IMPERIAL COLLEGE

OF SCIENCE & TECHNOLOGY

EAST GREENLAND

1966

THE EXPLORATION BOARD.

I M P E R I A L   C O L L E G E

EAST GREENLAND EXPEDITION

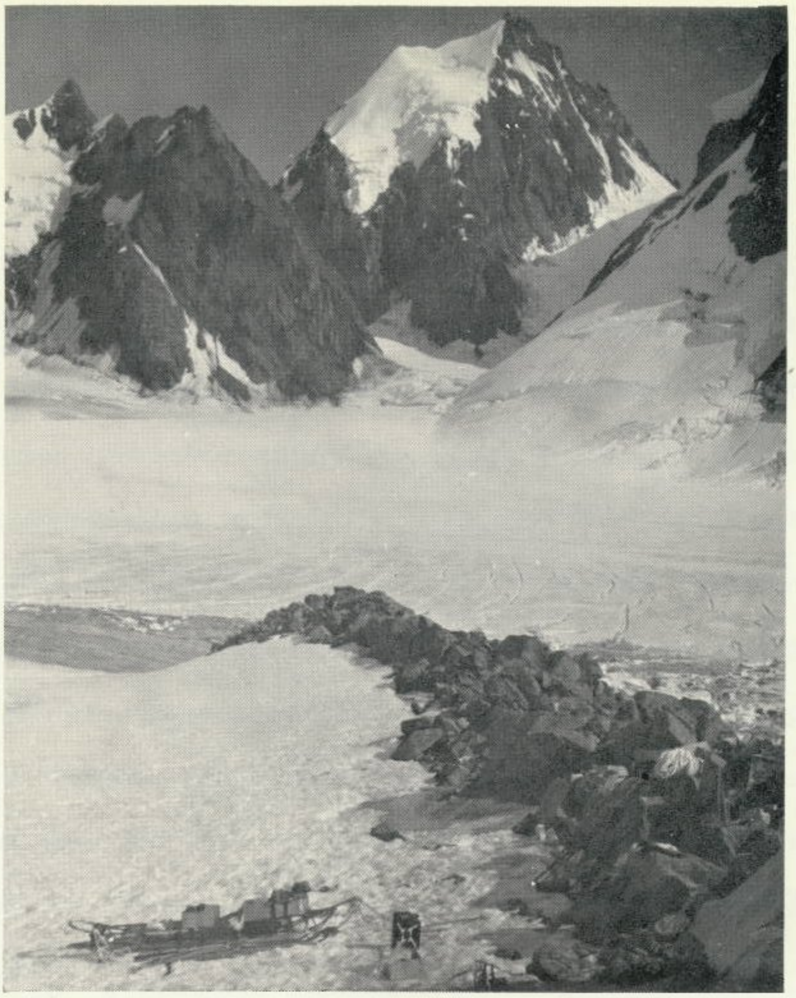
1966

Final Report

Imperial College Exploration Board
Imperial College
London, S.W.7.

CONTENTS

SCHWEIZERLAND EAST GREENLAND
Grd North
Mont Forel
Kristians Gl.
Champs Elysees Gl.
Jura Gl.
Femstjer-
nen
Pourquoi Pas Gl.
France
Midgarrdgletscher
Knud Rasmussens Gl.
Tasissarsik
ANGMAGSSALIK
KULUSUK
GREENLAND
Mt. Forel
KULUSUK
ICELAND
IMPERIAL COLLEGE
EAST GREENLAND
EXPEDITION 1966
Scale 1:1,000,000



INTRODUCTION

Planning for the 1966 Imperial College East Greenland Expedition started in the spring of 1965. Following the success of the College Expedition to the Stauning Alps in 1964 it was decided to try to organise a similar operation during the summer of 1966. Initial plans included expeditions to both the Petermann Peak and Gunnbjoms Field regions, but in each case it was finally decided that the problem of access demanded too ambitious a solution to be feasible.

Instead the mountains around Greenland's second highest peak, Mt. Forel, were chosen. Presenting an interesting, but not insoluble, access problem, they had been the target of several expeditions since 1938 when Forel was climbed. None of these parties however had reached the area (see Section 3).

To overcome the difficulty of transporting the bulk stores into an area seventy miles from the nearest access point on the coast an airdrop was arranged. Food and equipment were parachuted to the site of the base camp on the Paris Glacier. The parachute and non-disposable gear were to be sledged out at the end of the expedition. As will be seen, an unforseen accident caused serious difficulties in carrying out these plans. None the less, seven major and nine minor peaks were climbed by members of the expedition and the basic glaciological programme carried out.

COMPOSITION AND AIMS OF EXPEDITION

The expedition consisted of eight members, three postgraduate and five undergraduates.

G. J. Pert Ph. D.	- Postdoctoral Physics	24	(Leader)
M. C. Clark	- 2nd year Civil Engineering	22	
A. G. Cram	- 3rd year Chemistry	20	
C. D. Dean	- 2nd year Civil Engineering	19	
F. Ekman B. Sc.	- Computer specialist with a Civil Engineering firm	25	
M. H. Key Ph. D.	- Postdoctoral Research Fellow at Royal Holloway College	25	
R. W. Rowe	- 3rd year Physics	21	
J. R. Taylor	- 3rd year Metallurgy	21	

All the undergraduate members of the expedition were from Imperial College. The others were all former members of the College. Key, Ekman and Pert had all been to Greenland before in 1963 in the Stauning Alps[1]. In addition Pert had been to Spitsbergen[2] in 1962. The other members all had considerable mountaineering experience both at home and abroad.

The first problem to be solved by the expedition was the selection of a suitable area in which to attempt the type of work envisaged. As outlined in the Introduction several ambitious projects were considered and rejected. Final possibilities considered were a return to the Staunings, Schweizerland (and the Mt. Forel group) and the Tasennuit fjord region in the south of Greenland. Access to all these districts is comparatively easy as there are nearby airstrips at Mestersvig, Kulusuk and Narssarssuak respectively.

cont/...

The Staunings was rejected for personal reasons. Three members, who had visited the region in 1963, felt they would prefer a change. However, in some ways the Staunings is the finest area. It possesses the best weather and the area is smaller allowing easier travel through it. Unfortunately it is now being rapidly climbed out and thus was not entirely suitable for the type of expedition planned.

The Tasennuit district suffers from bad weather and was therefore rejected.

The Schweizerland district remained as a suitable area. Consultation with the Royal Navy and Swiss expeditions, who were also planning to go to this region, decided us to work in the mountains along the Paris Glacier. These magnificent peaks had been seen and described by Roch in 1938 but had never been attempted. We therefore decided to make de Quervain's Bjerg and Pointe d'Harpon our objectives for the mountaineering programme.

The second half of the expedition was to be devoted to glaciology. One of the major difficulties in any glaciological programme is to measure the depth of the ice in glacier. The ice resistivity technique is a standard geophysical procedure but has not been much used on ice. Conditions on the Paris Glacier seemed suitable for a test of this experiment under conditions not tried before. To obtain a comparison measurement of the depth the surface flow rate was to be measured.

We now had both area and programme, one problem left: how to get there! Since 1938 three expeditions had attempted to reach the Paris

cont/...

Glacier and failed. In 1965 a party of seven Japanese man-hauled into the area, but this method was not suitable for us.to use as we required to get in a considerably larger bulk of equipment than possible in this manner. We thus had to use a somewhat original mode of access. Air-drops had been successfully used in similar expeditions to the Staunings in 1961 and 1963. This seemed the ideal solution to our tramsport problems. And in fact, apart from the difficulties of the return journey, it did present a very satisfactory solution to the problem.

---

1. Imperial College East Greenland Expedition 1963, preliminary report January 1964.

2. Imperial College Svalbart Expedition 1962, preliminary report November 1962.

PREVIOUS EXPLORATION

The mountains of Schweizerland were first seen by de Quervain during his celebrated crossing of the ice-cap in 1912[1]. De Quervain identified Mount Forel, at that time considered to be the highest peak in Greenland, but did not visit the region.

The first attempt on Forel was made by Stephenson and Wager[2] in 1931. During the course of Watkins' Arctic Air Route Expedition, Stephenson, Wager and Bingham sledged from their base camp on Sennilik across the ice-cap to Forel. After climbing minor peaks, Wager and Stephenson attempted Forel, but had to turn back at the base of the summit ice. They found the ice-slope at the top to be extremely hard and difficult and therefore retreated.

In 1937 Paul-Emile Victor, with one Eskimo, sledged from the coast (Depotfjord) to the base of Forel, but was prevented by bad weather from attempting the mountain[3].

In 1933 Roch and the A.A.C.Z. expedition swept in with their dogs from Svoralik. They successfully climbed Forel[4] from the south. On their way out they climbed some of the finest peaks in the region - Lauper's Bjerg, Solvergjoerg, Rotebjerg and Rytterknaegten.

The next party to visit the interior from the coast were the Austrians in 1959. Following the Roch route with dog sledges and Eskimo drivers, they reached Col des Poulies when the dog-team drivers refused to go any further. Man-hauling one sledge, the party continued onward as far as Conniats Bjerg making 24 ascents mainly to the north of the 16th September Glacier[5].

cont/...

In 1963 the Scottish[6] East Greenland Expeditions again set out for Pointe d'Harpon and de Quervain's Bjerg with dog sledges and local drivers. Once again the dogs failed after one day, due to the soft snow on the glacier surface. Despite this the Scots continued their expedition in the local Claedonian Alps and made 24 ascents, 21 being first climbs.

At the same time a Swiss-German expedition using hand-drawn pulkas sledges and skis climbed 44 peaks, of which 40 were first ascents, in the neighbouring ar a around the 16th September Glacier[7].

In 1965 a Japanese expedition at last penetrated to the Forel group again. Using man-hauled sledges they followed the Roch route to Forel. Their attempt of Forel was defeated, like that of Stephenson and Wagner before them, by the severe ice conditions on the mountain[8]. One further point needs to be noted in that during their epic march they found that the glaciers had changed considerably. Ice-falls up which Roch had sledged with no trouble were now impassable even on foot. The Japanese did not have the opportunity to attempt more than Forel before shortage of time forced them to leave.

In addition to these expeditions small Danish parties climbed on the fringes of the area in 1962, 1964 and 1965[9].

References:

1. Medd. om. Gron. 50 1926 p.20-271.

Quer durch Gronlandeis - die Schweizerische Grönland Expedition 1912-1913 E. Münich, E. Reinhardt 1914.

cont/...

2. Northern Lights (F. S. Chapman), Chatto & Windus 1932.

   Geographical Journal 1932, July vol. p. 1-14

   Alpine Journal.

3. Polar Record January 1938 p. 22, 23.

4. Berg der Wett 111 1948 p. 9.

   Alpine Journal XL1 1939 p. 105

   Die Alpen 15 1939, p. 41, 96, 152

   A.Roch and B. Ridemmann

   Quer durchs Schweizerland 1941

5. O.A.V. Jahrbuch 1960 p. 94.

6. Scottish East Greenland Expedition 1963, Final Report 1965.

   Alpine Journal 1964 LX1X 308 p. 127

7. Schweizerisch - Deutschen - Grönland Expedition 1963, Report 1964.

   Die Alpen 1964 40 p. 111

8. Personal communications

9. Personal communications

EXPLORATIONS IN 1966

The full flood of expeditions to the area was however reserved until 1966. In that year there were no less than five mountaineering expeditions working north of Kungmiut.

A Japanese party from Nihon University man-hauled from Svoralik to the mountains around Mount Forel itself, Splitting their party into two three-man groups they climbed several major peaks including Forel, Perfect and Flat Top.

A Swiss party of eight using two dog teams, which they drove themselves, sledged from Semmiligaq up the Haabets Glacier into the mountains east of the Glacier de France, and south of the Champs Elysee Glacier. They climbed about thirty peaks including Lauper's Bjerg and Pusugssivit.

A third method of access was tried by the Royal Navy expedition to the true Schweizerland district west of the Femstjernen. They attempted to sledge into the Femstjernen in the spring with Eskimo dogs and drivers. Once again the latter failed and a dump was established at Conniats Bjerg. The party was however able to continue its programme to Schweizerland on a reduced scale using a food dump laid by the Imperial College Expedition at the north-west corner of the Femstjernen. This expedition climbed 31 peaks around Conniats Bjerg and in Schweizerland, but tragically lost two of their party in accidents.

cont/...

The Imperial College Expedition set its sights on Pointe d'Harpon and de Quervain's Bjerg. The fourth different solution to the access problem was tried here - an airdrop. This was a success and a total of seventeen peaks including Pointe d'Harpon, de Quervain's Bjerg and Flat Top were climbed.

In addition a Swedish-Norwegian expedition worked in the Caledonian Alps region.

ORGANISATION

Initial planning started in the spring of 1964 for an expedition in the summer of 1965. Due to thesis troubles the expedition had to be postponed until 1966. Provisional approval was granted by the Imperial College Exploration Board in 1964 and re-granted in 1965. By October the expedition had received both the approval and support of the Mount Everest Foundation - it was really on!

Several major difficulties remained. The complete financial problem was only solved when the Goldsmiths Company made a block grant to College to aid Exploration in May.

In December an application for approval from the Danish Government was filed with H.M. Foreign Office. By March nothing had happened. Even allowing for official bureaucracy this was a bit much. A phone call set things going; then a letter from Lusaka dated December - the reply to our original letter (had the Rhodesia crisis taken the F.O. to Zambia?) Eventually all was sorted out and the F.O. got things moving. We got approval in April.

One of the big headaches was the air-drop. Thanks to the co-operation of the University Air Squadron we were able to arrange a loan of 'chutes from the Army. The Army also agreed to train three members in dropping techniques and to pack our equipment - one problem solved!

cont/...

Icelandair were prepared to use one of their D.C.3.'s for the air-drop - now only the problem of the ground party.

To prevent loads being blown down the glacier after the drop it was necessary to have a ground party. A party of three were sent a fortnight in advance to Greenland by Icelandair tourist flight, to be at the dropping zone in time for the air-drop. This party would also establish base camp and get the glaciology under way before the others arrived.

At the end of the expedition 'chutes and equipment were to be sledged out. It was planned to make two journeys to Conniats Bjerg - about half-way - to ease the load. Further details about the travel will be found in the appropriate section.

