NORGES SVALBARD- OG ISHAVS-UNDERSØKELSER
LEDER: ADOLF HOEL

SKRIFTER

Nr. 86

THE SURVEY OF BJØRNØYA (BEAR ISLAND) 1922–1931

WITH 1 MAP OF THE ISLAND ON THE SCALE OF 1:25000,
22 FIGURES IN THE TEXT, AND 2 PLATES

OSLO
I KOMMISJON HOS JACOB DYBWAD
1944

RESULTS OF THE NORWEGIAN EXPEDITIONS TO SVALBARD 1906—1926 PUBLISHED IN OTHER SERIES

(See Nr. 1 of this series.)

The results of the Prince of Monaco's expeditions (Mission Isachsen) in 1906 and 1907 were published under the title of 'Exploration du Nord-Ouest du Spitsberg entreprise sous les auspices de S. A. S. le Prince de Monaco par la Mission Isachsen', in Résultats des Campagnes scientifiques, Albert Ier, Prince de Monaco, Fasc. XL—XLIV. Monaco.

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With map: Spitsberg (Côte Nord-Ouest). Scale 1 : 100 000. (2 sheets.) Charts: De la Partie Nord du Foreland à la Baie Magdalena, and Mouillages de la Côte Ouest du Spitsberg.

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Bear Island. 1 : 25 000. 1925. Kr. 10,00.

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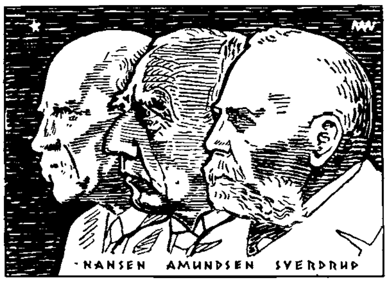

OSLO
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1944

A. W. BRØGGERS BOKTRYKKERI A/S

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Illustrations.

Introduction.

Bjørnøya (Bear Island) in the Arctic Sea is the southernmost island of the Svalbard island group and is one of the most solitary of the Arctic islands. It extends from 74° 20.5′ to 74° 31.3′ Lat. N. and from 18° 46′ to 19° 17′ Long. E. The distance from Norway is 240 nautical miles, and from Sørkapp (South Cape) on Spitsbergen 120 miles. The climate is mild (average for the year: — 3° C) considering the high latitude. In the summer the island is enveloped in fog most of the time. Drift ice may be met with even in the summer.

The island is of triangular shape and pointing southwards. The greatest length is 20 km from north to south, and 15.5 km from west to east. The area is 178.07 sq.km (68.75 sq. miles).

The island can be divided into three natural regions: (1) the northern plain covered with numerous shallow lakes, (2) the mountain Miseryfjellet with three peaks, one rising to 536 m above sea-level, the highest point of the island, and (3) the southern mountains attaining an altitude of 440 metres. The lakes and ponds number abt. 700, by far the greater number of which are situated in the northern plains (see accompanying map). The coasts of Bjørnøya consist almost entirely of steep cliff, and only at few points is it possible to land. The southern part of the island consists of rocks of Cambro-Silurian age. They are dolomites, limestones, and slates. The northern plain and Miseryfjellet are built up of coal-bearing sandstones of Devonian age, and sandstones and limestones of Carboniferous age (northern plain only). The three peaks of Miseryfjellet consist of Triassic rocks, this formation being the youngest in the island.

The surface of the ground is quite bare or covered with fragments of the bed-rock, and when this is hard sandstone, as is the case in the greater part of the island, the passage across this country is exceedingly trying. Only in a few places has anything approaching soil been formed. There are no glaciers on the island.

Coal has been known in the island since 1609.[1] In 1898 claims to land were staked off by a German, Theodor Lerner, and also by the German Fishery Association in the same year. In the year 1915 the island was claimed by Norwegians, and the following year coal-mining operations on a small scale were started by a company registered at Stavanger in Norway. The mine was situated in the north-eastern part of the island. Mining continued until 1925, when work was suspended, it being found impossible to work the thin seam in times of ordinary coal prices. The total tonnage shipped amounts to 116,094 metric tons.

A wireless station was built at Tunheim in 1919, and a meteorological station established here in 1923. This station, being owned by the Norwegian State, continued its work also after the cessation of mining operations.

Bjørnøya was discovered on June 10, 1596 by a Dutch expedition sent out to find a North-east passage, and of which Willem Barents was the chief pilot. The island was named "Beeren Eylandt" after a polar bear killed when the ships were close to the island. The island was a no — man's — land until 1925, when it came under Norwegian sovereignty according to the Spitsbergen Treaty of Feb. 9th, 1920 signed in Paris.

In 1919 the Norwegian Government became financially interested in the *Bjørnøen A/S*, the Stavanger company operating the mines since 1918, through advancing funds for development work. In 1922 Mr. Adolf Hoel proposed, as leader of the State-supported Norwegian Svalbard expeditions that, owing to the considerable State interests involved, detailed investigations of the coal resources of the island and workability of the seams should be carried out. A large-scale topographical survey of the island was part of this programme. The plans were considered by the Government Coal Committee, who recommended that the work should be carried out, and the plans were finally approved by the Department of Trade and Industry. The topographical survey was effected in the summers of 1922, 1923, and 1924; and the geological work in the summers of 1924 and 1925.

[1] The history of the island is dealt with in the following paper: Gunnar Horn and Anders K. Orvin. Geology of Bear Island with special reforence to the coal deposits, and with an account of the history of the island. Oslo 1828. — Skrifter om Svalbard og Ishavet. Nr. 15.

Older Maps of Bjørnøya 1598—1910.

In 1596 a Dutch expedition undertook a voyage in the Arctic Sea, attempting to find a northern passage to China. The leading spirit of the expedition was the aforesaid Willem Barents. On this voyage Spitsbergen and Bjørnøya (Bear Island) were discovered. It is possible that the island was known to the Norwegians or Icelanders long before that, but no records are known of such a discovery. Fig. 1 shows a part of the map by Barents, published in 1598, containing his discoveries. On this map will be found the name given to the island by Barents, *T'veere Eylandt*, and its latitude is quite correctly given as 74° 30′ N. Considering the small scale of the map he can hardly have attempted to give the island any definite shape, and it can only be regarded as a position. Spitsbergen is called *Het nieuwe land.*

On a series of maps of these tracts from the 16th and 17th centuries, Bjørnøya has been given the most varied shapes. The maps are as a rule on a small scale and are reproduced in the important work by F. C. Wieder (1919).

The Scottish whaler, W. Scoresby, has drawn a sketch of the island seen towards ESE from a distance of 10 miles (Fig. 2) (Scoresby (1820), Vol. II, Pl. III). This sketch, showing three pointed peaks to the left, must have been used for the map published by the German geologist, von Buch (1847). This map (Fig. 3) was drawn by Professor B. M. Keilhau of the University of Oslo, but the three mountains have probably been placed on the map by von Buch. As Scoresby does not show any of the low land actually existing to the left, a confusion has arisen, and the three summits representing Miseryfjellet (Mount Misery), have been taken as being in the foreground, that is, in the northwestern part of the island, where there are no mountains. The same error is found on the map by Petermann (1865), Fig. 4. On this map will also be found some islets and the cliff along the coast. Some new names and a description have also been inserted.

During the Swedish expedition to Spitsbergen (1864), the sketch reproduced in Fig. 5 was made by N. Dunér and A. E. Nordenskiöld

