge of the mountains could not be fixed without travelling well within the crevassed area, which made the speed of travelling too slow and the course too devious. However we obtained a very good idea of the positions of the outlet glaciers, and from the tops of the mountains around Forel

we were able to connect these up with the glacier systems within the mountains, thus adding considerably to the detail of De Quervain's map. Judging from our experiences, both on the west and east coasts, the delineation of the inland border of the coastal mountains is very inaccurate in most parts of Greenland.

On all the Ice Cap journeys meteorological observations were taken three times a day. The pressure was usually read from a Negretti and Zambra or a Palelin aneroid, which registered up to 4570 m and 3050 m above sea-level respectively. These observations have all been corrected and adjusted at the Meteorological Office, and when in combination with the results of Nansen and De Quervain they supply sufficient detail for an approximation to the shape of the Ice Cap in Southern Greenland.

North of the Ice Cap station the inland ice rises to a maximum height of nearly 3050 m in the region of the German centre station. At the Ice Cap station itself and for a distance of 100 miles south of that latitude the height is in the region of 2440 m. Farther south it rises again, and the maximum height reached on the crossing to Ivigtut was 2800 m. At first sight it appears then that there is a trough running across Greenland in the latitude of 65° to 67°, as assumed by De Quervain and by Lauge Koch. This assumption was based on the theory that the maximum height of the Ice Cap was slightly to the east of the centre of the continent, and that the north-south line joining the maximum heights of the various crossings represented the highest part in any particular latitude. This theory does not fit in with the results obtained by Rymill and Hampton on their crossing from the base to Holsteinsborg. On this journey they passed the region of the Ice Cap station at a height of 2440 m, and then continued to rise, and did not reach their maximum height of about 2740 m until about 60 miles west of the supposed summit. From this it appears that the line of maximum height comes south from latitude 71° to 67° slightly east of the middle of the continent, then it swings in to the west for 60 miles in the latitude of 65° to 67°, and finally continues to the south, slightly east of the central line. The latter factor agrees with the position of the maximum height reached on the Ivigtut crossing.

The surface of the ice itself consists of a series of continuously rising broad undulations up to 3 or 4 miles across and 90 or 120 m deep. It is very difficult to determine the direction of these valleys, at they invariably appear to be crescentric and seem to have no connection with the direction of movement of the ice. For a distance of about 60 miles in the centre these undulations are much less notice-

able and the surface is almost flat with little rise or fall. On the east coast the fall of the ice is steeper than on the west coast, with the result that the crevasses are restricted to a much narrower belt on the east. Except at the head of big valleys such as Sermilik Fjord, the crevasses do not extend more than 15 miles from the edge of the Ice Cap; whereas on the west coast they are encountered 70 to 100 miles inland. The difference in slope also accounts for the large difference in the amount of surface water in summer. On the east coast these streams occur, but they are restricted to narrow channels, occasionally collecting into lakes a mile or two in diameter. On the west coast however Rymill and Hampton encountered rivers of thaw water, 40 to 50 feet wide and 4 or 5 feet deep, at a distance of 25 miles from the mountains. Similar conditions were forecasted by Scott's party when they reached the Ivigtut district in July, for even then, a month before the wettest period, there were wider streams and larger lakes to be crossed than on the east-coast in August.

Sledging Rations

H. G. Watkins.

Sledging rations of the B.A.A.R.E. were very different from any previous Arctic or Antarctic rations. I based these rations originally upon those used by Scott and Shackleton in the Antarctic, modified by up-to-date knowledge of dietetics and also by practical experience gained in Edge Island and Labrador.

Daily Food Ration for one Man

H. G. Watkins.

Bovril Pemmican	8 ozs.
Maypole Margarine	8
Plasmon Wholemeal Ship's Biscuits ...	4
Hewitt's Peaflour	2
Plasmon	2
Plasmon Oats	3
Tate and Lyle Cube Sugar	4
Cadbury's Cocoa and Milk Powder	1
Cadbury's Milk Chocolate	3
Horlick's Malted Milk	0.5
Total ...	35.5

Also small quantities of—

Cod Liver Oil.
Dry Yeast Powder.
Lemon Juice.
Essential Salts.

The total value of this ration was about 6000 calories, and it contained correct proportions of carbohydrate, fat, and protein. Vitamins A and D were supplied by the the cod liver oil; Vitamin B by the dried yeast powder, manufactured by Pharmaco Chemical Products, Ltd.; Vitamin C was supplied by the concentrated lemon juice, specially

Fig. 2. The Moth-aeroplane at Angmagssalik.

prepared by Messrs. Lyons. This ration differed essentially from all others in the small quantity of biscuit and the large quantity of margarine (8 ozs.). Reducing the carbohydrate and increasing the fat was the only way to increase the total calorific value of the rations without increasing their weight. There was no difficulty at all in assimilating this extra quantity of fat. In fact, in very cold weather, working hard, we frequently felt we would welcome more margarine.