Equipment, food, medicine, gear etc. were each taken in hand by one or two members, who were responsible for it - details in the appripriate section. Ordering was all done through the official college channels.

About April the gear started to arrive and piled up. At the start of June packing started and was just completed when the advance party left three weeks later. Except for some major items (sledge, skis) which had not yet turned up all was ready. Frantic 'phone calls to Norway found them and they arrived just in time for the main party, the advance party unfortunately having to use some old unsuitable skis.

Eventually all was ready and the main part of the expedition finally assembled after a succession of crises and disaster at the quai at Edinburgh.

cont/...

EXPEDITION DIARY

by C.D. Dean

I think the best time to begin is Thursday, 14th July, when the main party of the expedition was assembled in a spare hanger at Reykjavik airport, bivvying beside the nearly-complete parachute loads, still rolling about as a result of the three-day sea voyage on the "Gullfoss" from Leith. The last traces of civilised man had disappeared, and we stood around, padded like an advert for Michelin tyres, waiting for the work to begin. Of course, as in all expeditions, an iceberg-like nine-tenths of the work had already been done before we left London, particularly by Geoff Pert, Mike, Frank and Maurice.

The advance party had left a fortnight ago and, having marched on iron rations into the interior for 80 miles, should have been waiting at a pre-arranged location on the Paris Glacier, ready to receive the air-drop. We were to fly from Reykjavik to Kulusuk Island, then fly into the interior to air-drop the vast majority of our equipment and stores. After returning to Kulusuk, we were then to advance on foot to the Paris Glacier to meet the advance party. Alternative plans had been laid to meet altered circumstances.

Thursday, 14th July. We had already discovered that our skis were without bindings, that the sledge was huge, and that we had lost a food box in transit. The sledge was our greatest worry, but despite the pilot's objections it was cleared for air-dropping the following day by the Chief Engineer, who also authorised the removal of both rear doors from our chartered military-version D.C.3. Our gear was loaded in the

cont/...

afternoon, completely filling the fuselage but for our six seats - five for the expedition and one for a mechanic. We flew out over a cloud-covered sea, eventually breaking through to land on the compacted-dirt airstrip of Kulusuk Island.

We met for the first time Paul Carlsen, the airport chief, and Benny his wireless operator and right-hand man: they stood watching as the two doors were removed and the despatch board was bolted in position. The pilot was still very worried about dropping the sledge, and so were we. However, in a great cloud of dust and swirling turbulence we roared away up the airstrip and into the interior. All worries about the drop were soon dispelled by the fantastic scenery, the finest we had ever seen, but a new difficulty soon emerged. The advance party were not on the glacier. We cruised up and down at 1,000', but there was no sign of them, so as previously agreed we did the drop anyhow. This was fascinating, and a terrific strain as well, hanging on as the pilot circled steeply round at each end of the run, the great hole in the side looking straight down to the glacier, and then action on each run, struggling with the 400 lb. loads, and the rushing and roaring as they left the plane. The whole thing went off perfectly - including the sledge.

We decided to fly out over the route in, but had seen no sign of the advance party when we were called in to Kulusuk Island because of rapidly thickening sea mist. We were left in a cloud of doubt as thick as that at the airport, where, still shouting with excitement,

cont/...

we were once more met by Mr. Carlsen, who took us down to the airport reception room to relax, and then supplied us with a super-luxurious hut to sleep in.

We were now dependent on the local eskimo transport to take us the necessary 30 miles to the far end of Tasissarssik Fjord, where our march began. The boat was to be arranged by Mr. Berg-Sorensen at Angmagssalik, and we could only wait, spending our time on trips to the local eskimo village, Kap Dan, a real "fester-hole" of the first degree, and also getting involved in a rather alcoholic evening with the Danes at the airbase, as well as the Americans at the local Dew Line station.

Eventually, after several abortive false starts, the boat arrived on the afternoon of Monday, 18th July. Although it was only small, it was covered, and we crouched down in a pile of sealskins with our minimum-possible marching gear on the roof. We sailed for six hours through the pack-ice up the fjord, a depressingly monotonous voyage, with low cloud and drizzle. On arriving at the head of the fjord there was great excitement, as the water is very shallow with a good chance of running aground. Although there was a time when we thought we might have to wade ashore with our gear on our heads, we eventually docked at the Royal Naval Expedition's food dump, and unloaded. The boat left, then returned with the only object we had left on board - a bag containing all our eating irons. This was probably the nearest we came to disaster during the whole expedition.

cont/...

The equipment for the march-in was absolute minimum, a Black's mountain tent and two Brigham's Bivvy tents. The first evening was a struggle, firstly trying to find out how to use the Bivvy tents, and secondly because Black's had made a mistake with our order. Inside the bag stamped "Mountain tent", and inside a similar bag stamped "flysheet", was a set of mountain-tent poles - and an Arctic guinea. The whole, as a tent, cannot be recommended, and caused considerable inconvenience and discomfort throughout the expedition. This same evening we got our first taste of the super iron-rations we were to march in on, and they were revolting.

The next day, the 19th, we set out for the Paris Glacier, wondering when, if ever, we would contact the main party. The going was very bad, and the mosquitoes worse. We were soft with city living, and could only make the Scottish expedition's Sodom camp by the evening. The packs were, however, around 70 lbs., and cumbersome with skis on. A further day's travel in bad weather saw us at a camp on the "Sahara" of the Swiss Expedition of 1963. From here we could see a black object out in the great ice-plateau, but we took it for a food dump of the Royal Navy, many of which we had passed already. However it was a dump left by our advance party, with a message explaining the delay owing to bad weather.

Our next day's march, which included the steep Col des Poulies, we had decided to do at night to get better (harder) snow conditions.

cont/...

We struck camp at 3 p.m. and marched for an hour, when we discovered the Swedish-Norwegian expedition, all in fantastically coloured raiments, making a film on the glacier. They gave us tea, and were amazed that we carried none ourselves. We were very impressed by their really lightweight gear, and also posed for their film. After regretfully leaving we rushed off at a ridiculous pace until out of sight, then collapsed. Using ice-axes and crampons, and roped, we achieved the top of the col by 11 p.m. and then ran into the worst going of the whole journey. A hard ice-crust, too fast for us to ski on, and too thin to walk on without breaking through into 18" of soft snow. We carried on for about five miles then stopped, utterly exhausted.

Friday 22nd was our first good day. We skied easily down the 16th September Glacier and camped beneath the Col des Eskimaux, which appeared totally uncrevassed in the odd light. However, the following day disproved this, as we skied roped over soggy snow bridges, trying to get to the top. The steep parts we tackled easily in crampons, and were rewarded with a superb downhill run of perhaps three miles in perfect conditions for skiers of our incompetent nature.

We pressed on up the Col to Conniats Bjerg using for the first time the Klisten wax, which we found to be excellent. Arriving at the top at midnight we were dumbfounded to find Geoff Pert, layed up with a broken ankle and Rob Rowe and Geoff Cram out climbing. Obviously some drastic changes in plan were called for.

cont/...

The advance party had left Tasissarsik on the 9th July and having been badly delayed by bad weather and difficulties following from Geoff Pert's injury, the result of a skiing accident on 11th July, reached Conniats Bjerg on 15th July. Failing to follow Roch's route through the ice-fall on to the Midgaard Glacier on the 17th, Geoff's ankle finally failed and the party returned to Conniats Bjerg on the 19th July. Whilst waiting for the Navy and the main party, Geoff Cram and Rob climbed three peaks: Zweihorn, Conniats Bjerg and "Spangle Ridge." On the 23rd, just before the Navy arrived the party finally ran out of food and were forced to broach the Navy rations.

On Monday, 25th, Geoff's ankle was set in plaster by the doctor of the Navy expedition, Dr. Noel Dilly. The Navy expedition had arrived during the previous night to collect their food, which had been dumped at Conniats Bjerg after the unsuccessful attempt to reach Schweizerland by their advance party the previous Easter.

It was decided that one man (Jeff Taylor, who was feeling rather shattered) should remain with Geoff, whilst the other six continued to the Paris Glacier, picked up the air-drop, established base camp and then sledged the parachutes to Conniats Bjerg. If possible the entire expedition would then advance once more to the area, taking Geoff with them on the sledge.

That evening the main party once more set off, leaving Jeff and taking Rob and Geoff Cram. The descent of the Conniats Bjerg Col was not, at this stage, difficult, as most of the crevasses were covered

cont/...

with snow bridges, and the following morning the party had reached the extension of the Midgaard Glacier. A monster meal here was somewhat spoiled by the recalcitrance of the Optimus petrol stoves. These stoves had been giving trouble continually, doubtless because of dirt in the petrol. There was now insufficient accommodation for everyone, but fortunately the weather held and those not in tents could sleep on the glacier without coming to harm. From this camp, a day's march over very badly crevassed territory saw the party in the middle of the Femstjernen, rapidly decreasing loads helping. A delightful camp-site beside a melt-water stream was christened "Oasis" camp, and all surplus food was there abandoned.

The gigantic scale of this ice-basin led to an error in navigation during the next evening's march (26th) and a loss of one or two hours, but nevertheless the drop zone was reached by mid-day on the 27th, when the first parachute was found, this being on the surface.

A quick reconnaissance of the drop zone revealed the second handicap of the expedition. Most of the parachutes had been carried for about one mile by the wind, and the loads had fallen down deep crevasses which cut across their path. Very little food or equipment could be found, and that evening a very depressed party settled down to sleep in makeshift parachute tents. (These, by the way, were a great failure, the katabatic wind blew straight through, making life miserable and cold for the inmates.) The odd appearance of these structures led to this camp being named "Bedouin" camp.

cont/...

We stayed at Bedouin Camp for about four days, spending our time searching crevasses, following drag trails, and managed to find everything except an entire Stilton cheese (ripe), which although absolutely a disaster did not at the time appear so. A suitable location for base camp had been found, a high rocky outcrop on the opposite side of the glacier, surrounded by a negotiable ice-fall, immediately called Fortress Camp. All the gear was carried across the glacier, and after about seven runs base camp was established, with a cooking shelter, a six-man fester tent, dry rock for drying the parachutes, even the odd flower. Although not comparable with, for example, the Scottish "Montenvens" camp near the coast, it was one of the best locations possible and gave fine views down to Lauper's Bjoerg, and of the peaks we were to climb.

On Monday August 1st we had yet another Greenland fester day, i.e. a day spent mending and cleaning followed immediately by 12 hours hard work. The work in this case was the running of a load of food (still at Bedouin Camp) to a selected point on the Femstjernen for the Royal Navy. This was a "swap" for food and fuel given to our injured leader at Conniats Bjerg. Although we expected this to be a fairly easy journey, it was in fact a sledging epic, a tortuous route over 6' - 8' ice hummocks in the Paris Glacier Icefall, taking three hours for its length of one mile. From the bottom of the icefall a line seemed with hundreds of crevasses necessitated many long detours and general meandering in order to make progress. Eventually we came to realise

cont/...

that the selected point was a region of utter chaos, huge crevasses and tottering blocks. Progress became impossible on foot even, and so the food was left with a large marker flag as near as possible to the rendezvous. The journey back the following day was as bad, and as depressing, as that out, enlivened only by the finding of ski-tracks on the Paris Glacier icefall. We later discovered that these were the tracks of the Navy party, who had arrived earlier than expected, had found neither food nor us, and had force-marched back to Conniats Bjoerg. We arrived back at Fortress camp very early, and roused Maurice, who had stayed to put the glacier stakes in as part of our scientific programme, because he dislikes getting up early.

It was decided that, judging from our experiences of the last two days, if we took the parachutes by sledge to Conniats Bjoerg no time would be left for climbing, and so instead a party of four would immediately climb Pointe d'Harpon, the dominant peak of the area, and one of these four would return (with another person) to replace Jeff at Conniats Bjoerg, taking extra food. Although, of course, it was impossible to include the men at Conniats Bjoerg in our discussion we felt that this was the right decision.

Consequently, Wednesday evening Maurice, Rob, Frank and Geoff Cram set off to climb the mountains in heavy cloud, the only bad day for weeks. Mike and myself stayed at base camp (Fortress) to continue with the scientific work.

cont/...

The actual ascent turned out to be quite an epic, with a monster crevasse and a steep ice wall on the first half of the route, which lay up a glacier very similar to, and named after, the Nantillons. Scracs of considerable proportions guarded its flanks, and it extended to a saddle high up the mountain. The second half of the route lay up a long, loose, shattering ridge, with difficult route finding and a hard pitch to finish. The descent was exactly the same (in reverse), and the total time taken to and from the airy perch of the summit was 24 hours, bringing a very shattered party back to Fortress Camp. Also a satisfied one. The snoring that particular night defies description.

On Friday the 5th the climbing party recovered, whilst Mike Key and myself skied up the Paris Glacier and then up the Avant Garden Glacier to examine the big mountains up there. Several routes up various peaks were discovered, and the map cursed as inaccurate. The journey back was somewhat difficult, the north-facing crevasses having ablated differentially, so as to present an overhang for the return.

The evening of the 6th, Frank Ekman, who was to replace Jeff Taylor, and Rob Rowe departed very late to Conniats Bjoerg. They took with them masses of food, a terrific weight, and only a flysheet as protection against the weather, which they hoped would hold for their 37 miles journey.

The initial survey of the glacier stakes was completed next day, very tiring work using a 1-inch instrument with masses of glare off the glacier. That evening the remaining four of us departed with a sledge load of climbing gear, ostensibly to climb in the Avant Garden area.

cont/...

However, after a few hours rough going it was decided to camp and tackle either one of the two largest peaks on the western side of the Paris Glacier. The excellent pyramid tent established on a piece of God's earth rather colder than others, and known as "Arctic" camp.

On the 8th we rose with murder in our hearts to climb the big snow peak which we later called Pyramid Peak. We departed at 6 p.m. so as to get the best snow conditions, and after about an hour's travelling to the base of the mountain ran into the Japanese expedition, who were delighted to see us. They were very hungry and living on hardly anything at all, yet they readily gave us cocoa and soup and dried fruit. We conversed for some time and then left, after inviting them to Fortress Camp for a feast. They struck us as an exceptionally hard bunch of people, as well as extraordinally nice. The peak was ascended without any difficulty (see Mountaineering Report) although the experience was spoiled in my own case by continual trouble with the crampon straps, which worked loose. On the only difficult piece of ice on the entire climb they fell off altogether. We fell back into our tents after 24 hours on the go, and slept like logs.