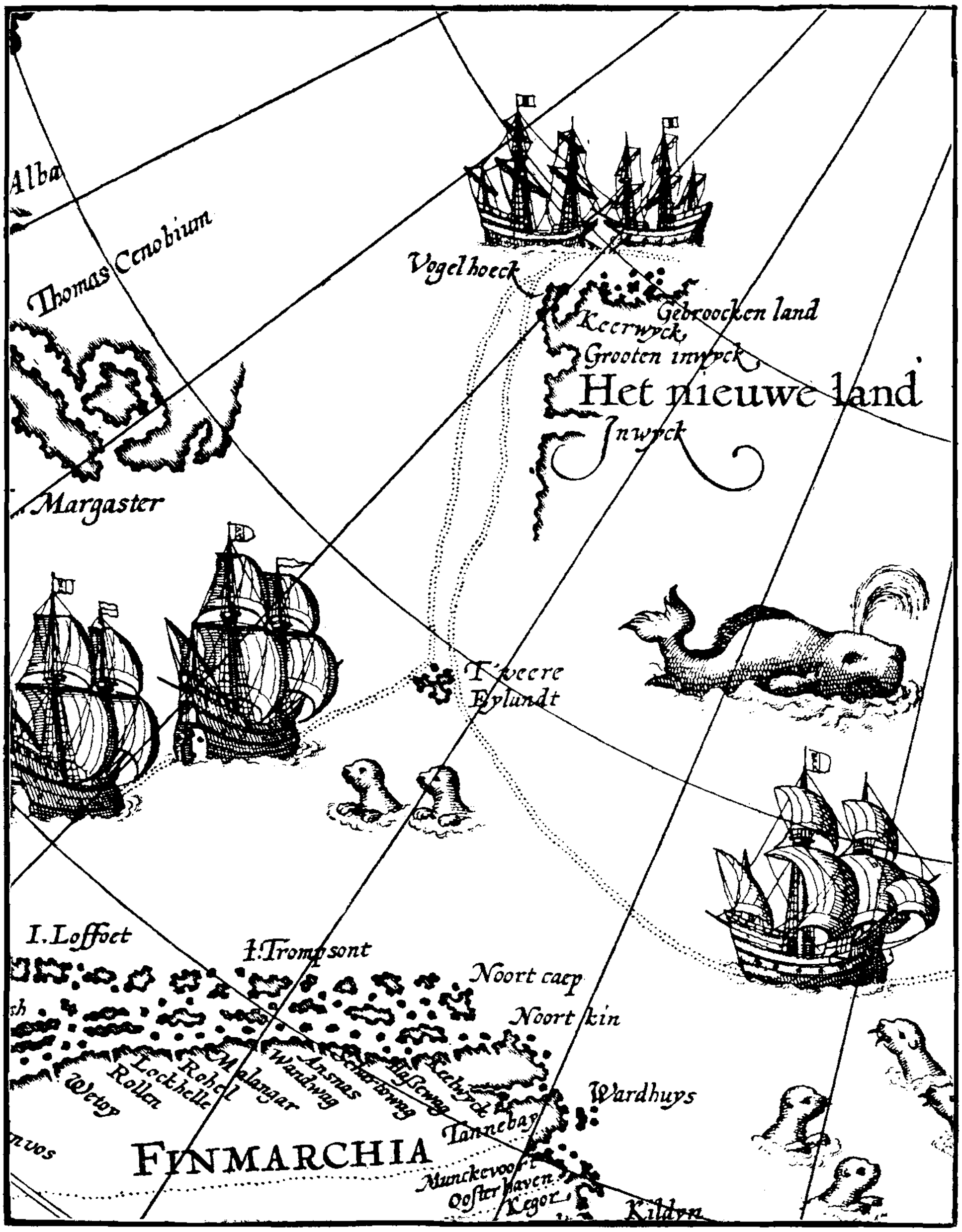

Fig. 1. Norway — Spitsbergen. From Barents' Map of 1598.

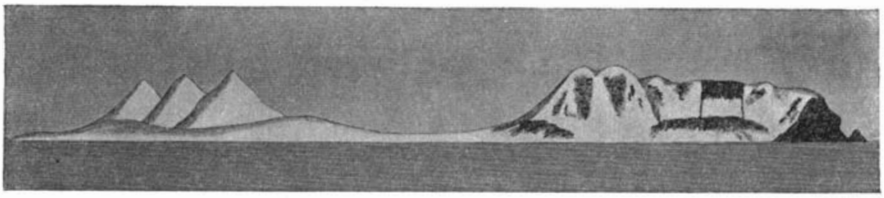

Fig. 2. View of "Cherie or Bear Island, bearing E. S. E. distant 10 Miles."
Scoresby 1820.

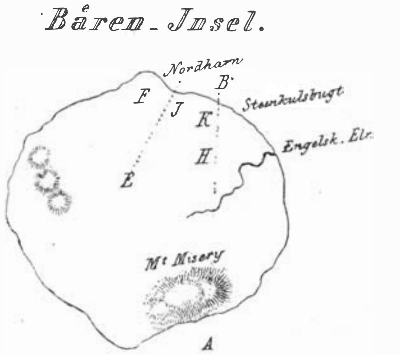

Fig. 3. After B. M. Keilhau, published by v. Buch 1847.

Fig. 4. After B. M. Keilhau, published in Petermanns Mitteilungen 1865.

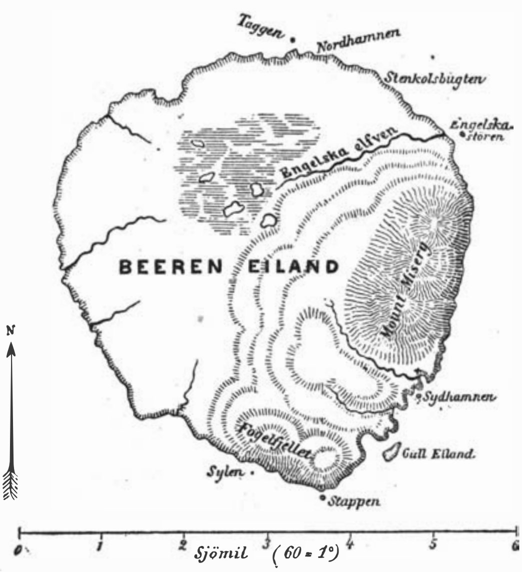

Fig. 5. After Dunér and Nordenskiöld 1864.

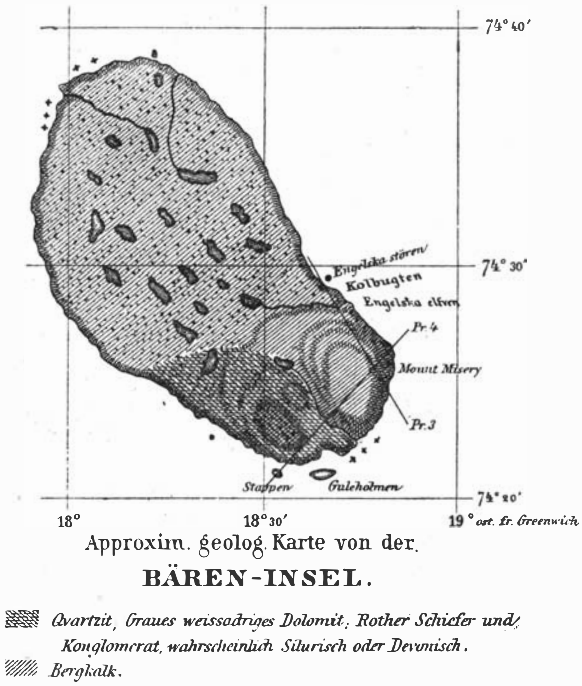

Fig. 6. After Oswald Heer 1871.

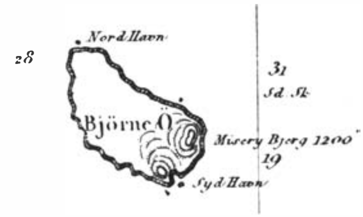

Fig. 7. From Danish Chart published in 1877.

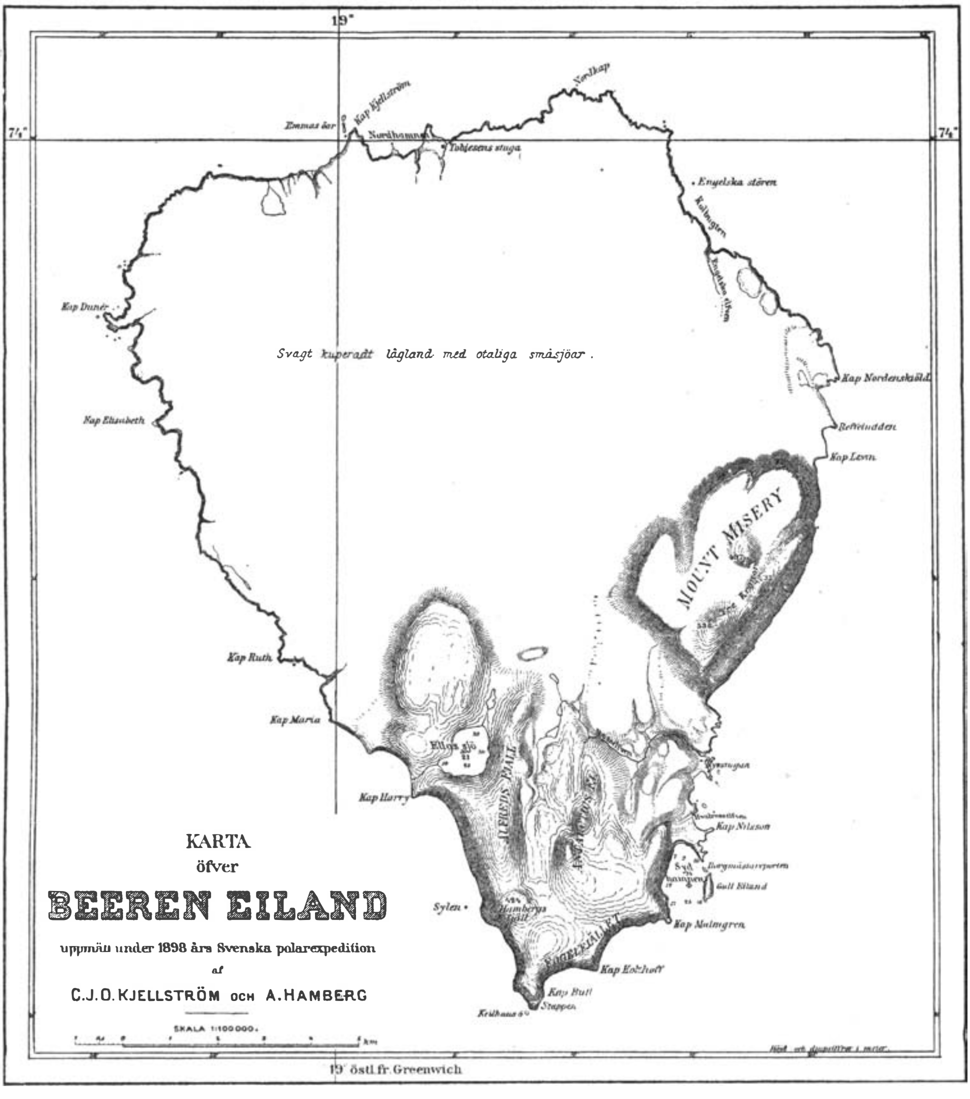

Fig. 8. After Kjellström and Hamberg 1898, reduced.