We soon found that these rations were more than enough for men travelling between 20 and 30 miles a day at low temperatures at a height of about 8000 feet, and towards the end of our time in Greenland wee reduced the rations by about one-third, so that the total amount eaten by one man in a day was 23.6 ozs. This was found ample for all normal winter sledging work. On all future expeditions I would keep the rations per man per day under 1½ lb. I would cut

out biscuit altogether, but would slightly increase the chocolate or sugar rations.

On several occasions sledging parties lived for two months on these rations, and all the men used to feel extremely fit at the end of every journey. Courtauld, at the Ice Cap station, lived for five months on these rations on a reduced scale, and was perfectly fit at the end of it, showing no signs indicating lack of anything essential.

On coast journeys where seal meat can be obtained it is unnecessary and foolish to take any ration whatsoever, since seal meat and blubber supply everything that is necessary to life. And after a week

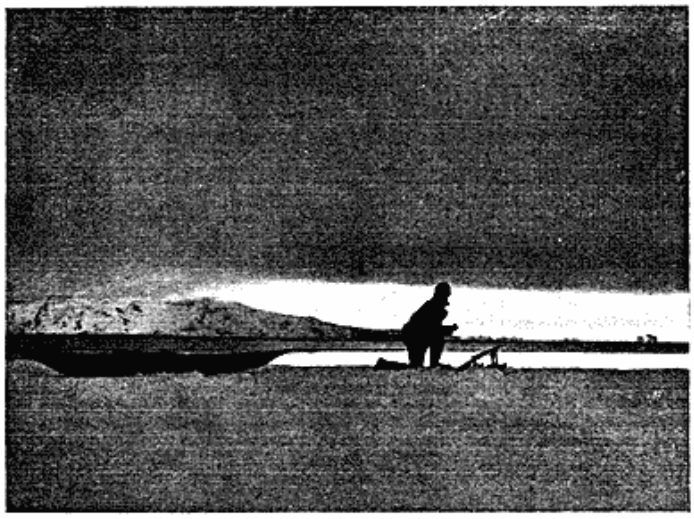

Fig. 3. Seal-hunting.

or so of living on seal meat most of us lost all desire for civilized foods.

The sledging rations for the dogs consisted of a pound of Bovril dog pemmican and a quarter of a pound of Maypole dog fat per dog per day. On the longest journeys in cold weather the dogs kept perfectly fit on these rations. On summer journeys the extra fat is not necessary.

I am deeply indebted to Dr. Zilva, of the Lister Institute of Preventive Medicine who assisted me enormously in the preparation and calculation of the rations of this expedition.

Birds Seen on the Inlandice.

As there seem to be no notes about birds met with on the Greenland Ice Cap, other than an occasional mention of Snow-Buntings by Nansen, I will mention, the birds seen on the various journeys from the base to the Ice Cap station. Lack of space prevents me from

including all Ice Cap journeys. It seems that in spite of the extraordinary number of birds encountered there are at present insufficient data to decide whether birds willingly and regularly migrate across the Ice Cap, or if the following notes are of mere casual wanderers.

The Ice Cap station was in lat. 67° 03' N., long., 41° 49' W., and about 120 miles north-west of the base. It was approximately 2620 m above sea-level.

1930

Aug. 21. Four "dark snipe-sized birds" circled low over the sledges with an incessant sharp note, and went off eastward. This was 85 miles in.

23. Twenty miles farther in a "thick-set puffin-like black and white bird" settled in the snow near the sledges.

Sept. 23. Twenty miles in I heard a Snow-Bunting but could not see it.

26. Thirty miles farther in a Snow-Bunting flew aimlessly westward. Later on I saw five Waders going west. I had a good view, and think they were Grey Phalaropes.

28. Two thich-set "ducks or guillemots" seen 75 miles in, these flew off eastward. Though I was only a few miles to the east of the party that saw them on this day, they did not pass me. Later on I saw a Red-necked Phalarope approaching from the east, calling often.

Oct. 1. One hundred and ten miles in a Snow-Bunting flying west.

2. Four miles farther in a Snow-Bunting heard.

4. A single Gull (species uncertain) appeared from the south-east and flew off north-west.

1931

April 6. Scott found a dead male Snow-Bunting 120 miles in. He could be certain from the snow conditions that it had not been there more than a day.

23. Twenty miles in a Snow-Bunting circled round us and went off east of south.

May 3. One hundred and ten miles in a Snow-Bunting flying east.

8. Sixty miles in a Snow-Bunting flew over us and went off north-west.

10. Several Snow-Buntings 15 miles in.