The weather was bad when we next arose, Wednesday 10th, and the day was spent in discussion. Most of the problems of the world were solved by about 5 p.m.; however, opportunity to put them into practice was not at that time available. The next day was bad as well, and was also my birthday (20th), consequently our own expedition and the Japanese returned to Fortress to feast. An incredible amount of food and drink

cont/...

was consumed, and many songs sung. The highlight of the evening was undoubtedly the singing of Auld Lang Syne in English and Japanese. The Japanese, who were leaving that evening for the coast, gave each of us a pair of duvet boots, and then returned to sleep. They left with no fuss at 1 a.m. when their alarm rang. Shortly after a plaintive "Hallo" announced the return of Rob and Jeff from Conniats Bjoerg. Owing to the bad weather they had marched the 37 miles of rough going continuously, and were too tired to eat.

On the 12th we first of all listened to the news from Conniats Bjoerg, then split into two teams, four of us - Geoff Cram, Mike Key, Maurice Clark and myself - to climb De Quervains Bjoerg, and Rob and Jeff to climb what we thought was a small mountain near Pointe d'Harpon. The afternoon was spent for us in sledging down to our mountain and then reconnoitring a route in its complex of ridges of buttresses. The ascent (see Mountaineering Report) was the nearest to a continuously difficult ascent of the expedition, and was really enjoyable. After a short bivvy, the final ridge to the summit was terrific, with the first appearance of the Aurora and meteorite swarms. After seven hours sleep we returned again to Fortress, to be greeted by Rob and Jeff, who informed us that the "small" mountain was not in fact as small as it seemed, and had taken them 18 hours to climb, involving some difficult ice climbing.

The evening of the 16th another sortie was made in the direction of the Avant Garden, this being again thwarted by bad weather. Maurice and Mike remained at base camp to complete the scientific work.

cont/...

The following day it was decided to split into two ropes of two, and each do an individual peak. Rob and Jeff left to climb a peak in the Avant Garden, and Geoff and myself departed to climb Bastille, the most north-westerly peak on the glacier. The journey to the peak involved some very dangerous crevasse crossing, often on thin snow cornices on crevasses no more than 10 ft. wide. The actual ascent was uneventful apart from one pitch, which was rather like climbing down Hazel Groove on Clogwyn y Grochan (done in crampons of course), and the sight of Geoff changing into his long woolly underwear on the summit in a high wind and many degrees of frost.

We skied back to Arctic camp on the coldest night of the expedition, and later greeted the other successful rope, and after sleeping returned to Fortress. This particular night was probably the coldest of the expedition.

Before our return which, after our experience of sledging on the very badly crevassed sections and considering our rather excessive loads, had been advanced by several days, there was still time for one more ascent. Maurice and Mike scaled the last remaining peak behind Fortress camp (Serac Peak - so named after a colossal serac guarding its northern flank). They returned victorious on the 20th, our last day at our base. Time was devoted to packing loads and abandoning all the heavy climbing equipment, some badly damaged parachutes, and all other less essential items, to try to get the load down to about 1100 lbs., still far too heavy for the sledge.

cont/...

We departed for the coast at 4 a.m. on Sunday, August 21st, having first securely fastened down everything we were leaving in case of a return expedition, and in two days of fine weather travelling crossed the Femstjernen, with only the usual difficulties of crevasses, melt-water streams etc. The sledge, however, suffered considerably, the combination of hard-ice sledging and the heavy load rapidly abrading the runners. Also during the crossing of rather wider-than-usual crevasses the front and rear bows had been demolished, but temporary repairs were effected by means of pack-frames and rope, although the frames also broke later.

The journey continued uneventfully to below Conniats Bjoerg, although the weather had now definitely worsened, with intermittent rain and soft, muggy snow making for very difficult pulling. Some back-packing had been necessary, but most of the distance had been sledged.

By noon on the 25th we were below the Conniats Bjoerg col. Most of the snow on this steep col had been ablated, revealing colossal crevasses where we had previously trodden fearlessly. The load was split and the sledge pulled to the top, carrying only camping gear, as we wished to join our leader and Frank that evening. As we ascended the col the cloud closed in, snow started to fall thickly, and finally at the top turned to a driving blizzard. We were greeted by our two companions, who were not expecting us so early, thinking that we would have been delayed by the blizzard, which had been blowing for four days. We pitched a very damp and miserable camp in the driving snow.

The next day the rest of the gear was man-packed up the col in loads of about 90 - 100 lbs., in deep soft snow, an exhausting procedure. At the top matters grew worse as the sledge, brought down for the final haul, refused to move in the heavy snow, and had to be pulled behind. Over this day and the next life became increasingly wet and intolerable, until by the evening of the 27th it had become necessary to wear cagoules inside sleeping bags to keep out the wet.

Fortunately a few fine hours turned up next day, some gear was dried, the buried tents and sledge were dug out, and a gathering held to decide our next moves. It was decided to move, come what may, as we were by then growing short of food and time.

The Royal Naval Expedition had by this time arrived back from Schweizerland, bearing the sad news of another death in their party. Their doctor had removed the plaster from Geoff Pert's ankle, and had decided that he could walk out, provided he took things easy. Once more we were ready to roll.

We struck camp on the 29th, having great difficulty digging out our belongings from beneath the many feet of fresh snow (in fact one of the party lost one ski-stick here, and had to ski miles using only one). Despite our carrying loads on our backs and skiing pulling the sledge, the brute still would not move in the thick fresh snow (the blizzard was still swirling around us), and more equipment, unfortunately including all the remaining parachutes, had been cached. With the lightened load we struggled down from Conniats Bjoerg, the heavy snow

cont/...

turning to heavy rain as we lost altitude. However, on this day we managed to reach a rocky island ("Botany Island") beneath the Col des Esquinaux by the end of the day. The sledge had been lowered on a belay down the col, without too much trouble, although it did overturn once or twice and also cracked a runner running into some stray boulders. Six inches of fresh snow on old compact snow on a steep slope is not the best of sledging conditions.

We were dreading white-out conditions for the next stage of our march on the featureless ice-plain of the 16th September Glacier. Fortunately the cloud cover was not very low, in fact it broke for an hour or two about noon, but by the evening we were flogging away in calf-deep snow in the perpetual drizzle, and camped about a mile from the col leading off the glacier.

The ascent of this col was probably the most difficult part of the bad weather part of the journey. Conditions were total white-out with driving snow blowing down the col. Wildly zig-zagging through the thick snow, the party was often on its hands and knees trying to keep the sledge moving. Despite this it stopped many times, each time requiring a great deal of effort to restart. At the top of the col progress was made by following the well-nigh invisible tracks of the departed Japanese and Swiss expeditions. Finally below the old Scottish Winlatta camp the snow became so deep that the sledge wouldn't move at all. The loads were man-packed up to the old camp-site, and over a short brew it was decided to pitch camp there, and

cont/...

ferry half the load as far as possible across the very high snow plateau towards Col des Poulies.

Rock camp-sites were very much in demand, as several of the expeditions airbeds had collapsed irrepairably. Their previous owners were now reduced to sleeping on the soggy cadboard containers, in which we transported the remains of our goods, for insulation. This was, apparently, unsatisfactory.

We left Geoff Pert, whose recently healed ankle we did not wish to over-tax, to assemble a camp, and sledged half a load on. As the visibility had now increased, it was possible to see the famous patch of snow on which Geoff had in fact come unstuck.

On September 1st we had to cross our last obstacle, the descent of Col des Poulies. However, as the weather had at last cleared, this was relatively easy. At the top of the Col we were greeted by three members of the Royal Naval Expedition, who had previously been at the coast, and they kindly helped us in the descent, and we joined them on the Scottish "Montenvens" camp site. They were awaiting the arrival of the rest of their own expedition, and were excellent company during our short stay. That evening was scenically magnificent, the Aurora playing in the dark sky above the awe-inspiring beauty of the basin of the Karales Glacier and its surrounding peaks. No doubt the relief of the tension resting on the party helped a great deal.

Two more days, so both our own and the Navy expedition esconced at the head of the Tasissarssik Fjord, from which we sailed by Eskimo boat (previously arranged) to Kulusuk Island, and then once more to England.

cont/...

Only two items stand out from this period of relaxation and journeying. The first concerns the fishing to be had at the head of the fjord. A relatively well-stocked salmon stream, which flowed conveniently close to the camp, was devastated in two days by the demon I.C. salmon ticklers (trained by a certain "Jumper" Collins of the Navy), who proceeded to eat approximately 60 lbs. of fresh salmon in two days.

The second item was also a gastronomic feat of no mean size. During the return sea voyage, on the "Gulfoss" again, the expedition accepted the excellent food and hospitality of the line and broke the eating record for any journey.

MOUNTAINEERING REPORT

The mountains surrounding the Paris Glacier were scenically magnificent, comparing favourably with both the Western Alps and the Dolomites, and the ascent of all the major peaks was a most satisfying achievement of the expedition.

The mountains usually gave 5,000' climbs from the main glacier (4,000' above sea level) often comprising a difficult glacier followed by a fairly loose rock ridge. North ridges especially were usually difficult ice-climbs. All the peaks had large and complicated glacier systems with ridges and faces of weathered red granite into which black basic rock had been intruded.

In all, seven peaks were climbed from the Paris Glacier (and approximately eight more in Conniat's Bjoerg region) and the main feature proved to be the time taken - some of the routes took less than 14 hours and two 25 hour ascents were made. Eventually one bivouac became normal and many classic Alpine "difficile" routes were done. Perhaps a new feature for expeditions to Greenland was the fact that a certain amount of difficult rock-climbing in the ascents of several peaks, notably de Quervain's Bjerg and Serac Peak. Pointe d'Harpon was perhaps the finest mountain climbed, although four of us will not forget 16 hours of rock climbing on de Quervain's Bjerg.

Finally a note on the weather. It was usually incredibly good for climbing either by day or by night. In the evening an extremely cold low-level wind would blow down the glacier from the ice-cap, and the converse was observed after bad weather when thick low-level mist rolled up the glacier from the sea. By August 20th the night was approximately 4 hours long and was becoming extremely cold.

EQUIPMENT

The routes were normally done by two parties of two, each climbing on 150' of No. 3 nylon rope. These proved adequate for the extremely hard wear. Rock pitons were not used at all, although they might have been needed in several places. Ice-pegs were in great demand (not only for pitching tents and sledge lowering!) The two-man bivvy tents proved most useful with the associated equipment. Full marks were probably gained by the long snow gaiters.

PEAKS ASCENDED FROM PARIS GLACIER

Pointe d'Harpon - 2,900 m. F. Ekman, M. Clark, A.G. Cram, R. Rowe.
3.8.66. 25 hours.

Difficile. The western glacier took five hours. South ridge (Grade 111) was very loose and the gendarmes of the summit ridge were avoided by a traverse across the N.E. face (111). The summit block was gained by two pitches (1V, V) including an impressive hand-traverse. The ascent took approximately nine hours - a very fine peak.

De Quervain's Bjerg - 2,600 m. M. H. Key, C. D. Dean, A. G. Cram, M. Clark. 13/14.8.66. 24 hours.

Difficile. The long S.S.W. ridge of the mountain (above the 2,000' "Red Wall") was ascended. It was gained from a small glacier in the western area by a 2,000' ramp (pitches of 111). Bivouac four hours. The ridge led over the Red Wall (mainly 11 with 1 pitch 1V sup.) and eventually to the very fine summit (16 hours). Descent via eastern glacier was relatively easy followed by a six mile walk back to camp (eight hours).

Serac Peak - M. H. Key, M. C. Clark.

This peak is situated to the south of the Nantillon (W.) Glacier which was climbed as for Pointe d'Harpon. From the top of the Nantillon the south-west ridge was followed to the snow field above the seracs. This was crossed and the easy angled face beyond was climbed to the final summit ridge which was followed to the top. Descent was by the same route.

"Fortress Peak" - 2,600 m. R. Rowe, J.R. Taylor.

13/14.8.66. 18 hours. 2 hour bivouac.

Difficile at least. A very mixed route including some exposed ice pitches. The climb started up the avalance cone of the seracs poised between the west ridge and the long northerly ridge which runs down to the Avant Garden Glacier. The rock rib on the left of the track led up and around onto the western flank of the north ridge. The crest of the ridge was gained above the seracs and was followed very pleasantly to the summit cone. Descent by same route.

"Pyramid Peak" - 2,500 m. A.G. Cram, C.D. Dean, M.H. Key, M. Clark.

8.8.66

P.D. A classic snow route. The glacier on the N.W. side led easily to a high col. From here short route ridge (1V) followed by a superb snow summit ridge led to the final pyramid.

"Bastille" - 2,300 m. A.G. Cram, C.D. Dean.

17.8.66. 14 hours.

P.D. The glacier on the N.W. side was reached via a "gripping" ice-fall. It led easily to the west ridge. An intermediate summit (V) and impressive ice-col led to the summit ridge.

"Table Mountain" - 3,000 m. R.W. Rowe, J.R. Taylor.

17/18.8.66 20 hours from Arctic Camp.

Difficile. 4 hours bivouac. First ascent - Nihon University, Japan, a few days earlier, probably by a different route.

The glacier valley between Table Mountain and Double Top was ascended from the Avant Garden glacier to the end, overlooking the Forel Basin. The narrow rock ridge which forms the northern edge of the western flank of Table Mountain and overlooks the Forel Basin was followed almost to the summit. The last few pitches were steep snow leading to a vertical cornice and the summit plateau. Descent by the same route.

PEAKS ASCENDED FROM CONNIAT'S BJERG

These peaks are called Conniats Bjerg on the large scale map 66Ø2 L but are not the highest in the group, which are to the south.

Conniats Bjerg - 1,750 m. R.W. Rowe, A.G. Cram. 21.7.66.