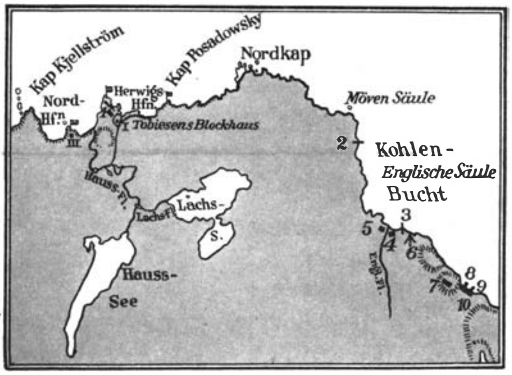

Fig. 9. North-eastern Part of the Island, after Part of Map by Deutscher Seefischerei-Verein 1899.

(1867), but owing to lack of time, it was possible to make only a rough sketch. However, it gives quite a good picture of the shape and appearance of the island; but the area of the low country is too small, and the capes are not sufficiently pronounced. The scale given next to the sketch corresponds to 1 : 165 000, but should really be 1 : 300 000. Dunér determined the geographical coordinates of the hut in Russehamna, and found it to have a latitude of 74° 22′ 56″ North, and a longitude of 19° 15′ 15″ East of Greenwich, which figures do not vary very much from the actual ones.

The map (Fig. 6) published by Oswald Heer (1871) represents a step backwards. Here the low country is too large, and the shape is so distorted that many features are quite unrecognisable. The longitude and the azimuth determinations are not good.

On the Danish chart "Nordlige Ocean med Hvide Hav" Kjøbenhavn 1857 (corrected to 1877) the island has been given a similar shape and size (Fig. 7).

The first map proper of the island was surveyed by C. J. O. Kjellström and A. Hamberg on the Swedish Polar Expedition 1898 led by A. G. Nathorst, and published on the scale of 1 : 100 000 in the Swedish journal "Ymer" 1899 (Fig. 8). Hamberg surveyed the hilly southern part of the island. He intended to use photogrammetry, but the weather was so hazy that he had to be content with the other methods. Kjellström used a plane table and surveyed the stretch from the southern end of Miseryfjellet along the east, north, and west coasts of the island as far as Kapp Maria. Of the numerous lakes situated on the low ground only three near the coast were surveyed. The surveying was done in the course of a week and, considering the short time, it must be said to be a fine piece of work. This map had, it is believed, no trigonometrical base. On the same occasion Kjellström made a large scale plan of Sørhamna, also containing soundings. A similar special map of Russehamna was surveyed by C. A. Forsberg on the Swedish expedition in 1899.

During the expedition of the *Deutscher Seefischerei-Verein* in 1899 Haussvatnet and Laksvatnet were surveyed and plotted on the map of Kjellström and Hamberg (Fig. 9), and a polygonal traverse was also run along the coast from Herwighamna to Engelskelva. Herwighamna was surveyed on a larger scale and soundings taken. The work was performed by J. Kessler, the Mine Surveyor.

On the Norwegian Isachsen Expedition to Spitsbergen in 1910 Norskehamna was charted on the scale of 1 : 25 000. The soundings were done by Captain A. Hermansen, Norwegian Navy, whilst the coast line was measured by A. Koller, Civil Engineer, and Captain Arve Staxrud, Norwegian Army.

Literature.

Beschrijvinghe van de drie seilagien door de Hollanders gedaen ande Noordt syde van Noorweghen, Moscovia, Nova Sembla, ende door de Weygats ofte Strate de Nassou so mede het deel van Groenlandt op de 80 graden . . . door Willem Barents van Amstelredam . . . Cornelius Nicolai excudebat. Baptista á Doetechum schulp. ao. 1598. (Scale abt. 1 : 10000000, 42 × 56 cm.) See Wieder. The Dutch discovery and mapping of Spitsbergen (1596—1899). Amst. 1919. P. 47, pl. 1.

Cherie, or Bear Island, bearing E. S. E. distant 10 Miles. — W. Scoresby. An account of the Arctic regions. Vol. 2. Edinb. 1820. Pl. III, 1.

Bären-Insel. (4 × 4 cm.) — Leopold von Buch. Die Bären-Insel. Nach B. M. Keilhau geognostisch beschrieben. Berlin 1847. Pl.

Die Bären-Insel. Nach B. M. Keilhau. Maßstab etwa 1 : 500000. (5 × 5 cm.) — Petermanns Mitteilungen. Erg.h. 16. Berlin 1865. Pl. 2.

Beeren Eiland. (Scale 1:165000. 7 × 7 cm.) — Svenska expeditioner till Spetsbergen och Jan Mayen, utförda under åren 1863 och 1864 af N. Dunér, A. J. Malmgren, A. E. Nordenskiöld och A. Qvennerstedt. Stockh. 1867. P. 32.

Approxim. geol. Karte von der Bären-Insel. (8 × 9 cm.) (in Oswald Heer. Fossile Flora der Bären Insel). — Kungl. svenska vet.-ak. handlingar. N. F. B. 9. Nr. 5. Stockh. 1871. Pl. 15.

Nordlige Ocean med Hvide Hav. (Scale abt. 1:1 830 000.) Kjøbenh. 1857. [Danish chart.]

Karta öfver Beeren Eiland. Uppmätt under 1898 års svenska polarexpedition af C. J. O. Kjellström och A. Hamberg. (Scale 1 : 100 000. 20 × 23 cm.) (in A. G. Nathorst. Några upplysningar till den nya Kartan öfver Beeren Eiland.) — Ymer. Årg. 19. 1899. Stockh. 1900. Pl. 2.

Karta öfver Sydhamnen å Beeren Eiland. Uppmätt under 1898 års svenska polarexpedition af C. J. O. Kjellström. (Scale 1 :15 000. 12 × 18 cm.) (in A. G. Nathorst. Några upplysningar till den nya kartan öfver Beeren Eiland.) — Ymer. Årg. 19. 1899. Stockh. 1900. Pl. 3.

Special öfver Rysshamnen å Beeren Eiland. Uppmätt under svenska expeditionen 1899 af C. A. Forsberg. (Scale 1:5000. 11 × 18 cm.) (in C. A. Forsberg. Meteorologische und Wasserstand-Beobachtungen auf der Bären-Insel während der schwedischen Expedition 1899.) — Bihang till K. svenska vet.-ak. handlingar. B. 25. Afd. 1. Nr. 6. Stockh. 1900.

Karte von der Bäreninsel. Nach der Kjellström'schen Karte copirt und bezüglich des Hauss-Flusses und der zugehörigen Seen vervollständigt durch J. Kessler. (Scale 1 : 125 000. 14 × 17 cm.) (in Herwig. Die Expedition des Deutschen Seefischerei-Vereins in das nördliche Eismeer vom Jahre 1899.) — Mitt. d. Deutschen Seefischerei-Vereins. B. 16. Nr. 1. Berlin 1900. Fig. 1.

Situationsplan der Nordküste der Bäreninsel vom Herwigs-Hafen bis zur Möven-Säule und der Ostküste bis zum Engl. Fluss. Aufgenommen im Jahre 1899 durch J. Kessler. (Scale 1 : 30 000. 31 × 21 cm.) (in Herwig. Die Expedition des Deutschen Seefischerei-Vereins in das nördliche Eismeer vom Jahre 1899.) — Mitt. d. Deutschen Seefischerei-Vereins. B. 16. Nr. 1. Berlin 1900. Fig. 2.

Situationsplan vom Herwigs-Hafen an der Nordküste der Bäreninsel. (Scale 1 : 4 000. 21 × 21 cm.) (in Herwig. Die Expedition des Deutschen Seefischerei-Vereins in das nördliche Eismeer vom Jahre 1899.) — Mitt. d. Deutschen Seefischerei-Vereins. B. 16. Nr. 1. Berlin 1900. Fig. 3.

Die Bären Insel. Unter Benutzung der Kjellström'schen Karte und nach den Aufnahmen von J. Kessler i. J. 1899 berichtigt. (Scale 1 : 150 000. 12.5 × 19.5 cm.) (in Henking. Die Expedition nach der Bären-Insel im Jahre 1900.) — Mitt. d. Deutschen Seefischerei-Vereins. B. 17. Nr. 2. Berlin 1901.

Bären-Insel. Unter Benutzung der Karte von Kjellström- Hamberg und Kessler nach Aufnahmen von K. Flegel. Entworfen von G. Scholz. (Scale 1 : 50000. 35 × 43 cm).

Norske Hamna paa Bjørnøya. (Scale 1 : 25 000. 13 × 13 cm.) (in Gunnar Isachsen. The hydrographic observations of the Isachsen Spitsbergen expedition 1909—1910. Christiania 1912. Map. Nr. 8.) — Vid. selsk. skrifter. I. 1912. Nr. 14.

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Astronomical Determination of Longitude, Latitude, and Azimuth; and Determination of the Magnetic Variation on Bjørnøya in 1923.

BY

HANS HENIE

Method of Observation and Instruments.

1. Method of observation. In connection with the geodetic survey which was performed in Bjørnøya in 1923, some astronomical observations were also made for the purpose of determining the geographical position of the island.

As the climate of Bjørnøya is extremely unfavourable for any observations, especially for astronomical observations, only the simplest and most rapid methods were used.

The work was based upon the following programme.

a. Azimuth determination of the sun.
b. Determination of time of star transits in the meridian and, in connection with this, determination of circummeridian altitudes of the circumpolar stars observed.
   Pointing of terrestrial signal for exploiting the azimuth computation obtained by the transit observations.
c. Latitude determination from observations of transits in the prime vertical.
d. Azimuth determination of Polaris.

As will be noted, this programme gives an increasing degree of accuracy, so that "a" and "b" would suffice, while "c" and "d" would add to the accuracy of the result.

The obstacles which it had been foreseen would impede the work of observation in Bjørnøya, really proved to be so considerable as not to admit of the full carrying out of the above programme. No serious difficulties arose in the way of observations of the sun, as the short, bright periods can be made use of during the process, and the observation be delayed till the favourable time. During observations of star transits in the meridian, on the other hand, the observer is dependent upon fixed moments, for which reason the passages are, in most cases, wholly or partly destroyed by low, drifting clouds or mist suddenly setting in. During the work in Bjørnøya there was, from August till October, only one night in which continuous observations could be made. Section "b" of the programme was then successfully carried through.

On the following day the instrument was adjusted in the prime vertical, without a single observation being, however, attained in this position of the instrument. Thus the second half of the programme has not been carried through.

2. Instruments. The astronomical instrument used was a theodolite called Olsen's small microscope-theodolite with a broken axis, lent by *Norges Geografiske Oppmåling* (Geographical Survey of Norway), Oslo.

The instrument was made by *H. C. Olsen,* Oslo in 1863. It has a striding level and a fixed level on the alhidade of the vertical circle. It has a fixed horizontal circle with movable micrometer microscopes and a movable vertical circle with fixed verniers.

Graduation and reading of the circles. On the horizontal circle directly to 10′ is read by means of the microscope for 10″ and by estimation to one second. The head of the micrometer screw is divided into 60 parts, each of 10″. Thus one complete revolution of the screw corresponds to 10′ or the interval between two divisions of the limb.

On the vertical circle directly to 20′ is read by means of the verniers to 10″.

The division of the levels are numerated consecutively through the whole length of the tube. The striding level has a contrivance for regulating the size of the bubble. The value of one division is 4″.

Table for Filament-Intervals.

Small theodolite of Olsen	
Time-second	Logarithm.
s	
32.10	1.50652
15.82	1.19915
1.84	0.26482
1.84	0.26482
16.47	1.21661
32.59	1.52625

Microscopes in the vertical circle are wanting in the instrument, so that this circle must be read off by means of verniers. This process proved ineffectual for observations of altitude, as the reading was troublesome and somewhat unreliable. It was difficult to get the filament sufficently illuminated, and the number of the threads in the filament is too small. Otherwise the instrument is efficient and its stability good.

In the observation of time, a mean time chronometer belonging to H. Henie was used. The rate of the chronometer was very small and regular, provided it remained untouched. During the observations

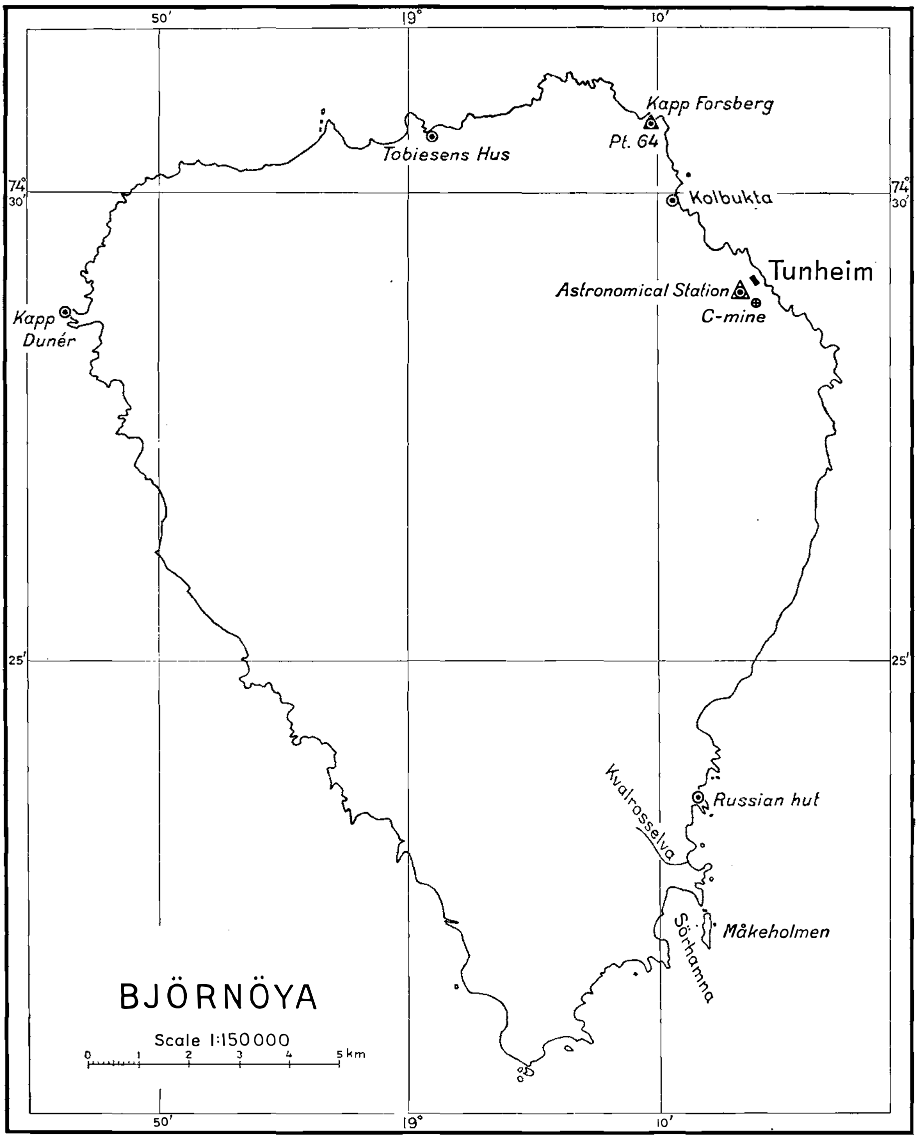

Fig. 10. Astronomical Points 1839—1923.

in Bjørnøya, however, it was used in field work, which led to the rate being in some degree affected.

3. The astronomical station in Bjørnøya was chosen as near as possible to the wireless station (Bjørnøy Radio) at Tunheim (Fig. 10), as transport across the exceedingly broken ground is a matter of considerable difficulty. The concrete foundation of the northwestern backstay of the western mast of the wireless station was chosen as the place for the astronomical station. Here an observation pillar was erected,

the centre of which was marked with a copper bolt, and above the latter the instrument was placed.

As no observatory tent was at hand, a removable box was built to protect the instrument when not in use. Above the observation pillar a pyramidic signal was raised.

4. The time signals. The rate of the chronometer according to Greenwich Mean Time was determined by means of the wireless signals from the Eiffel Tower. The so-called "new system" was chosen, as it was the most reliable one in point of being caught, and had to be considered quite accurate enough for the purpose. The series of ten determinations of time of which it consists, admit of a determination of the rate of the chronometer with an uncertainty of at most one-tenth of a second. The observation of time during the field work was carried out directly from the half second beats of the chronometer.

Determination of Longitude.

1. After the instrument had been adjusted in the meridian by means of observations upon the sun, transit observations upon stars were made on the 18th and 20th of September. On the 18th only one star transit was attained, while on the 20th it was possible to observe five time stars and one circumpolar star. (In the observation on the 18th, there is wanting a simultaneous determination of the errors of the instrument; the observation is, however, included here and treated together with the rest).

The stars observed are the following:

Star	Dec.	R. A.
α Aquilae	8° 40′ 13″	19^h 47^m 4.04^s
γ Cygni	40 1 0	20 19 30.43
α Cygni	45 0 45	20 38 51.17
ε Pegasi	9 31 41	21 40 27.15
16 Pegasi	25 34 10	21 49 36.52
ζ Cephei	57 49 42	22 8 15.00
39 H Cephei	86 53 16	23 28 15.16

The coordinates have been taken from the Greenwich Nautical Almanac for 1923.