Difficile. The preminent twin summits were ascended in the S.E. gully to col. The north summit was climbed first (111) followed by the rock and snow ridge of the south summit (111). 10 hours.

"Spangle Ridge" - (Peak 1,800 m. climbed first by Austrians in 1959).

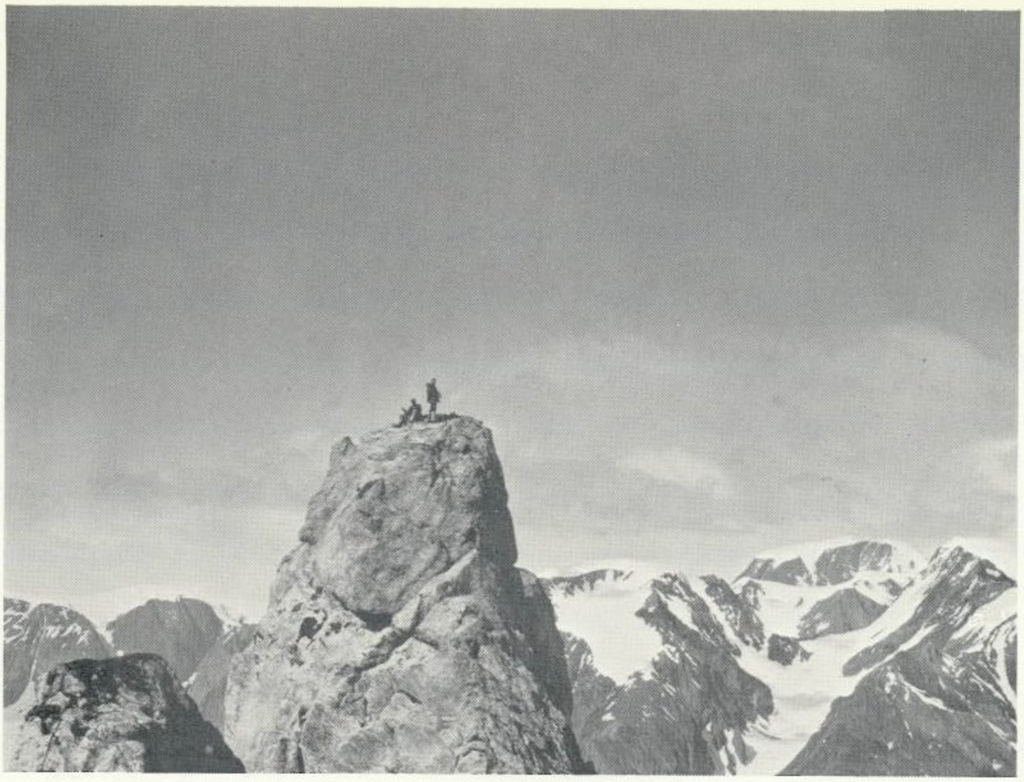
A.G. Cram, R.W. Rowe.

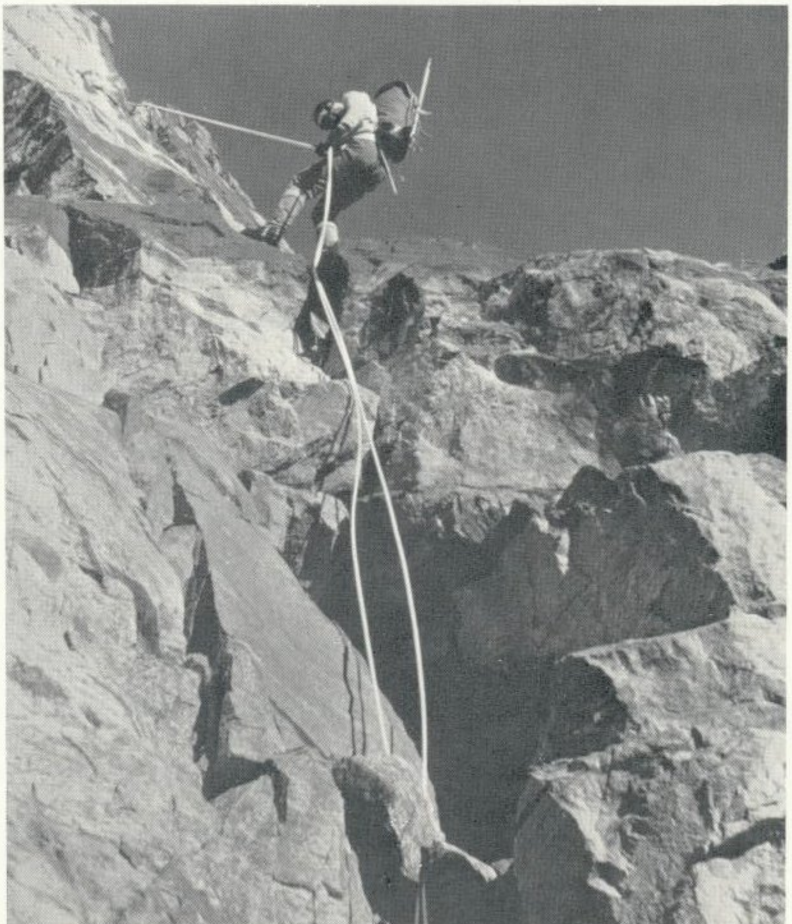
T.D. The north ridge gave a very impressive ice route approximately 2,000' long. 7 hours.

Zweihorn - (Swiss 1963) 2,000' loose north ridge (111) ascended by

A.G. Cram (solo) on 12.7.66. 5 hours.

The following climbs were done from the camp at Conniats Bjerg in conjunction with, and largely organised by, the Royal Navy East Greenland expedition.





The mountains around Conniats Bjerg are on a smaller scale than those around the Paris Glacier, the peaks being 2,000 m. or under, climbed from a glacier system of around 1,500 m. Round trips from camp back to camp took 7/8 hours. Skis are almost essential and an early start on hard crusts is probably the best but most painfull method. Times are from Conniats Bjerg camp.

Solvervbjerg - 2,000 m. Austrians 1959. R. Wallace (R.N.) K. Rowe (R.N.), P. Garden (R.N.), R. Dearman (R.N.), J.R. Taylor.
28.7.66. 7/8 hours.

The long, straight forward southern ridge was climbed. The lower three-quarters was snow, with rock 11 or 111 leading to the summit. Descent by the same route.

"The Thumb" - 1,750 m. J.R. Taylor, R. Dearman (R.N.)
29.7.66. 7 hours.

An enjoyable climb up the obvious, most northern gully on the western face to join the southern ridge which leads steeply to the summit (111). Descent by same route.

Badeiulls Bjerg - 1,800 m. Probably first ascent by Austrians, 1959.
J.R. Taylor (solo), R. Dearman (R.N.), R. Wallace (R.N.), P. Garden (R.N.), K. Rowe (R.N.).
31.7.66 9 hours.

The long southern ridge was joined from the western side about a quarter of the way up. The ridge was of loose rock (111) and took $1\frac{1}{2}$ hours. Descent by same route.

One of Conniats Bjerg Peaks - 1,750 m. R. Wallace (R.N.), P. Garden (R.N.),
K. Rowe (R.N.), J.R. Taylor.
1.9.66. 3 hours.

The most southern peak of Conniats Bjerg was intended as an easy day's saunter, but included some nice rock pitches lV sup. The route started up the snow patch to the north of the S.E. corner of Conniats Bjerg and followed the ridge to the subsidiary summit. Descent was by the east face to rejoin the ridge.

Peakby Henry Lerns Bjerg - 2,000 m. R. Wallace (R.N.), K. Rowe (R.N.),
C. Stocker (R.N.), J.R. Taylor.
8.8.66.

The ascent was via the western buttress leading to the north ridge and along this to the summit. The climb took 2/3 hours and was fairly straightforward, but varied and always interesting. Descent was by an easy rake cutting across the western face. 2 hours ski back to Conniats Bjerg.

Pointed Peak - First ascent Austrians 1959. C. Stocker (R.N.),
J.R. Taylor, R. Wallace (R.N.), K. Rowe (R.N.)
2,000 m. 9.8.66. 10 hours.

A fine peak on firm rock 111 and lV. The southern rock ridge was followed from the glacier keeping to its western edge. Descent was on looser but less exposed rock to the east of the ascent line.

FOOD REPORT

The ration boxes were based on those used on the Imperial College Expedition to the Stauning Alps in 1963. Each box contained 16 man-days food, so that the expedition members could work in twos for a period of eight days. To overcome the problem of carrying a reasonable amount of food into the area, an air-drop was used.

For the march-in a light ration was particularly planned. The weight per man-day was cut to two pounds - approximately 4,000 calories. The calorific value of the march-in food was enough to supply energy for a full day's effort. On the other hand there was insufficient bulk to stop stomachs rumbling, but this was to be expected.

Base camp boxes contained extra luxury rations, including a large cheese and fresh apples. The former item proved to be one of the disasters of the expedition, as it was lost in a crevasse, never to be seen or smelt by the cheese connoisseurs!

All the food was packed in polythene bags, which were then packed in "Fibram" boxes. In the air-drop sugar bags suffered the greatest damage, but most bags survived, and on the whole the packing was adequate. Some bundles had the misfortune to be dragged into water-filled crevasses but most recovered to an edible condition.

The main ration box was found to be adequate. The time spent at base camp was much reduced and there was therefore a surplus of food. The only complaints to be heard at base camp were of overeating!

Cocoa and Ovaltine proved to be popular and on reflection more beverage could have been taken.

The sledge rations for the journey out were made up from the 16 man-day boxes. All the luxury items were left behind - only the essentials were taken, so that the rations were very similar to those on the march-in.

The main ration box for 16 man-days consisted of:-

Dried Milk	2 lb.	Salt	¾ lb.
Sugar	6 lb.	Curry Powder	2 oz.
Porridge	3 lb.	Oxo	2 pkts.
Dried Egg	⅔ lb.	Tomato Puree	1 tin
Margarine	2 lb.	Chocolate	4 lb.
Healthy Life	2 lb.	Kendal Fruit Cake	2 lb.
Crispbread	4 lb.	Dates	2 lb.
Steak & Kidney Pudding	2 lb.	Raisins	1 lb.
Stewing Steak	2 lb.	Custard	¼ lb.
Corned Beef	2 lb.	Christmas Pudding	1 lb.
Luncheon Meat	1 lb.	Complan	1 lb.
Vesta Meal		Bemax	½ lb.
Soup	4 pkts.	Jam	½ lb.
Pom	1½ lb.	Marmalade	½ lb.
Dehydrated Peas	1 lb.*	Lemonade Powder	
" Cabbage	½ lb.*	Sauce	
" Carrots	½ lb.*		
" Beans	½ lb.*		

* rehydrated equivalent weights

Rice		½ lb.	Extra Base Camp Items:
Spaghetti		½ lb.	56 lb. Cheese
Coffee	)		Crate of apples
Cocoa	)	1 lb.	Tin Fruit
Ovaltine	)		Tin Sausages

The one man-day march-in ration consisted of:-

Dried Milk	2 oz.	300 calories
Sugar	6 oz.	672 "
Coffee	½ oz.	
Porridge	3 oz.	345 "
Dried Egg	1 oz.	165 "
Biscuits	4 oz.	464 "
Margarine	2 oz.	452 "
Soup	2 oz.	100 "
Salt	½ oz.	
A.F.D. Meat	4 oz.	500 "
" Vegetable	2 oz.	120 "
" Pom	2 oz.	184 "
Chocolate	4 oz.	668 "
Total:	33 oz.	3,970 "

MEDICAL REPORT

The majority of the medical equipment was obtained from Boots. There was also a gift of pharmaceuticals from I.C.I. and a magnificent selection of medical dressings from Messrs. Smith & Nephew, which were much used.

With minor exceptions, everyone remained in excellent health throughout the expedition, although it was noticeable that the demand for throat pastilles was inversely proportioned to the supply of rations.

The equipment taken was as follows:-

1 First aid set
24 Cooltan Cream
1 Dermene Cream
2 Iodine pencils
Strepsol
100 Tablets Codeine Co.
30 Dijex tablets
100 Cascara tablets
4 Sped foot powder
Viso eye drops
2 Golden eye ointment
Tooth tincture
Sal Volatile
24 Screen tablets
1 Balca
1 Analgesic balm
2 splints
1 medicated talc

3 x 3" crepe bandages
2 x 2" " "
Much Elastoplast
2 oz Cotton wool
2 Triangular bandages
1 Clinical thermometer
Surgical spirit
Gutta Percha tooth stopping
2 eye shades
Finger stall
3 Nivea Creme
Gypsona bandage
Penicillin tablets
Tetracycline tablets
Phthalylsulphathiazole tablets
Imperacin (Oxytetracycline)
Sulphaguanidine tablets

The expedition is extremely grateful to Dr. Grey and Sister Gallie for their advice, assistance and patience.

TRAVEL

This part of the report deals with the movement of food, equipment and personnel in England and Greenland and between. The flow diagram p. shows the basic operations and how it was planned that they were to be carried out but owing to the accident a certain amount of re-arrangement was necessary.

THE AIR-DROP

This was very successful, all the parachutes opening and no loads being lost. Because the advance party were not on the ground to receive the drop as planned most of the loads were later blown down crevasses but even so they were all recovered, with some difficulty, except for the Stilton cheese which broke loose from its load.

Three members of the expedition were given a three-day course on air despatch by the 22nd Army Air Despatch Unit at R.A.F. Tangmere, who also packed our parachute loads and lent us the parachutes. There were 12 parachute loads with an average weight of about 300 lbs. which is too heavy to be comfortably handled, but it was necessary to cut down on the number of parachutes which would have to be carried out. Most of the loads consisted of four food boxes (steel banded **Fibram** boxes) with two 4-gallon "Jerry" cans strapped on top with a sheet of polythene between to prevent contamination (the fuel was not dropped individually in case one load was lost; we were allowing for a 20% loss). The loads were fitted with percussion or "perky" heads to take the impact and there were no breakages except for two climbing crash hats!

The dropping of our 12 ft. Nansen sledge was most problematical as there was a very real danger of it being caught in the slipstream of the aeroplane and hitting the tailplane. It was necessary to increase the weight to volume (air resistance) ratio so some heavy poles were attached to it but it was important that these hit the ground first or the sledge would smash on impact. The Icelandair pilot was reluctant to drop it but by a brilliant piece of flying managed to lift the tail plane clear by almost stalling the plane.

The loads were too heavy to throw out so a despatch board was used. Two loads were despatched for every run over the dropping zone and the spread was over about three-quarters of a mile.

ESKIMO BOATS

These were found to be ideal for the movement of equipment and personnel along the coast. The standard charge in 1966 was 12.50 Kr. an hour and one had to pay for the boatman's return journey as well. The one draw-back is the unreliability of the Eskimoes to turn up on time.

FINANCE

The account present here summarises the overall finances of the expedition.

At present it is not possible to close the account completely as some small items of equipment still must be sold to help balance the small deficit shown below.

INCOME

		£	s.	d.
(a)	Direct Grants of Money			
	The Mount Everest Foundation	700	0	0
	Imperial College Exploration Board	300	0	0
	The Goldsmiths Company	200	0	0
	The Royal Geographical Society	100	0	0
	The William Johnson Yapp Trust	75	0	0
	The Gilchrist Educational Trust	75	0	0
	The Gino Watkins Memorial Trust	75	0	0
		1525	0	0
(b)	Individual Contributions in cash 8 x £50	400	0	0
(c)	Equipment bought for the expedition by the Exploration Board and returned to the Board for future use	200	0	0
(d)	Contributions from other expeditions to the sharing of chartered aeroplanes to and from Greenland:			
	a) Royal Navy E.G.E.	342	0	0
	b) Swiss E.G.E.	142	0	0
		484	0	0
(e)	Equipment & insurance payments from individual members of the expedition	201	3	5

	£	s.	d.
(f) Sale of photos to Observer Colour Supplement	20	0	0
(g) Cash residue	7	17	9
Total Income:	£2838	1	2

LOANED EQUIPMENT

Surveying equipment for use in the scientific work was loaned by the Royal Geographical Society.

Parachutes and auxiliary equipment for the air-drop were loaned by the Army Air Despatch Corps.

The Army has very generously agreed to carry the loss of parachutes consequent on the mishaps experienced by the expedition in the field.

INSURANCE

Insurance against personal accident for those members of the expedition who were full time members of Imperial College was provided by the Exploration Board via the Imperial College insurance brokers.

Insurance for personnel and expedition equipment was arranged similarly.

EXPENDITURE

The total of cash withdrawn from the expedition account or paid out by individuals was	£2874	14	11

	£	s.	d.
Income	2838	1	2
Part of the income was payment of insurance premiums which were not part of the expenditure viz	18	17	0
Therefore true income was	£2819	4	2
Expedition cash deficit January 1967	£55	10	9

Against this deficit there is still the sale of an AVO meter and Airmec Valve voltmeter of new value £102.

It is most useful when planning an expedition to be able to assess which aspects of the project will contribute importantly to the total cost.

The following section of the accounts shows a breakdown of the costs into interesting categories rather than presenting them in the form in which bills were paid out.

EXPENDITURE

Travel:-		£	s.	d.
a)	Icelandair - charter of DC3 and airdrop, Reykjavik - Kulusuk. Charter of Fokker Friendship Kulusuk - Reykjavik. Flight on tourist plane for 3-man advance party Reykjavik - Kulusuk. (Partly shared by other expeditions)*	£1494	8	0

* (See Income (d))

		£	s.	d.
b)	McGregor Gow & Holland. Passages per MV Gullfoss Leith - Reykjavik 3rd class	84	15	0
	Reykjavik - Leith 2nd class	141	5	0
		£226	0	0
c)	Freight costs Leith - Reykjavik Reykjavik - Leith per MV Gullfoss	£68	6	0
d)	Eskimo boat transport Kulusuk - Tasissarsik Tasissarsik - Kulusuk	£36	12	0
e)	Movement of equipment in England, between London and Tangmere for airdrop packing and London - Leith	£42	2	0
f)	Movement of equipment in Iceland between Reykjavik docks and airport	£7	16	0
<u>Total costs in connection with travel</u>		£1875	4	0
<u>FOOD</u>		£158	8	10
<u>EQUIPMENT</u>				
a)	Scientific equipment for use in the resistivity experiments Valve voltmeter (Airmec)	£90	0	0
	AVO meter	£22	8	0
	Switches, wire, etc.	£22	9	9
		£134	17	9
b)	Nansen sledge and 8 pairs of cross country skis	£177	1	6

		£	s.	d.
c)	Tents (2 mountain, 1 pyramid, 2 bivvys)	£100	5	0
d)	Ski mountaineering boots - eight pairs	£82	12	0
e)	Specialised mountaineering equipment	£55	2	11
f)	Personal mountaineering equipment bought by individuals	£141	1	5
g)	General expedition equipment, tools, cleaning equipment etc.	£40	6	10
h)	Fuel purchased in Iceland	£7	5	0
i)	Films bought by individuals	£41	5	0

MISCELLANEOUS PURCHASES ETC.

		£	s.	d.
a)	Maps from Danish authorities in Copenhagen	£5	19	0
b)	Telephone, post, petty cash	£18	1	8
c)	Small items bought in transit to and from Greenland	£25	19	3
d)	Lost equipment allowances	£11	4	9
	Total expenditure January 1967	£2,874	14	11

EQUIPMENT REPORT

GENERAL

The air-drop resulted in there being excessive quantities of certain items, articles that could only be described as luxuries and items included just to be on the safe side. An allowance for losses during the drop had to be made but the generous supply of equipment was partly due to the "We're using an air-drop; why not!" attitude. In practice, there was very little loss of equipment except food, as a result of the drop, (See Travel Section) even with no ground party, and a more careful selection and estimate of quantities of equipment could have resulted in fewer loads.

A party sledging into the region would have little risk of losing items and much stronger motive for including only essential and light-weight equipment and would rely on ingenuity and improvisation. Consequently, as a guide to future expeditions, this report consists of discussion and comments about the more vital items of travel, camping and cooking. A few suggestions of alternatives and improvements are made.

TRAVEL

Skis:- Bona skis, 210 cm. with aluminium edges

Excellent in field, easy to handle, light to carry. May need to be adjusted in the field, so it is worth having a small screw-driver and bradawl and a few spare screws. A delay in delivery resulted in the advance party having to use old and heavy skis on their march in. Important to order well in advance. Binding straps had to be purchased in great panic at Reykjavik.

Waxes:- Great variety taken although use not fully understood. Klisters was extremely good for uphill work although very difficult to apply at low temperatures (even more difficult to scrape off the skis). The greatly increased adhesion made it possible to ascend quite steep slopes directly with heavy loads. Downhill wax was not used and for inexperienced skiers could be dispensed with. The use, costs and durability of skis could well be investigated.

Ski poles:- Eight pairs bamboo with large bamboo baskets (purchased at Pindisports after searching most of London's dealers) and two extra pairs of alloy poles were taken. The bamboo were light and excellent for their price. Two broke completely, two baskets tended to fall off. The alloy are much stronger but also very expensive.

Sledge:- 11 ft. Nansen sledge made by Bonnaski, Norway.

Stood up very well to the 70 mile obstacle course on the march out. Invaluable in retrieving the parachute loads and a perfect means of transport for climbing parties of any number. Adds security to travelling on glaciers. Loads in excess of 1,000 lb. were transported. The hard glacier ice and ice falls caused damage to the runners. Both front and rear protection bars were smashed and one runner was displaced off the vertical stays. The bindings needed a certain amount of attention and some replacement. After the expedition the sledge needed completely overhauling.

Two smaller Nansen sledges would have been better for a party of six or eight sledging in. It would be easier to carry more with two teams of three or four. In difficult terrain, crevassed regions or ice falls, there are many places where only a few men can be in a position to pull, making a large and heavy sledge difficult to handle.

Sledge harnesses:- Made from car safety belting. Two shoulder loops connected behind with a large eyelet. Cheap and easy to make. If the loops had been made slightly larger they could have been used round the waist. Only one broke at the eyelet but was repaired with cord.

Pack frames:- Government surplus, green painted alloy variety. Robust and cheap. Head bands were never used but could be experimented with. Skis were always difficult to attach securely but an efficient method could be devised. Spare straps were very useful. Climbing sacks and kit bags were easily strapped on.

Better pack frames are now on the market (American and Continental) but are always very expensive.

<u>CAMPING</u>

Tents:- Advance party (3) used one Blacks Mountain tent without flysheet. This proved very uncomfortable, especially as much rain, drizzle and snow was experienced. The saving in comfort and consequently time would have more than compensated for the additional weight of a flysheet. A flysheet is essential for three or more men in a tent. Two can cope quite well without.

The main party (five) used one Blacks Arctic Guinea plus one mountain flysheet (manufacturers error) and two Brighams bivouac tents. These were excellent in the circumstances. A bivouac tent can be supported by skis and ice axe and can accommodate one man. An air bed or foam rubber mattress is essential for insulation.

Additionally one Blacks Mountain tent and two flysheets, one pyramid Benjamin Edgington tent and a massive base camp tent were air-dropped in. The pyramid was excellent in every way for sledge travelling for four or more men. Very easy to assemble. The large base camp tent was supported with a dexion instant pole assembly kit. It was extremely luxurious but took up about half a parachute load and could have quite easily been omitted.

With the expedition's original plans and a mountaineering party of four at any time, the combination of two mountain tents with flysheets, two bivouac tents and the pyramid tent, would have been the best.

Tent pegs are a complete waste of money, weight, time and effort. Tents can easily be pitched with a combination of skis, poles and ice axes or boulders.

Air-beds/foam rubber mattresses:- The latter are superior if only for reliability considerations. In all three air beds failed beyond repair. Only very new ones should be used and there is still risk. Some form of insulation is essential for prolonged camping on snow.

COOKING

Stoves:- Two ½-pint petrol stoves and several 1-pint paraffin stoves of the Primus type were used. Both the ½-pint petrol stoves (one vertical type and one sliding tray type) proved inadequate, under the strain of continuous use and rough handling, and were eventually abandoned. Of the 1-pint paraffin stoves, one was broken beyond repair in the air-drop but all the others proved robust and reliable, even with low grade and dirty fuel. For consistant performance they needed fairly regular attention and cleaning. Spare fitting, prickers and tools, correctly labelled, are essential for their upkeep. Small polythene funnels were found to be extremely useful for refueling. It is suggested that an expedition (economising on weight) needs one stove per two or three man tent or two stoves per four man tent. Much could be gained by investigating the market (continental) particularly for the stove/billy can combinations.

Fuel:- Only one out of ten 4½ gallon cans was lost in the air drop. Consequently there was an excess of fuel. ½ or 1 gallon polythene bottles were ideal for carrying fuel on sorties from base camp. It is suggested that only one type of fuel be used depending on the type of stove.

Metafuel or Profol prove very good for priming, the latter better in wet conditions although more difficult to ignite. Regular use preserved condition of stoves.

Utensils:- An excess of billies were air-dropped and eventually abandoned. The large type were most useful for more than two men especially at base camp. More care with choice of billies with respect to size of parties is recommended. For a party of two, three billies and two plates is perfectly adequate. There is a wide range on the market. Various luxuries such as ladles were air-dropped in for use at base camp and proved very useful. It is extremely important that mugs should be of equal capacity and at least one spare should be taken.

SCIENTIFIC EQUIPMENT

Following is a list of equipment used in the scientific work:

Glaciology:-

24 stakes - pine - $\frac{3}{4}$" square, 9' long
1 1" theodolite
1 steel tape 100 m.
Yellow paint
Red bunting
Aneroid barometer
4 tape measures
2 pairs binoculars
2 ice drills
1 brace + 15' extension rods
4 allan keys for above

Resistivity:-

12 120 v. DC batteries (dry)
1 transistorised valve voltmeter
1 Avometer
1 reversing switch system
24' x 5' chicken wire
1$\frac{1}{2}$ miles insulated wire
Crocodile clips
Wire cutters
Insulation tape
Screw driver
Snow spade
1 x 100' measuring tape
Salt
10 x 5' steel stakes 1" diameter

Miscellaneous:-

Note books
Biros
Erasers
Maps
4 prismatic compasses

RESISTIVITY MEASUREMENTS O.J THE PARIS GLACIER

INTRODUCTION

The standard geophysical technique of earth resistance prospecting involves measurement of the electrical resistance between electrodes placed in the earth at various separations. An obvious use of this technique is to measure the depth of a glacier where the ice-rock interface provides a distinct boundary between layers of differing conductivity. Results obtained on temperate glaciers[1,2,3] have been promising, but those in cold ice[4] have been ambiguous. The Paris Glacier was in many respects a suitqble glacier for such an experiment on a cold glacier and the test included in the expedition programme.

The theory of the ice-resistivity experiment is formally simple but computationally difficult. The glacier ice is considered as a bulk electrical conductor with isotropic resistivity varying with the depth only and constant along a plain parallel to the surface. This is in fact probably a good approximation provided the width of the glacier is much greater than its depth, as in the case of the Paris Glacier.

The starting point of the theory is the well-known relation between the current density $\underline{j}$ and the electric field $\underline{E}$ in an isotropic medium for steady current flow.

$$\underline{j} = \sigma \underline{E}$$

σ = conductivity.

As div $j = 0$ (except at a "pole" i.e. a current source) we may immediately use the analogy with the standard electrostatic theory of dielectric media

$$j \equiv D \quad \text{- displacement}$$

$$\sigma \equiv k \quad \text{- dielectric constant}$$

to give the distribution of j throughout the medium.

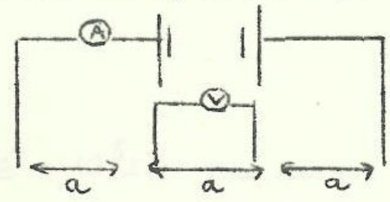
In most cases of geophysical interest the earth is layered in distinct strata - each of which may be assumed to be homogenous. In this case the electrostatic solution is given by the well-known method of images. However the computation involved for more than two or three layers is considerable and the experimenter usually analyses his results by referring to one of the set of "master curves" that have been published[5].