2. The transit observations are as follows:

Date	Star	Chronometer time	Level readings W—E	Remarks
		h m s		
Sept. 18	Ocular West	7 43 36 8	Level	
	α Aquilae	53.5		Work interrupted by increasing cover of clouds.
		10.5	32.3 11.0	
		26.5	8.0 29.2	
		44 42.5		
„ 20	γ Cygni	8 7 0 5		Sky bright with intense auroral light. Strong breeze impedes apprehension of second beats from the chronometer. Gradually increasing cover of clouds.
		21.0		
		42.0		
		3.5	32.0 13.3	
		8 24.0	6.5 25.1	
„ 20	α Cygni	8 26 14 0		
		39.0		
		0.0		
		23.5	11.9 30.6	
	Ocular East		30.3 11.5	
„ 20	ε Pegasi	50.0		
		8.5		
		-		Drifting clouds cover the star.
		-		
		9 28 57.0		
			36.2 13.0	
„ 20	16 Pegasi	-	5.7 31.0	
		15.0		
		32.0		
		50.0		
		9 38 8.5		
„ 20	ζ Cephei	13.0	Level	
		43.5	W E	
		13.5	8.3 28.2	
		43.0	32.1 8.9	
		9 57 15.5		
„ 20	39 H Cephei	11 7 24.0		
		12 30.0		
		Instr. revers.		
		16 45.0		
		17 52.0	9.9 29.1	
		22 13.0	29.2 10.0	
	Ocular West	27 5.0		

3. Reduction of the transit observations. When reduced to the middle of the filament the times of transit for the time stars are as follows:

α Aquilae	γ Cygni	α Cygni	ε Pegasi	16 Pegasi	ζ Cephei
h m s	h m s	h m s	h m s	h m s	h m s
7 43 10.78	8 7 44.36	8 27 1.52	9 28 22.55	9 37	9 56 13.29
10.16	42.50	2.29	24.54	32.54	13.21
10.50	42.00	0.00	-	32.00	13.50
10.50	42.95	1.12	-	31.75	12.07
10.03	42.08	1.09	22.94	31.34	12.41
7 43 10.39	8 7 42.38	8 27 1.20	9 28 23.34	9 37 31.91	9 56 12.90

Of these the first three stars were observed with *ocular West*, the last three with *ocular East*.

For the polar star 39 H Cephei there will be the following reduced times of transit:

	h m s		m s
Ocular East	11 17 15.5	Mean:	17 18.25
	21.0		
Ocular West....	18.9	Mean:	17 17.90
	18.1		
	22.0		
	13.5		
		E—W	0.35

Hence is deduced the *error of collimation*, which is:

$$\tfrac{1}{2}(E—W)\cos\delta = 0^s.0095$$

a quantity which may at once be neglected, that is to say, the instrument is free from collimation error.

4. The rate of the chronometer. By means of the above time-signals the chronometer correction was determined with the following result:

September 18 correction $5^s.43$
— 20 — 5 .83 Referred to $21^h\,30^m$ G. M. T.
— 21 — 4 .94

As mentioned above, the rate is affected by the chronometer being used in field work, which appears from the three values of the correction.

The acceleration of the chronometer in one hour is:

On September 18—20 —$0^s.008$
— 20—21 +0 .037

Thus it will be seen to have increased, which was also to be expected.

The computation of the chronometer correction is based upon the fixed values of the rate and is applied to the means of the transit times, whereupon these are converted into sidereal time (U). The difference between this "U" and the right ascension (α) of the stars determines the correction of the chronometer according to local sidereal time. This difference, however, is still influenced by the errors of the instrument.

5. One of the *errors of the instrument*, viz. the collimation error, has already been found insignificant, so that the two transits of the polar star may be combined.

The *inclination* of the instrument may be seen from the level readings. The value of one dlvision of the level was examined and found to be 4″. The level reading East and West as well as the calculated inclination will be seen from the following table.

Level.

W	E	W	E	i
				s
32.3	11.0	8.0	29.2	0.40
32.0	13.3	6.5	25.1	0.91
11.9	30.6	30.3	11.5	0.05
36.2	13.0	5.7	31.0	0 83
8.3	28.7	28.1	8.9	0.00
9.9	29.1	29.2	10.0	0.00

The *azimuth of the instrument* is deduced by a combination of the time stars and Polar star, and is computed separately for each position of the telescope. The following values were arrived at:

	W	E
k =	$17^s.36$	$17^s.29$
	17 .26	17 .29
	17 .23	17 .46
Mean:	17 .27	17 .37
Mean W and E:		17 .32

As will be seen from these values, the difference between the azimuths of the instrument in the two positions of the telescope is so inconsiderable that there is no reason for assuming two values, and they may therefore be combined to a mean value:

$$k = 17^s.32$$

which is employed in the further reduction.

In view of the fact that the method of observation employed is simple and that collimation error is negligible and the azimuth of the instrument is constant, there is little reason for carrying out the final computation according to the method of the least squares.

Each star wlll therefore be reduced according to the formula:

$$T = U - \alpha + I.i + K.k + c. \sec \delta,$$

where the last term, the collimation, is accordingly neglected. The reduced transit times are as follows:

	h m s
α Aquilae	— 1 16 54.29
γ Cygni	54 94
α Cygni	53.80
ε Pegasi	54.09
16 Pegasi	54.51
ζ Cephei	54.70
Mean	— 1 16 54.22

with a mean error of $0^s.14$.

In the computation of the mean value, the same weight has been applied to every single value.

6. The longitude. The above mean will be the longitude of the station.

As for the accuracy of the obtained determination, it must be noted that the deduced mean error is a measure of the inner agreement of the single results. When other sources of error are also taken into consideration, such as: the unreliability of the catching of the time signals and the inaccuracy due to the change of the rate of the chronometer, the mean error must be increased, and may be estimated at about 1/4 second.

As a final result of the performed observations and computations we have:

The longitude for the astronomical station in Bjørnøya.

$1^h\ 16^m\ 54^s.22$ E Greenwich

Mean error: $\pm\ 0^s.25$.

Determination of Latitude.

In connection with the observations of star transits in the meridian some meridian altitudes were taken, and for the star 39 H Cephei also six altitudes immediately after this star had served as polar star during the determination of the time.

As regards the measurements of altitudes by means of the employed theodolite, two verniers were used as already mentioned, each giving a reading of the circle with an accuracy of 10″. The reading, however, is not easy, especially by artificial illumination. The observations of altitudes must accordingly be characterized as weak.

The zenith point of the vertical circle is placed quite arbitrarily, and was found, on closer examination, to be very near 48° 52′ 0″.

The six altitudes being equally distributed between the two positions of the telescope, an error in this quantity will be compensated at the average.

Altitudes of 39 H Cephei.

	1	2	3
Vert. circle	306° 27′ 35″	306° 26′ 50″	306° 26′ 15″
Chronometer time	$11^h\ 33^m\ 20^s$	$11^h\ 39^m\ 4^s$	$11^h\ 42^m\ 41^s$
	4	**5**	**6**
Vert. circle	331° 18′ 30″	331° 18′ 55″	331° 19′ 55″
Chronometer time	$11^h\ 48^m\ 40^s$	$11^h\ 52^m\ 56^s$	$11^h\ 56^m\ 45^s$

These altitudes are subject to correction for the refraction (15″), and are reduced to the meridian according to the simple formula of reduction:

$$\sin\frac{H-h}{2} = \frac{\cos\varphi\cos\delta}{\cos\frac{H+h}{2}}\sin^2\frac{t}{2}$$

If the zenith distance of the star: 3° 6′ 47″ is added to the reduced altitude we shall have the latitude. As already mentioned, the latter is subject to an error of index caused by the zenith point, and manifesting itself as a constant addition in one position of the telescope, and a reduction in the other, with compensation in the mean. In the computation of the mean error it is eliminated beforehand.

The six altitudes give the following values for the latitude:

	74°	28′	71″
			56
			45
			46
			71
			51
Mean	74	28	57

The mean error of a single observation will be 10″, corresponding to the accuracy of the reading of the vertical circle of the instrument.

The mean error of average value will be: ± 4″.5.

The observations and computations carried out give the following results:

The latitude of the astronomical station of Bjørnøya.

74° 28′ 57″

Mean error: ± 4″.5.

Determination of Azimuth.

1. The observations. On the 3rd of September some observations upon the sun were made for the purpose of adjusting the instrument as accurately as possible.

The reason why these observations were carried out so elaborately was that, when the latitude and the longitude of the station had been determined, there might later on also be based upon them an accurate determination of the azimuth for the direction from the station to the trigonometrical point "Kapp Forsberg".

The instrument having no single mean thread, and the transit of the sun's limb over the centre between the two adjacent threads in the middle of the filament being unreliable, the transits of the right and left sun's limbs were noted instead of the first and last threads of the filament.

The observations are:

	1	2	3	4
	h m s	h m s	h m s	h m s
Right limb—first thread	9 14 3.5	9 33 25.0	9 52 38.0	10 11 0.0
— last —	15 10.5	34 31.0	53 44.0	12 7.0
Left limb—first —	16 13.0	35 47.0	54 47.0	13 10.0
— last —	17 20.5	36 41.0	55 53.5	14 15.5
Mean	9 15 41.8	9 35 2.6	9 54 15.6	10 12 38.1

The observations 1 and 4 were taken in the position of the telescope denoted as "Diopter up", while 2 and 3 were taken with "Diopter down". The first of these positions corresponds to "Ocular East" when the instrument is adjusted in the meridian. The two threads employed will therefore be I and VII, whose distances from the middle of the filament are respectively $32^s.10$ and $33^s.59$, accordingly, with an asymmetry of $1^s.49$. The mean point between the outer threads will therefore deviate with one half of this amount ($0^s.75$ or $11''.2$) from the centre of the filament. The correction for this asymmetry will be quite analogous with the ordinary correction for collimation errors.

The level readings and the computed inclinations are:

l	r	l_2	r_2	i
33.1	9.5	12.0	34.0	— 3.4
7.5	29.0	28.0	6.8	+ 1.7
5.5	27.2	36.0	13.8	—17.7
33.1	10 0	31.1	25.0	+15.0

2. Reduction. The noted times are converted into apparent solar time, and the azimuth is computed separately for each of the four observations. The instrumental errors cause a correction for the circle readings which are computed from the formula:

$$i.\ \text{tang. } h + c.\ \text{sec. } h$$

where "h" is the altitude of the sun, being read from the vertical circle (20° 16′ and 21° 40′ during the two series of observation). The position of the meridian on the circle as well as circle reading corresponding to "Kapp Forsberg" are grouped in the following table.

	1	2	3	4
Meridian	210° 38° 4″.4	210° 38′ 2″.5	180° 27′ 27″.7	180° 27′ 34″.5
Kapp Forsberg	118 26 4 .5	181 26 7 .5	151 15 37 .0	150 15 36 .0
Azimuth	330 48 0 .1	5 .0	9 .3	1 .5

Hence the *azimuth* for the direction:

Astronomical Station — Kapp Forsberg:

330° 48′ 4″.0.

With a *mean error of* ± *2″.0.*

3. Verifying the azimuth. The above determination of azimuth may be verified by means of a quite independent determination of the direction of the meridian in connection with the determination of the time already given. The azimuth of the instrument was deduced from the transit observations and as the horizontal circle was read simultaneously, the position of the meridian on the circle may be deduced. A subsequent pointing of Kapp Forsberg gives occasion for a determination of the azimuth of the direction of this point. The calculation will be the following:

Circle	180° 23′ 22″.0 + 4 19 .8
Kapp Forsberg	180 27 41 .8 151 15 41 .6
Azimuth	330 47 59 .8

i. e., a value only differing about 4″ from the azimuth determined by means of the sun. The latter value is therefore adopted as quite sufficiently accurate.

Determination of the Magnetic Variation.

1. Instrument and stations. For the purpose of determining the *variation* in Bjørnøya there were carried out in all, in the summer of 1923, four series of observations with an instrument "Bamberg 9631" lent by *Universitetets astronomiske og magnetiske observatorium* (The Astronomical and Magnetic Observatory of the University), Oslo. The magnetic part of the instrument consists of a double magnetic needle supported on a pivot and enclosed in a protective box, furnished with the necessary openings for light to enter. The optical part of the instrument consists of a small reversible telescope. The horizontal circle is read by means of verniers, and gives the proximate half minute. The method of observation was the one employed at the observatory of Oslo, consisting of twenty adjustments in all, with circle readings and inversion of magnet and telescope. The time was determined by comparing a watch with a chronometer.

As a station a point was chosen near the C-mine, sheltered by a house, where two complete determinations were carried out. A third determination was effected under shelter of the mess. On account of an increasing cover of clouds a pointing of the sun was attained only in one position of the telescope. A fourth determination was carried out at Kapp Forsberg with the mounting above the station bolt in a trigonometrical point, but as no pointing of the sun was attained, the observations in this station have not been computed.

The instrument must be characterized as very suitable for determinations of variation, being light and manageable and giving an accuracy sufficient for the purpose.

2. The observations. In the following grouping of the observations that were made, the observations of the sun have been reduced to the centre of the sun and the mean of the circle readings have been calculated.

28th Aug. 1923. C-mine.
Watch: —7ˢ.0.
Prism up.

Sun: 12ʰ 52ᵐ 43ˢ.7	*Circle*: 183° 59′.5	*Magnet*:	
55 37 .0	184 45 .7	Prism up	161° 4′.95
58 58 .0	185 40 .2	reversed	32 .65
Prism down		Prism down ..	28 .90
12 42 47 .5	181 17 .2	reversed	160 51 .55
45 58 .5	182 8 .7	Mean	161 14 .51
45 57 .5	182 58 .2		

The sky clouded over. The sun dimly visible now and then through the changing cover of clouds. The limb of the sun well defined. The weakest solar glass used.

4th Sept. 1923. C-mine.
Watch: —16ˢ.7.

Sun: 6ʰ 38ᵐ 41ˢ.5	*Circle*: 25° 8.75	*Magnet*:	
41 49 .5	53.75	Prism up	275° 20′.60
Prism down		reversed	52 .05
6 45 36 .0	26 48.25	Prism up	50 .65
48 28 .5	27 29.75	reversed	28 .25
		Mean	275 37.89

A bright stripe in the western horizon, where the sun could be observed at the middle of the series of observation. Calm weather. Favourable conditions.

22nd Sept. 1923. The staff house.
Watch: + 13ˢ.0.
Prism down.

Sun: 11ʰ 3ᵐ 4ˢ	*Circle*: 181° 32 0	*Magnet*:	
11 6 0	182 17.5	Prism down ..	186° 22′.90
		reversed	38 .95
		Prism up.....	45 .30
		reversed......	24 .40
		Mean	186 32 .89

The sun could be observed only in the first position of the telescope. Light breeze.

3. Computation of the observations. The result of the computation of the solar observations is given in the following table. This contains: The time observed, the calculated azimuth of the sun, the circle readings and the meridian.

Date	Time	Az.	Circle	Mer.	Mean
August 28th....	$12^h 42^m 47^s.5$	15° 56′.95	181° 17′.20	165° 20′.25	165° 20′.80
—	12 58 58 .0	20 18 .85	185 40 .20	165 21 .35	
September 4th..	6 38 41 .5	105 38 .70	25 8 .75	279 30 .05	279 30 .40
— ..	6 48 28 .5	107 59 .00	27 29 .75	279 30 .75	
— 22nd..	11 3 4 .0	−8 30 .50	181 38 .00	190 8 .50	190 8 .30
— ..	11 6 0 .0	−7 50 .60	182 17 .50	190 8 .10	

Hence the direction of the meridian has been determined, and the magnetic variation will be the difference between the circle reading for the meridian and for the magnetic needle, as follows:

Date	Merid.	Magnet	Var.
August 28th.....	165° 20′.8	161° 14′.5	4° 6′.3
September 4th...	279 30 .4	275 37 .9	3 52 .5
— 22nd...	190 8 .3	186 32 .9	3 35 .4
Mean...........			3 51 .4

If the same weight is applied to the three determinations, the mean error of the mean will be: ± 8′.65.

As the final result for the *magnetic variation in Bjørnøya* for the area about Tunheim we shall have the value:

3° 51′.4 ± 8′.95 West.

As for the annual decrease of the variation, see below.

Discussion of obtained Values.

1. Earlier astronomical observations. On examining the publications of the early Arctic expeditions we find that some observations have been carried out during their stay in Bjørnøya. As these expeditions did not have the investigation of Bjørnøya as their chief aim, and as their astronomical observations were often rendered difficult through bad weather, it is only to be expected that the early determinations of the position of the island were few and unreliable. The first determination of longitude and latitude in Bjørnøya was carried out by a French scientific expedition in the corvette "La Recherche" led by Paul Gaimard, to the Arctic regions in July 1839. Delaroche, the officer of this expedition, managed to determine the position of the

western point of the island, the present Kapp Dunér (Fig. 10), and the coordinates found for this point were:

Latitude: .... 74° 30′ 52″.
Longitude: .... 16° 29′ 10″ East Paris.

The next expedition to make an astronomical determination of position in Bjørnøya, was the Swedish expedition in 1864 led by A. E. Nordenskiöld. Sun observations were made on the 18th and 19th of June by N. C. Dunér at the Russian hut (Fig. 10) north of Sørhamna, and the result was as follows (Dunér, N. C. & A. E. Nordenskiöld, 1867, p. 32):

Latitude: .... 74° 22′ 56″.
Longitude: .... 19° 15′ 15″ ($1^h 17^m 1^s$) east Greenwich.

Four years later, in 1868, another Swedish Arctic expedition under the leadership of A. E. Nordenskiöld visited Bjørnøya, and performed in the last days of July astronomical observations from a station near the so-called Kolbukta north of Austervåg at Tunheim. The result of these observations was according to Nordenskiöld (1870) p. 579:

Latitude: .... 74° 28′ 35″.
Longitude: .... $1^h 16^m 38^s.2$ East Gr.

On the same occasion observations were also made on the north coast of the island, near Tobiesen's Hus, whereby the position of this place was determined. The position was found to be:

Latitude: .... 74° 38′ 55″.
Longitude: .... $1^h 15^m 46^s.6$ East Gr.

To these observations, made by v. Otter and A. E. Nordenskiöld, is annexed a note saying that the determination is unreliable owing to the cover of clouds.

In a work by A. Wijkander (1874), all the available determinations of geographical positions in Bjørnøya are grouped together (p. 55) in the following table:

	lat.			long.			
Tobiesen's Hus (House)	74°	38′	55″	1^h	15^m	14^s	F. W. v. Otter 1868.
Kapp Dunér	74	30	52	(1	5	57)	Delaroche.
Kolbukta	74	28	35	1	16	38	F. W. v. Otter 1868.
Russian Hut	74	22	56	1	17	1	N. C. Dunér 1864.
"Klippö" (Cliff Island) .	74	22	35	(1	17	1)	N. C. Dunér 1864.