The case of glacier ice is probably more complicated as throughout the ice-bulk the resistivity is continuously varying due to surface layers, thermal distribution etc., even at the bed-rock floor the resistivity may not change discontinuously. However, the computational difficulties involved in obtaining a solution with the resistivity continuously varying with depth are so large that it has not been attempted. The interpretation of the data on glaciers is usually performed in terms of finite discontinuous layers.

EXPERIMENTAL TECHNIQUES

The experiment is very simple. It simply involves the measurement of the total current flowing through two electrodes buried in the earth and the voltage drop between another pair. Separate electrodes are used for measuring voltage to avoid difficulties due to differing electrode resistances - this latter quantity is a sensitive function of the size of the electrode.

The electrode system used in this experiment was the Wenner configuration in which all the four electrodes are spaced an equal distance "a" apart (fig. I).



The resistivity in

expressed in terms of the quantity:

$$\rho_a = 2\pi a \frac{E}{i}$$

where E is the voltage between the potential electrodes and i the total current. In the case of a uniform infinite medium it is easy to show:

$$i = 2\pi e \sigma$$

$$E = e/a$$

where e is the strength of the equivalent pole. Thus the equivalent resistivity is in this case the true resistivity.

If the medium were uniform the equivalent resistivity would be constant. The presence of layers is shown by deviations from their constancy and occurs for values of "a" approximately equal to the depth of the layer.

By comparing the experimental profile of ρ_a with the "master curves" it is possible to determine the depth and conductivity of the layers with some precision.

The choice of instruments is simple in the case of ice. The limitation on current is determined simply by the region near the electrode. In the case of two spherical conductors of radius r the voltage V_e between them is given roughly by:

$$V_e = 2e/r$$

and the current by

$$i = 2\pi e \sigma$$

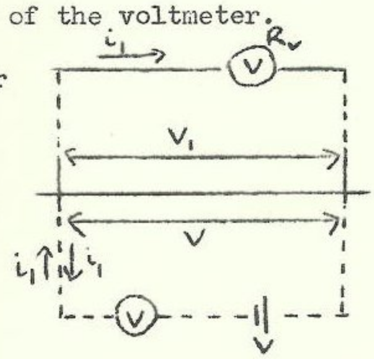
giving an electrode resistance

$$R_E = 1/\pi \sigma r$$

For typical values of r ($\sim$ 20-30 cm.) $R_E \sim 10^5 \Omega$. Thus to get a current of around 1 mA we require a battery voltage of about 100 v.

The current can be increased by effectively enlarging the size of the electrodes by surrounding them by electrolyte, e.g. common salt. This increase allows a greater current flow into the surrounding medium and consequently greater accuracy.

The choice of voltmeter requires care. The current taken by the instrument must disturb the current flow in the bulk as little as possible. Obviously the higher the input impedance of the device the better and a potentiometer or valve-voltmeter are needed. However, it is of value to derive the criterion for the input impedance of the voltmeter.



A current i_1 flows through the voltmeter which gives a voltage reading V_1 as in the upper diagram. Now consider a small battery V placed in the voltmeter circuit such that the total current through the voltmeter is zero. The voltage V across the term nals now is the true unperturbed value. Using the superposition theorem:

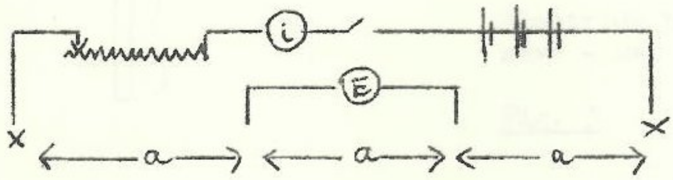
$$V = i_1 (R_V + R_E)$$
$$V_1 = i_1 R_V$$

and where R_V is the meter impedance and R_E that of the electrodes.

Thus the current is little disturbed provided $R_V \gg R_E$ - a result which could have been guessed from impeded circuit theory, but requires care because of the distribution of current in the medium. Thus a value voltmeter of input impedance greater than $10^7\ \Omega$ is required.

PRELIMINARY RESULTS

Measurements were made using the Wenner electrode system to obtain values of the apparent resistivity 'ρ_a' as a function of the separation of the electrodes 'a' (fig. 1).



(Fig. 1)

ρ_a is given by $2\pi a \frac{E}{c}$

The experimental apparatus was a 720 v. dry battery power supply with variable internal impedance. Current was measured on a Model 8 Avometer with 50μA fsd. Voltage was measured on a high impedance valve voltmeter (Airmec Type 314) with a maximum full scale resistivity of 300 mV. at an impedance of $10^8\ \Omega$. The electrodes were dural tubes ~1'x$\frac{3}{4}$" hollow with ~$\frac{1}{4}$" walls.

The measurements were made in the region covered by the grid of stakes used in the flow measurements. The plan shows roughly the layout, with the axis of the system 200 yds. on the left hand side of the medial moraine. The glacier surface in this region was transversley quite level with a small slope (a m/km) in the direction of flow. The area was relatively free of crevasses with rather narrow (~6") crevasses running perpendicular to the measurement axis at intervals of ~100 yds. These crevasses were water filled and none were present in the region of the short scale (a<40 yds.) measurements.

The electrodes were set up as drawn in Fig. 3.

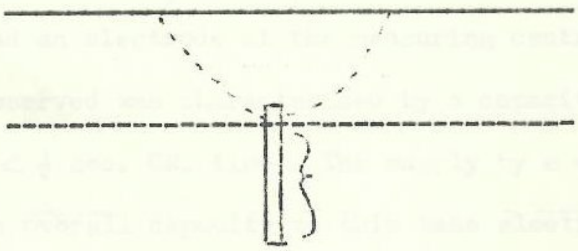


Fig. 3

The loose crystalline surface was shovelled away and the electrodes hammered into the underlying firn névé. This was waterlogged as evidenced by (1) water-filled crevasses, (2) the electrode hole would fill with water if the electrode was withdrawn.

The electrodes were buried under the loose surface material after insertion to prevent ablation effects.

It was found that no difference in ρ_a was observed with a=1.6 yds. and a=4.9 yds. whether the electrodes were buried or not, so that the loose surface was not contributary appreciably to the measurements.

A complete electrode and wiring system was set up for a values:

1.6
4.9
14.8
44.4
133
400 yards

This is illustrated in Fig. 4.

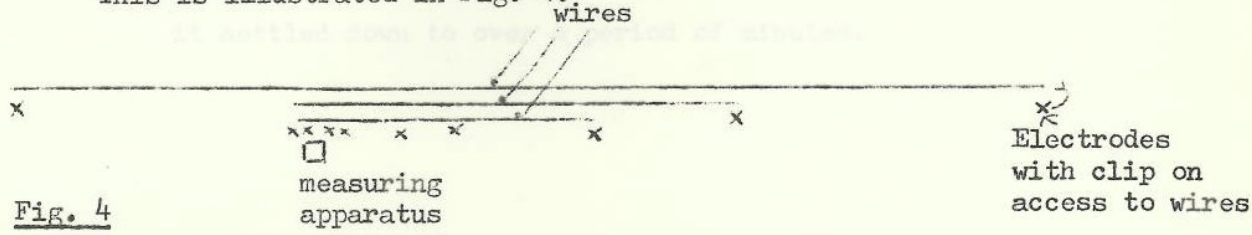


Fig. 4

The first measurement on this system was to connect all wires together isolated from the electrodes and to apply 720 V. between them and an electrode at the measuring centre. The total leakage current observed was characterised by a capacitive initial charging current $< \frac{1}{2}$ sec. CR. time. The supply by a series R of 100 KΩ indicating an overall capacity to this base electrode $< 5\ \mu$E.

This was followed by a few minutes of leakage at $\sim \frac{1}{4}\ \mu$H decreasing to $< 0.1\ \mu$A. This indicated that the insulation of the wiring was more than adequate for currents in the mA_o range.

The measurements made with this system are given in the tables.

Because of the saturated surface conditions it was considered important to check whether the freezing of the surface layer at night had any effect on the readings, particularly for small 'a' values.

The results (Table 1) show very little change between readings taken in the wettest conditions at mid-afternoon and the most frozen surface at midnight.

This is consistent with the previous observation that the loose surface layer did not contribute much to the measurements.

There were some slight complications to the measurements of a type observed elsewhere.

(a) The current was not steady initially and after the initial fluctuations it had a value about 10% higher than that which it settled down to over a period of minutes.

(b) Ground potentials up to 300 mV maximum were observed. These w were not steady over times of the order of minutes but drifted by tens of millevolts. (See repeated reading Tables 2 & 3.) In cases where the required E value was of the same order as the ground potential it was necessary to make a measurement with no current in the system to measure E ground then switch on the current and allow a couple of minutes for it to settle and measure E_{TOT} to give E signal by subtraction. Any drift of the ground potential in the interim would cause error in the measurements. In the worst cases this could be as much as $\pm$ 20 mV but with care this could be reduced to the order $\pm$ 10 mV.

A resistivity profile was obtained first using the Ag electrodes without electrolyte. A 100 KΩ wire impedence in the 720 V supply gave about half the voltage drop for currents ~ 1mA.

The resulting profile is shown in Graph 1. Reasonable accuracy is obtained except for a=400 yds. where the 14mV E signal measurement is subject to error from ground potential drift. To check on this it was necessary to increase the E value for a=400 yds.

The wire impedence was removed from the supply and the electrodes had a strong salt solution poured over them.

Current was increased to 8mA and consequently errors due to ground potential were greatly reduced.

The resulting profile is shown in Graph 2 and it follows the low current results quite well up to a = 100 yds. but diverges for the a = 400 yds. readings.

On this basis the high current results are thought to give the "true" profile of 'ρa' against 'a' for this particular electrode system.

TABLE I

a yds.	ρ_a Ω yds	Snow conditions	
133	71	Sun maximum	Wet surface
133	77.5	Frozen surface	Midnight
1	85	Sun maximum	Wet surface
1	93	Frozen surface	Midnight

TABLE 2 Unsalted Electrode Run

a yds.	i mA	Egr. mV	ETOT	E signal V	ρ_{aK} Ω yds.	Comments
						4.10 p.m.
1.6	1.2	-265	-12.6V	-12.3	106	One electrode steel ice piton
4.9	1.1	-147	- 6.7V	- 6.55	185	Egr. drifting
14.8	1.15	+ 55	- 1.12V	- 1. 8	955	
1.6	1.2	-255	-12.8V	-12.5	107	
44.4	1.1	+255	-90 mV	-0.345	87	
44.4	1.05	+170	-130mV	-0.300	80	
133.3	1.1	- 3	-110mV	-0.107	82	
400	0.55	+ 52	+3.8mV	-0.014	64	5.15 p.m.

TABLE 3 Salted Electrode Run

a yds.	i mA	Egr. mV	ETOT	E signal V	aK yds.	Comments
						Glacier freezin after sundown
400	8	+212	-110mV	0.322V	101	Salted xxxx
400	8	+300	- 65mV	0.365	114	Salted xxxx
133	6.6	+347	-260mV	0.607	77	Salted xxxx
44.4	6.7	+ 45	-1.96V	2.0	83	Salted xoox
14.8	3.6	+ 8	-3.7 V	3.7	96	Salted xooo
4.9	3.03	+ 75	-17.7V	17.8)	181	Salted xooo
4.9	3.1	+75	-18 V	18.1)		Salted xooo
1.6	5.2	-	-61 V	61	121	Salted xooo

x salted
o unsalted

The results obtained are provisional, but one or two points may be made:

(1) The feature for depths less than 10m. is due to surface phenomena - probably mainly the summer melt which extends down about 5m.

(2) The bulk ice resistivity has a value at about 100 kΩm. It does not however show the feature observed by Meyer and Rocthlisberger[(4)] on a cold valley glacier, namely a thin layer of ice of resistivity 100 kΩm. followed by higher resistivity ice (0.5 - 1.5 MΩm.)

(3) Near the base of the glacier the ice resistivity increases despite the fact that the rock presumably has a much higher conductivity. The possible causes of this are discussed in Ref. 4.

(4) The depth of the glacier was about 400 m.

The results will be evaluated in more detail later.

---

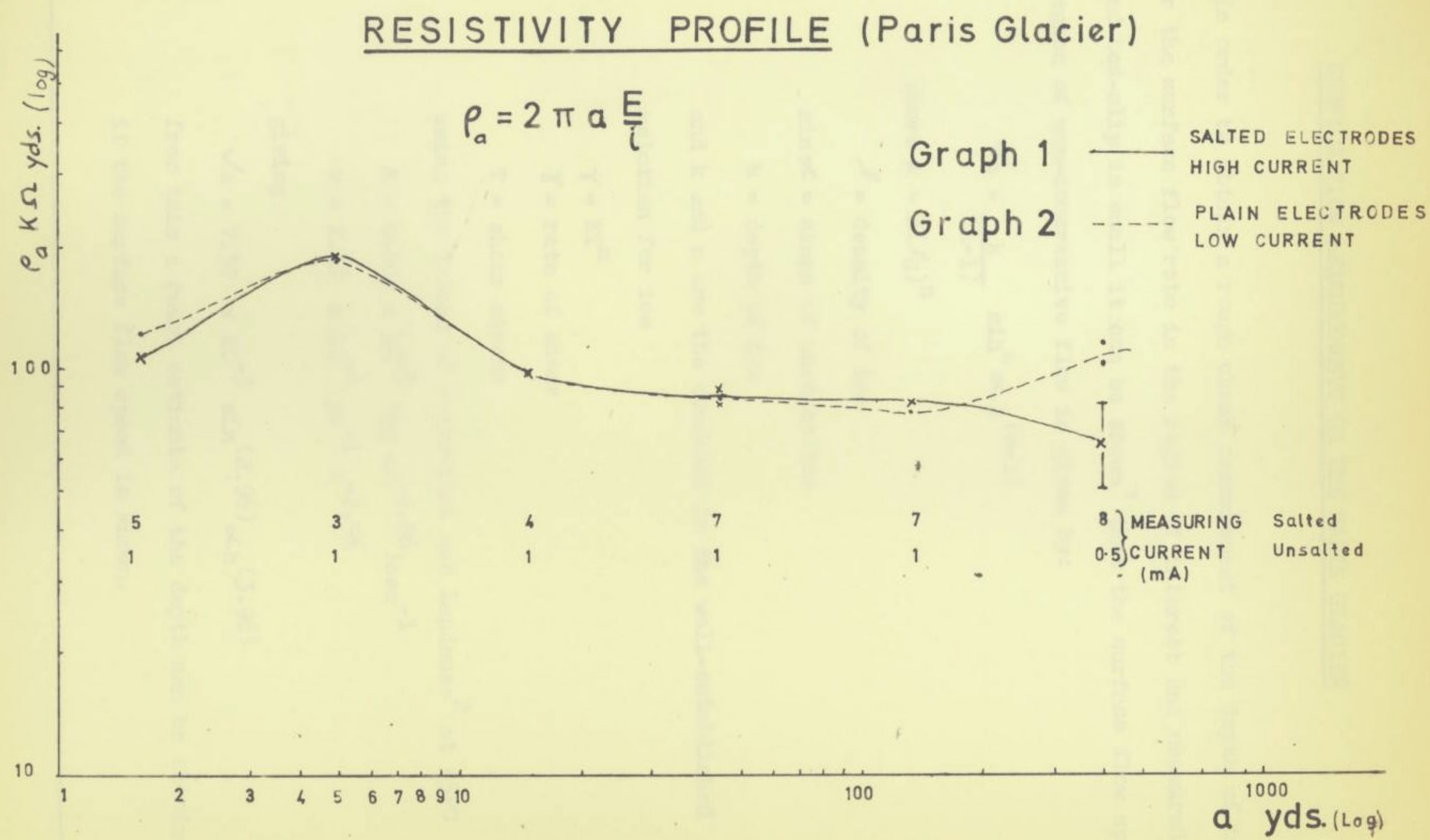
1. Lefévre, C; Albertuioli, P; Bauer, A; Gagniara, L; and Fournier, H. Mésures électriques et telluriques sur le Grand Glacier d'Aletsch. Annales de Géophysique, Tome 13, no. 1, p.54. 1957.