As will be seen, all these statements are in accordance with those published by the respective expeditions with the exception of the longitude of Tobiesen's House, which Nordenskiöld in 1870 states to be $1^h 15^m 46.^s6$, whereas the value by Wijkander is stated to be $1^h 15^m 14^s$. The reason is supposed to be a revision of the original computations of the defective observations performed by the expedition in 1868. To the above table by Wijkander may be added the values found by the Swedish Arctic expedition in 1898 conducted by A. G. Nathorst. The astronomical, photogrammetrical and magnetic works that were carried out on this expedition have been revised and published by Axel Hamberg (1905), and his paper contains information on determinations of positions as well as for azimuth in Bjørnøya.

The instrument employed was a theodolite with 12 cm circles. The atmospheric conditions impeded an accurate astronomical determination of latitude and longitude. A meridian altitude of the sun was, however, attained from a station at the mouth of Kvalrosselva north of Sørhamna. From this observation is deduced the following value for the latitude (p. 8):

$$74° \; 22' \; 2''$$

Hamberg makes a comparison between this value and the one given in Wijkander's table for the position of the Russian Hut. This point lies about 40″ north of the mouth of Kvalrosselva, being thus situated in latitude 74° 22′ 42″, and accordingly agrees well with Dunér's value.

Owing to misty weather, Hamberg could not perform any determination of longitude. There was, however, undertaken a determination of the magnetic variation of special interest for the orientation of the island. The variation was found to be 6° 23′ West. The orientation of the circles of latitude and longitude on the map of Bjørnøya by C. J. O. Kjellström and A. Hamberg on the scale 1 : 100 000 was based upon this determination of the magnetic variation and Dunér's determination of latitude and longitude (Nathorst 1899).

2. When the values for longitude and latitude found in 1923 are to be compared with the position previously attained in the island, the following points must be considered:

Tobiesen's Hus (House) ...	74°	38′	55″	1^h	15^m	14^s
Russian Hut	70	22	56	1	17	1
Kolbukta	74	28	35	1	16	38
Kapp Dunér	74	30	52	(1	5	57)

Dunérs determination of "Klippö", near Sørhamna, may be considered only as a confirmation of the situation of the Russian hut. The same applies to Hamberg's determination of Kvalrosselva.

In order that the earlier determinations of Bjørnøya may be compared with the position of the island deduced from the observations in 1923, all the earlier results are reduced to the same point, viz., to the astronomical station from 1923. It has been rendered possible to carry out such a reduction by means of the trigonometrical net covering the island, which admits of a determination of the rectangular coordinates for the points from where the earlier astronomical observations have been made. These coordinates are grouped in the following table:

	Y	X
Astronomical Station....	14 138.05	16 944.36
Kapp Forsberg (Pt. 64)..	13 116.43	20 614.33
Tobiesen's Hus (House).	8 520.85	21 866.75
Russian Hut...........	10 815.00	7 470.00
Kolbukta	13 600.00	18 130.00
Kapp Dunér	750.00	19 770.00

The trigonometrical point "Pt. 64" is identical with the above "Kapp Forsberg" which was made use of in the azimuth determination. The coordinate system to which these values are referred has an origo arbitrarily chosen and the direction of the X-axis is oblique relative to the meridian. In order to solve the question in hand it will therefore be necessary to reduce the coordinates of each point to the astronomical station and transform them to the meridian, the angle between X-axis and meridian being 13° 38′ 35″.2.

Hereby we have the following values:

	Azimuth	log.dist.	Y	X
Pt. 64	330 48 4.0	3.580869	— 1 858.44	+ 3325.44
Tobiesen's Hus (House)	297 35 6.3	3.873250	— 6 619.77	+ 3458.53
Russian Hut................	185 41 6.1	3.521529	— 994.54	— 9990.50
Kolbukta	321 57 23.3	3.114718	— 612.28	+ 1149.42
Kapp Dunér	268 16 33.6	4.136183	—13 676.82	— 411.65

The coordinates transformed in this way give directly the position of the several points north and east of the astronomical station. Hence the necessary quantities of reduction are found by computing the differences in latitude and longitude corresponding to the coordinates.

The differences found are added to the earlier values for longitude and latitude of the points. This gives for every single determination a value of the geographical coordinates of the astronomical station, which will, accordingly, be dependent upon the original determination and the transfer of the latter by means of the trigonometrical net. It is thus possible to make a simple comparison between the coordinates, based upon all the available determinations.

In the following table are given the computed differences in latitude and longitude, the observed and transformed latitude and longitude.

	$\Delta\varphi$	φ	φ	$\Delta\lambda$	λ	λ
Tobiesen's Hus (House).....	+ 1.8	38.9	74° 37′.1	— 53^s	15^m 14^s	1^h 16^m 7^s
Russian Hut..............	— 5.4	22.9	28 .3	— 8	17 1	17 9
Kolbukta	+ 0.6	28.6	28 .0	— 5	16 38	16 43
Kapp Dunér	— 0.2	30.9	31 .1	—110	(5 57)	7 47

It appears from the grouping that there is a wide disagreement between the older coordinates for Bjørnøya. If these values are to be combined to a mean, the respective values must be given unequal weight according to the accuracy of the different determinations.

The observations by Tobiesen's Hus are, as noted above, unreliable. If this determination is given the weight 1, it is proper to attach to the determination at Russian hut where the result has been verified, a considerable greater weight. The latter is estimated at 4. As for the determinations at Kolbukta and Kapp Dunér, no special information is available, but it may be taken for granted that they are more reliable than those at Tobiesen's Hus, for which reason they are given the weight 2. As for Kapp Dunér it may be noted that the determination of longitude in the table by Wijkander, quoted above, is placed within brackets. It also deviates so abnormally from the other determinations that it must be considered most proper to neglect it altogether.

3. The comparison. If the mean values are formed, based upon these reviews, the result will be as follows, where the mean error has been computed according to the formula:

$$m = \sqrt{\frac{[p\,v^2]}{[p]\,[n-1]}}.$$

Longitude	$1^h\ 16^m\ 7^s$	Weight	1
	69	—	4
	43	—	2
Mean..............	1 16 53	mean error: 18^s	
Latitude	74° 37′.1	Weight	1
	28 .3	—	4
	28 .0	—	2
	31 .1	—	2
Mean..............	74 29 .8	mean error: 2′.0	

As it appears from the computed mean errors, the earlier observations give a rather poor determination of the position of Bjørnøya. And, as might be expected, the greatest unreliability is to be found in the determination of longitude, where the mean error, in spite of the most deviating value being neglected, amounts to no less than 18 seconds of time. The error in the latitude is also considerable, being, as mentioned, 2′.0.

If the mean of the earlier values is compared with the position computed from the observations in 1923, the proportion will be as follows:

	Mean of earlier values	Mean 1923
Longitude	$1^h\ 16^m\ 53^s \pm 18^s$	$1^h\ 16^m\ 54^s.22 \pm 0^s.25$
Latitude	74°′ 29′8 ± 2′.0	74° 28′ 57″ ± 4″.7 (28′.95 ± 0′.08)

Hence it appears that the value from 1923 approaches surprisingly the mean value of earlier determinations, much more than might have been expected beforehand.

It is therefore proper to consider the determination of the position of Bjørnøya undertaken in 1923, as agreeing with the earlier values available, and also as being an improvement on them.

Azimuth determination and the magnetic variation.

No original determination can be seen to have been carried out in Bjørnøya, whereas there exists the above determination of magnetic variation by Hamberg, including an azimuth determination. This determination has been used for the orientation of the Swedish map of 1899. The determination is, however, not attached to any definite point in the island; comparison is therefore quite out of the question.

One single determination of the magnetic variation in Bjørnøya was made by Commander A. Hermansen of *Den norske Svalbard-ekspedisjon* in the summer of 1921, the result of which was the value:

3° 50′.48 W.

As will be seen, this value almost perfectly agrees with the one determined in 1923. It appears from a comparison between these two values and the early one found by Hamberg in 1899:

6° 23′ W;

that the magnetic variation is decreasing.

This is confirmed by later observations made in the year 1931. During the expedition of that year the hydrographic surveyor of the expedition, Lieutenant Rolf Kjær, carried out determinations of magnetic variation (see p. 71). The result is the following values of variation at 3 points in Bjørnøya.

Tunheim	2°	04′.5
Kapp Dunér...............	2	26 .7
Ellahytta	2	31 .4

As will be seen, the variation shows different value in the different places in the island. In order to find the approximate amount of the annual decrease of the variation, the following determinations will be used:

Magnetic	variation	1899	6°	23′
—	—	1922	3	51
—	—	1931	2	4

Here the two values from 1921 and 1923 are summed up, a mean value being considered as referring to 1922. Of the 3 determinations in 1931 the one performed at Tunheim will be used.

From 1899 to 1922 the variation has decreased 2° 32′ i. e. 6′.6 annually.

From 1922 to 1931 the variation has decreased 1° 47′ i. e. 11′.9 annually.

The magnetic variation of Bjørnøya (Tunheim) may be expressed by the equation:

$$2^\circ\ 4'\ \mathrm{W} - 12' \text{ annually. Epoch 1931.}$$

It is to be noted that the magnetic anomalies which the observations on land show have been observed also by navigators in the waters around Bjørnøya.