2. Queille - Lefévre, C; Bauer, A; and Girard. Premier essai de mésure électrique d'eppaisseur d'un glacier. Annales de Géophysique. Tome 15, no. 4, p.564. 1959.

3. Keller, G.V., and Fuschknecht, F.C. Electrical resistivity studies on the Athabadca Glacier, Alberta, Canada: Journal of Research of the National Bureau of Standards - D Radio Propogation vol. 64D, no. 5, p.439, 1960.

4. Meyer, A.W. and Rocthlisberger, H. Electrical D-C Resistivity Measurements on Glacier Ice near Thule, Greenland: U.S. Army Cold Regions Research & Engineering Laboratory Report, no. 87. 1962.

5. Mooney, H.M. and Wetzel, W.W. The potentials about a point electrode and apparent resistivity curves for a two- three- and four-layer earth: The University of Minnesota Press, 1956.


RESISTIVITY PROFILE (Paris Glacier)
$\rho_a = 2\pi a \frac{E}{i}$
Graph 1
SALTED ELECTRODES
HIGH CURRENT
Graph 2
PLAIN ELECTRODES
LOW CURRENT
ρ_a KΩ yds. (log)
100
10
5 3 4 7 7 8
1 1 1 1 1 0·5
MEASURING CURRENT (mA)
Salted
Unsalted
1 2 3 4 5 6 7 8 9 10 100 1000
a yds. (Log)

SURFACE FLOW MEASUREMENTS ON THE PARIS GLACIER

In order to obtain a rough check measurement of the depth of the glacier the surface flow rate in the region of interest was measured. Provided bed-slip is small it can be shown[1] that the surface flow speed in a region of non-compressive flow is given by:

$$V_s = \frac{k}{(n+1)} \sin^n \alpha \cdot h^{(n+1)}$$

where $k = K(\rho g)^n$

ρ = density of ice

$\sin \alpha$ = slope of surface ice

h = depth of ice

and k and n are the constant in the well-established relation for ice

$$\dot{\gamma} = KT^n$$

$\dot{\gamma}$ = rate of shear

T = shear stress

using the values of Butkovitch and Landauer[2] at -5°C

$$K = 0.863 \times 10^{-8} \, (\text{kg cm}^{-2.96})\text{sec}^{-1}$$

$$k = 2.18 \times 10^{-4} \, \text{yr}^{-1} \, \text{m}^{-2.96}$$

giving

$$V_s = 7.37 \times 10^{-3} \sin^{(2.96)} \alpha \, h^{(3.96)}$$

from this a rough estimate of the depth can be obtained if the surface flow speed is known.

SURVEYING

The surface flow profile of the glacier was measured using a one-second Watt's theodolite by triangulating from two stations set up on the edge of the glacier. As the theodolite could not be airdropped it had to be carried into the area but even so its accuracy was slightly impaired but this was not important as the total angular movement over 10 days was about 25 minutes.

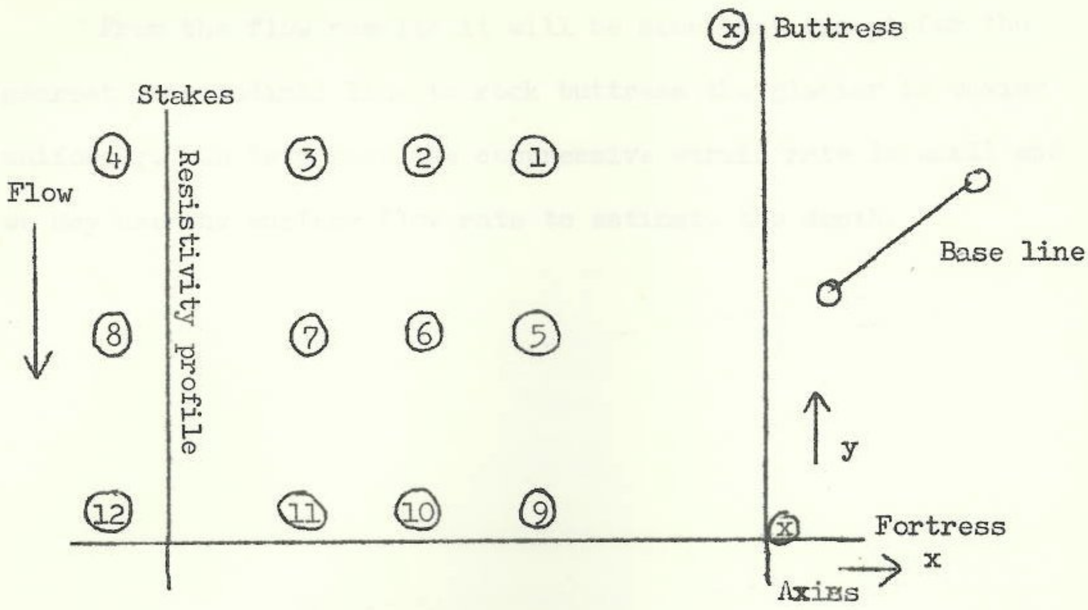
The two stations were set up on the east side of the glacier, one station being at base camp and the other half way up the south side of the second buttress to the north of base camp. A base line of about 500 ft. was set up on the ice between the two stations and was accurately measured with a steel tape.

Twelve stakes were drilled into the glacier and these were set out in three transverse lines of four reaching the middle of the glacier. The longest line of sight was about 2 miles. Ablation measurements were also made on six of the stakes.

STAKE COORDINATES AND DISPLACEMENTS

	x (ft.)	y (ft.)	x (ft.)	y (ft.)
11	3182.90	2409.91		
12	3185.74	2384.12	-2.84	25.79
21	4738.75	2373.56		
22	4742.19	2345.97	-3.44	27.60
31	5725.91	2350.86		
32	5725.88	2321.26	+0.02	29.61
41	6679.27	2328.66		
42	6681.24	2299.92	-1.96	28.74
51	3235.39	1710.04		
52	3243.41	1687.05	-8.01	22.99
61	4825.09	1518.72		
62	4824.38	1489.67	+0.71	29.06
71	5771.72	1390.58		
72	5770.21	1360.86	+1.51	29.72
81	6639.79	1273.08		
82	6637.09	1243.13	+2.70	29.96
91	3510.37	-110.18		
92	3510.86	-136.12	-0.49	25.94
101	4946.40	227.11		
102	4940.55	198.89	+5.51	28.23
111	5815.73	297.13		
112	5817.35	268.63	-1.62	28.50
121	6596.28	359.82		
222	6598.02	330.65	-1.74	29.17

Observation period 10 days



<u>Ablation Results</u>

Period: 10 days

Stake	
11	9.5"
7	8.5"
3	11 "
1	8 "
5	7.5"
9	8 "

From the flow results it will be seen that except for the nearest longitudinal line to rock buttress the glacier is moving uniformly. In this case the compressive strain rate is small and we may use the surface flow rate to estimate the depth.

ACKNOWLEDGEMENTS

This expedition was only possible as a result of the financial assistance given by the following bodies:

Imperial College Exploration Board
The Mount Everest Foundation
The Royal Geographical Society
The Gilchrist Educational Trust
The William Johnson Yapp Trust
The Goldsmith's Company
The Gino Watkins Memorial Trust

The loan of parachutes was arranged through the University of London Air Squadron R.C.T., to whom our grateful thanks are due for their understanding and help in making good the loss of the parachutes.

Official permission for the expedition was given by the Danish Ministry for Foreign Affairs and was obtained by H.M. Foreign Office.

During the expedition many individuals contributed their time and knowledge to help us:

S. Angerer, Swiss-German Expedition 1963
F. W. G. Annas, Accountant, Imperial College
Dr. F. Baastad, Swedish-Norwegian Expedition 1966
D. Bridgewater, Grönlandt Geologiske Undersogebe
P. Carlsen, Airport manager, Kulusuk
Major J. M. Dyas, 22nd Air Despatch Squadron, R.C.T
Dr. S. Evans, Scott Polar Research Institute
Major A. J. Gidley, 14th Air Despatch Squadron, R.C.T.
T. Green, Observer
Dr. C. Grey, M.O., Imperial College
Dr. P. W. F. Gribbon, Scottish Expedition, 1963
E. Hoff, Dansk Berg Club, Copenhagen.
Capt. J. A. Iveland, 22nd Air Despatch Squadron, R.C.T.
P. H. Jonsson, Icelandair
Col. M. M. Lewis, R.A.M.C.
Herr Meier, Kungmuit

Takashi Miyahara, Japanese Expedition 1965
J. Paran, Scott Polar Research Institute
Dr. H. Rothlisberger, Versuchoanstalt fur Warrerbun
und Erdbun der E.T.N., Switzerland
Dr. G. de Q. Robin, Scott Polar Research Institute
Wing Commander H. V. Sayfritz, University of London
Air Squadron
Major Scott, R.A.M.C.
P. Sellar, Imperial College Exploration Board
Group Captain A. J. H. Smyth, R.A.F.M.C.
Carsten Berg Soronan, Angmagssalik
A. Stephenson, Chairman, Imperial College Exploration Board
S. Stera, Accounts Department, Imperial College
P. F. Taylor, Imperial College Exploration Board
Lt. Cdr. M. B. Thomas, R. N. Expedition 1966
Dr. J. Thorley, Scottish Expedition 1963
P. E. Victor, Missions, P, E. Victor, Paris

Food was supplied by the following firms, often free or at a reduced cost:

A. Abdullah & Sons
Batchelors Catering Supplies Limited
Boris Bertoya & Company
Bovril Limited
British Cocoa Mills (Hull) Limited
Cadbury-Fry
William Carey & Son
Carr's of Carlisle Limited
J. & J. Colman Limited
W. H. Cullen
Energen Foods Company Limited
Farley's Infant Food Limited
Glaxo Laboratories Limited
H. J. Green & Company Limited
H. P. Sauce Limited
C. & T. Harris (Calne) Limited
Haywards Food Products Limited
H. J. Heinz Company Limited
Horlicks Limited
Hooper Struve & Company Limited
Imperial Chemical Industries Limited
Kavli Limited
George Mason & Company Limited
McDougalls Limited
Thomas Mitchelhill Limited

Oxo Limited
Park Cake Bakeries Limited
Pasta Foods Limited
Pearce Duff & Company Limited
Quaker Oats Limited
James Robertson & Sons
George Romney Limited
J. H. Senior & Company Limited
Severnside Foods Limited
C. Shippam Limited
Tate & Lyle Refineries Limited
Templeton Patents Limited
Thames Rice Milling Company Limited
United Biscuits Limited.(Wm. Crawford & Sons)
Van den Berghs Limited
Vitamins Limited
A. Wander Limited
H. S. Whiteside & Company Limited
Whitworths Holdings Limited
Winterbotham, Darby & Company Limited

In addition the following groups of people must also be thanked for their help:

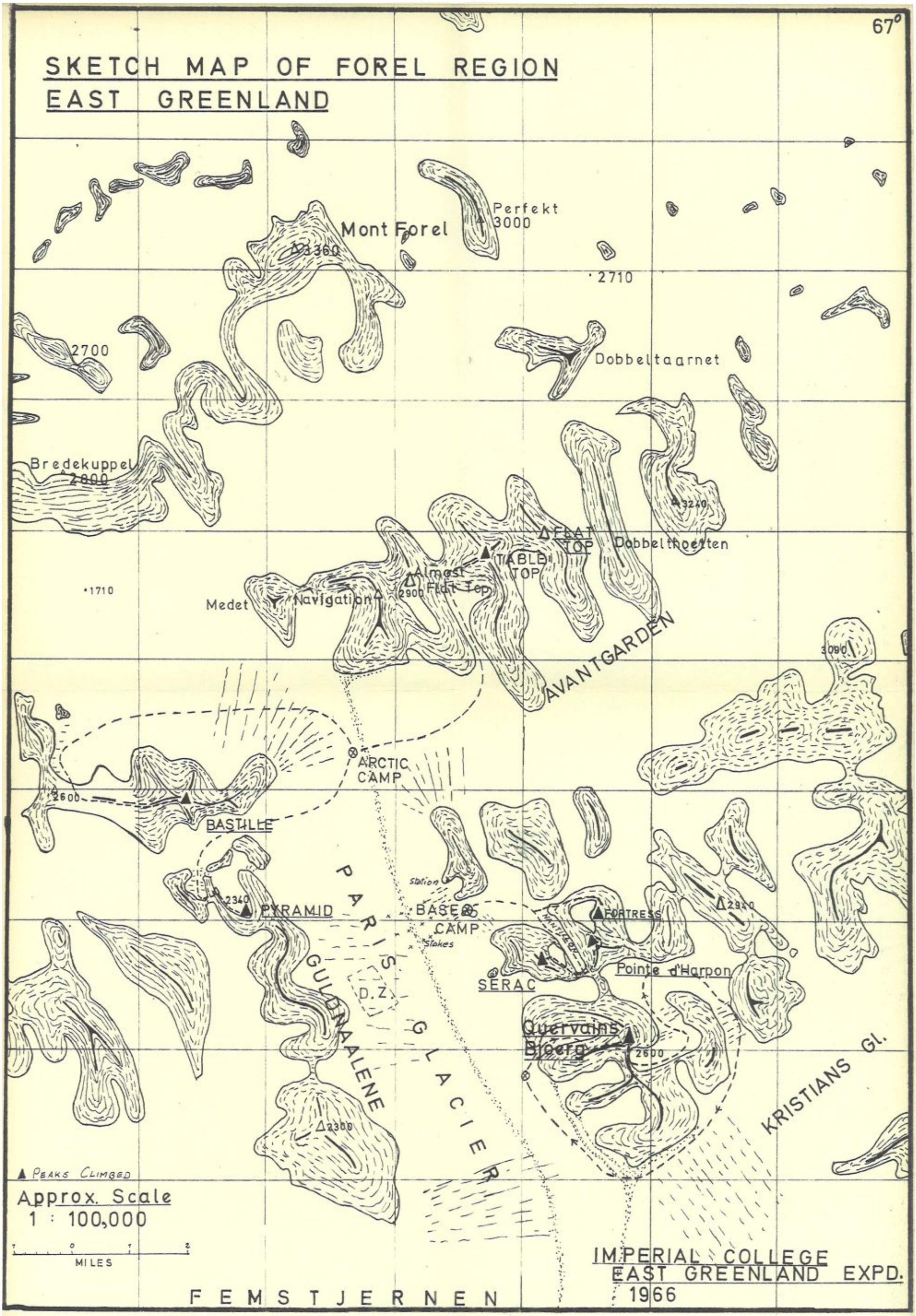
The Captain and crew M.V. Aarvak
Eskimo boatmen at Kungmuit
Royal Naval East Greenland Expedition 1966
Swiss Greenland Expedition 1966
Swedish-Norwegian Greenland Expedition 1966
Nihon University, Japan, Greenland Expedition 1966

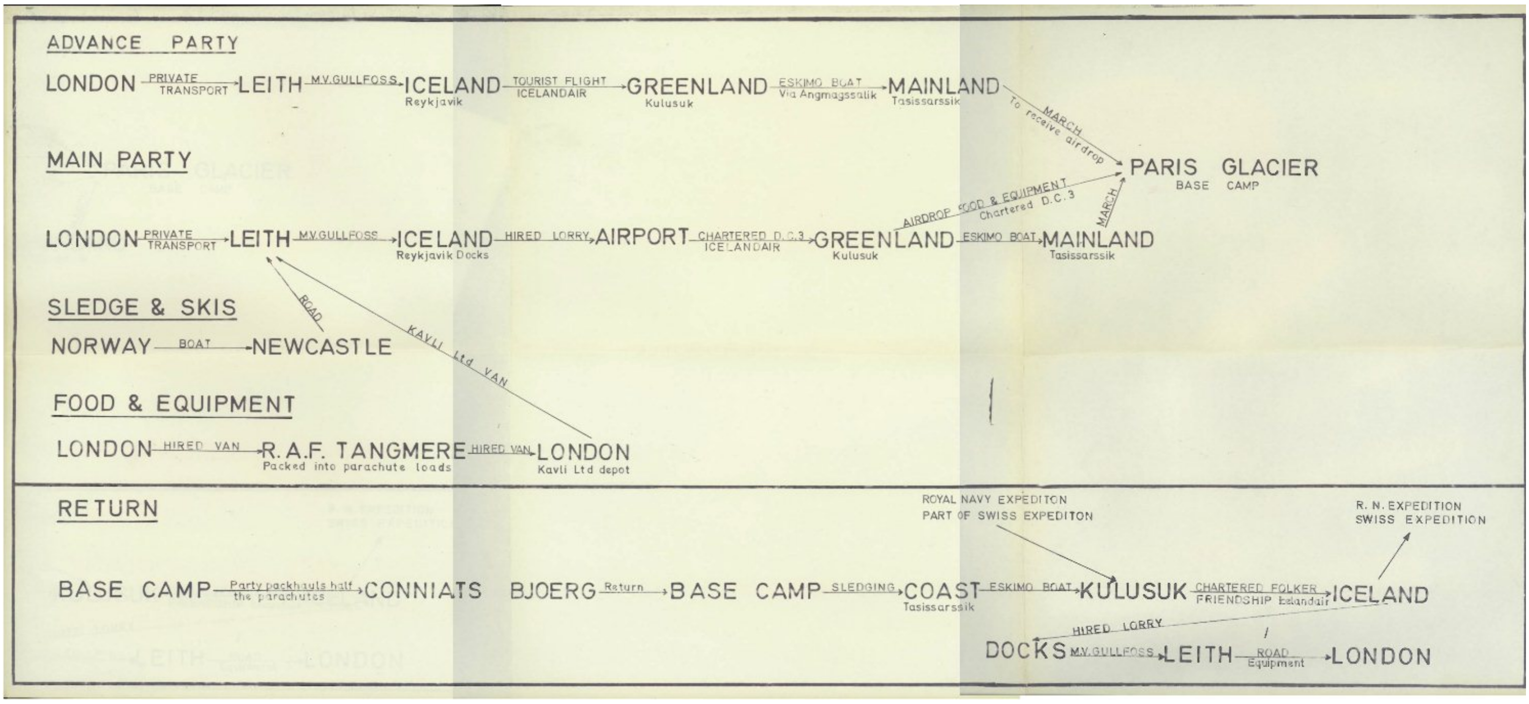
Many commercial firms helped with our equipment:

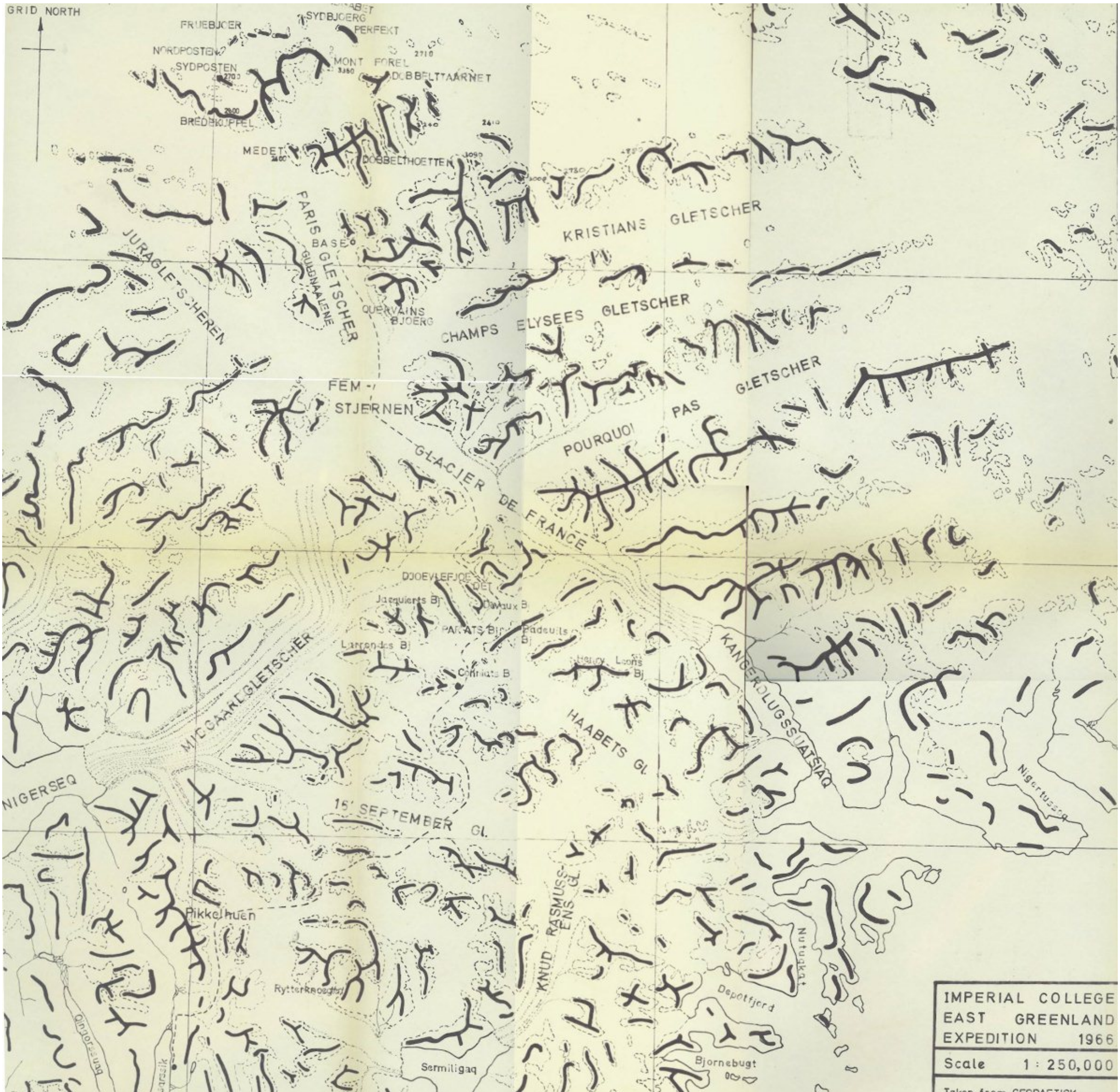
Airmec Limited
Beck & Pollitzer Contracts Limited
British Industrial Plastics Limited
British Ropes Limited
Ellis Brigham Limited
Ever Ready Limited
I.C.I. Fibres Limited
Kodak
Robert Lawrie Limited
A/S Lommedal Skijabrikk

Meltonian Wren Limited
Metal Box Company Limited
B. Packer (Greenock) Limited
Pharmaceutical Products Limited
Players Limited
Ronson Products Limited
Smith Bros. (Whitehaven) Limited
Smiths Clocks & Watches Limited
Jean Sorelle
Thames Board Mills Limited

Special thanks are due to Kavli Cheese Limited who transported all our equipment from London to Leith.


67°
SKETCH MAP OF FOREL REGION
EAST GREENLAND
Mont Forel
3360
Perfekt
3000
2710
2700
Dobbeltaarnet
Bredekuppel
2800
3240
FLAT TOP
Dobbelthoetten
TABLE TOP
Almost Flat Top
2900
1710
Medet
Navigation
AVANTGARDEN
3090
ARCTIC CAMP
2600
BASTILLE
PARIS GLACIER
Station
BASE CAMP
Stakes
2340
PYRAMID
FORTRESS
2940
SERAC
Pointe d'Harpon
D.Z.
GULDNAALENE
Quervains Bjoerg
2600
KRISTIANS Gl.
2300
▲ Peaks Climbed
Approx. Scale
1 : 100,000
1 0 1 2
MILES
IMPERIAL COLLEGE
EAST GREENLAND EXPD.
1966
FEMSTJERNEN


ADVANCE PARTY
LONDON
PRIVATE TRANSPORT
LEITH
M.V.GULLFOSS
ICELAND
Reykjavik
TOURIST FLIGHT
ICELANDAIR
GREENLAND
Kulusuk
ESKIMO BOAT
Via Angmagssalik
MAINLAND
Tasissarssik
MARCH
To receive airdrop
PARIS GLACIER
BASE CAMP
MAIN PARTY
LONDON
PRIVATE TRANSPORT
LEITH
M.V.GULLFOSS
ICELAND
Reykjavik Docks
HIRED LORRY
AIRPORT
CHARTERED D.C.3
ICELANDAIR
GREENLAND
Kulusuk
AIRDROP FOOD & EQUIPMENT
Chartered D.C.3
ESKIMO BOAT
MAINLAND
Tasissarssik
MARCH
SLEDGE & SKIS
NORWAY
BOAT
NEWCASTLE
ROAD
KAVLI Ltd VAN
FOOD & EQUIPMENT
LONDON
HIRED VAN
R.A.F. TANGMERE
Packed into parachute loads
HIRED VAN
LONDON
Kavli Ltd depot
RETURN
BASE CAMP
Party packhauls half the parachutes
CONNIATS BJOERG
Return
BASE CAMP
SLEDGING
COAST
Tasissarssik
ESKIMO BOAT
KULUSUK
ROYAL NAVY EXPEDITON
PART OF SWISS EXPEDITON
CHARTERED FOLKER FRIENDSHIP Islandair
ICELAND
R. N. EXPEDITION
SWISS EXPEDITION
HIRED LORRY
DOCKS
M.V.GULLFOSS
LEITH
ROAD
Equipment
LONDON


GRID NORTH
FRUEBJOER
SYDBJOERG
PERFEKT
NORDPOSTEN
SYDPOSTEN
MONT FOREL
DOBBELTTAARNET
BREDEKUPPEL
MEDET
DOBBELTHOETTEN
FARIS GLETSCHER
BASE
JURAGLETSCHEREN
KRISTIANS GLETSCHER
QUERVAINS BJOERG
CHAMPS ELYSEES GLETSCHER
FEM-STJERNEN
POURQUOI PAS GLETSCHER
GLACIER DE FRANCE
MIDGAARDGLETSCHER
KANGERDLUGSSUATSIAQ
HAABETS GL.
15' SEPTEMBER GL.
NIGERSEQ
KNUD RASMUSSENS GL.
Pikkelhuen
Sermiligaq
Depotfjord
Bjornebugt
IMPERIAL COLLEGE
EAST GREENLAND
EXPEDITION 1966
Scale 1 : 250,000
Taken from GEODAETISK
INSTITUT No. 66 Ö 2