The task that had been set in 1923 was to procure geographical coordinates for one point in Bjørnøya, and to perform an azimuth determination for the purpose of providing a settled and adjusted geographical net for the detailed map of the island. Desirable as it would be to arrive at a determination of high precision in Bjørnøya, there has, as yet, been no opportunity of doing so. And it must be regarded as quite impossible to attain the necessary observations for such a determination in the summer. If a determination of high precision is desired, a series of observations must be carried out in the winter when the pack-ice surrounding the island causes comparatively settled atmospheric conditions. Such a determination will, however, be very valuable and of importance to the study of the secular changes of the longitudes.

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Geodetic and Topographical Work on Bjørnøya 1922—1924.

By

Alfred Koller and Bernhard Luncke

Survey Work in 1922.

In 1922 the Norwegian Svalbard Expeditions led by Adolf Hoel were charged by the coal company, *Bjørnøen A/S*, to carry out the survey work for the proposed aerial ropeway, loading plant, etc. on Bjørnøya.

The tasks first to be carried out were:

1. Track for the aerial ropeway from Laksvatnet to Sørhamna on the scale of 1 : 2000 and contour interval one metre.
2. Sørhamna with surroundings, scale 1 : 1 000, and contour interval one metre.

Previously, the engineers E. Sørum and Claus Schive had carried out some mapping on behalf of the mining company on a scale from 1 : 250 to 1 : 10 000, e. g. a map of Sørhamna and part of the aerial ropeway track northwards to near the southwestern corner of Miseryfjellet, scale 1 : 10 000, and also a map of an area between Fugleodden and Austervåg, scale 1 : 5 000. Soundings were carried out in Austervåg, at Tunheim and north of Fugleodden and plotted on 1 : 500 scale maps. Of the maps mentioned only the one from Austervåg to Fugleodden, surveyed by Schive in 1918, can have been based upon a trigonometric survey with permanently fixed points, and whose heights are referred to bench marks which have been determined by systematic water level measurements. The other maps had no bench marks and were only provisional ones. Now that a survey of the proposed aerial ropeway track was to be carried out, extending nearly right across the island, it was natural to plan the work in such a way that the map could later be extended to cover the entire island, this being desirable for the following reasons: The reports on the coal and mineral deposits of the island available in 1922 were very favourable. The report showed that about two-thirds of the island probably contained high-grade coals. The harbour conditions of the island were also insufficiently investigated, and a detailed map of the island was necessary in order to get the possible harbours investigated, more particularly as new storage and loading plants were planned.

As the question of property rights was soon to be dealt with, a correct map was highly desirable for dealing with these problems.

Plan for Field Work.

The final decision about the Bjørnøya survey was taken late in the summer, and the more detailed plan for the field work was elaborated by the head topographer, Koller, at a conference on August 16th during Hoel's stay on the island. The following was agreed upon:

The survey to be carried out in agreement with the above plan. For the map of the aerial ropeway track, a stretch of country to be surveyed having a width of 1 kilometre, and based upon a trigonometrical net. The triangulation to be carried out with a precision theodolite. The fixing of the trigonometrical points to be made permanent if possible, so that they might be of use to the technical plants which might be erected in the future. Bolts in the solid rock or in large blocks are preferred. Crosses chiselled in the rock or drilled holes may also serve.

The number and situation of the trigonometrical points to "be chosen in the first instance with regard to a favourable development of the trigonometrical net". As the signals are to serve also as control points for the detailed photogrammetric survey, care must be taken to erect an adequate number of them for this purpose. The signals must be of such a size and shape that they can be found on the photographic plate.

The trigonometrical net to be built upon an accurately measured base line. The site of the base-line shall not be fixed until the surveyors have acquired a complete knowledge of the country to be surveyed.

In order to get a starting point for the heights, water level measurements shall be carried out throughout as long a period as possible. As a rule, the elevation of the trigonometrical points shall be determined trigonometrically.

For the detailed survey stereo-photogrammetry is to be employed, supplemented by tacheometry and depression measurements. As the weather conditions in Bjørnøya are very unfavourable, the spells of fine weather must be thoroughly utilised for surveying work, whereas days with bad weather must be used for the erection of signals, bringing up provisions, moving camp, etc.

The work is thus to be divided:

Alfred Koller, topographer, with Aksel Aaker, Magnus Abrahamsen and Per Hoel as assistants: the stereophotogrammetric detail survey.

Wilhelm Solheim, topographer, with Karl Kristiansen as assistant: the triangulation.

Werner Werenskiold, topographer, with Kristian Kristiansen as assistant: tacheometry, when he is not engaged in geological surveying. (W. also being a geologist).

Koller is the leader of the field work.

Instruments and other Outfit.

The surveying parties had the following instruments and outfit at their disposal:

1 Base measurement wire of invar metal 24 m, from *Gottschalk*, Stockholm.
4 Base tripods.
2 Spring balances.
Triangulation theodolite Nr. 901.[1]
Theodolite Nr. 535. From *Sigurd Baalsrud*, Oslo.
Theodolite Nr. 537. From *Sigurd Baalsrud*, Oslo.
Theodolite Nr. 11904. From *Otto Fennel*, Cassel.
Stereophotogrammetric field outfit Nr. 14800 from Carl Zeiss Jena, and hired from *Kartkontoret Stereografik A/S*, Oslo.
3 Steel measuring tapes.
2 Levelling staffs.
3 Stadia rods.
3 Foot-rules (2 metres).
3 Aneroids.
2 Thermometers.
6 Pocket compasses.
40 Dozen plate-glass photographic plates (13×18 cm).
8 Observation books.
5 Tents with tarpaulins.
8 Sleeping bags.
8 Life-saving jackets.
3 Kitchen boxes with dinner service and primus stove.
1 Tool chest.
Sundries.

Some of the provisions (tinned food) were brought from Norway, otherwise it was arranged with *Bjørnøen A/S* to provide the necessary supply of food.

Field Work.

When the decision was taken to commence surveying work on Bjørnøya, Koller and Solheim were working in Spitsbergen. On August 3rd they received a telegraphic message from Hoel ordering them to Bjørnøya, and on August 9 they arrived in Sørhamna in the collier S/S "Lynghaug". They brought with them 2 assistants. A camp with 2 tents was erected near the old whaling establishment in Kvalrossbukta. Later the

[1] Description p. 55. We may also refer to the instrument description in Adolf Hoel. The Norwegian Svalbard Expeditions 1906—1926. Oslo 1929. — Skrifter om Svalbard og Ishavet, Vol. I. Nr. 1. P. 77.

surveyors walked to Tunheim, where they found telegraphic instructions from Hoel ordering them to commence surveying the Sørhamna area at once. After having received provisions and various tools, etc. from the coal company, the men returned to the camp in Kvalrossbukta, and began the erection of signals. The next day 3 signals were put up on Miseryfjellet, of which one was on the highest summit, and 3 signals on and north of Antarcticfjellet.

On August 13 Hoel arrived in the M/C "Ringsæl", which anchored in Kvalrossbukta. The other members of the surveying parties (land and sea) also arrived along with the rest of the instruments and other outfit. The new members of the Bjørnøya survey were Werenskiold and 3 assistants. A hydrographic party was also landed, with Eilif Iversen, Engineer, as leader and 5 assistants. Their task was to make soundings in Sørhamna.

The following 3 days were devoted to preliminary work. Many signals were made, and several of them were erected around Sørhamna, some especially for the benefit of the hydrographic party. Quite a good site for the water gauge was eventually found near the head of the harbour, where there is an overhanging rock making it possible to fix a wooden plank with its lower end on the sea-bottom outside low-water mark. The upper end of the plank was kept in position by wedging it into the projecting rock. As soon as the survey was started Hoel left the island for Spitsbergen (August 17).

The first stereophotogrammetric exposures were made on August 16. Up to August 31 weather conditions were quite good, and the area around Sørhamna was practically finished. The narrow gorge of Russeelva was surveyed by tacheometry. From September 1 followed a period of bad weather with a gale on September 6 and 7 during which two tents were destroyed and the rowing boat damaged. Then came a spell of good weather. The boat was hauled to the top of the 36 metres high slope and down to safety in Kvalrossbukta. On the 14th there was a slight fall of snow, otherwise the conditions for observations were good. On September 16 one of the tents was moved near to the brook east of Blåsen, and a stone wall was built around it for protection against the wind. The 19th and 20th provided observation conditions, and Solheim fixed the points of the hydrographers, and had then finished his work in the southern part of the island. On September 21 "Ringsæl" arrived in Kvalrossbukta from Spitsbergen, and the hydrographic party, which had now finished its work, was taken on board. The topographers also moved, and all their outfit was brought to Tunheim on board the "Ringsæl". The same night Werenskiold embarked and the ship left for Norway.

The following 5 days brought slushy snow and fog. On the 28th a base line was measured, and then triangulation and detail surveys were carried out in the area around the base. More trigonometrical signals were erected in the area towards Laksvatnet. From now on about every other day gave working weather. During protracted periods of cold and wet weather the tents were uncomfortable and the time was then usually spent in the quarters at Tunheim. It was now getting late in the season, which was quite evident from the fall in temperature. On October 10 quarters were taken in the hut at Laksvatnet, where the room had a stove. On the 23rd Solheim finished the triangulation, the following day Koller finished the detail survey and the summer's work was done according to programme. On account of stormy weather the departure from the island did not take place until November 13. The period of waiting was spent in working up the observations and the base measurements.

The crossing to Norway was made in the ship of the Bjørnøen A/S M/C "Blomstersæl", and it was very stormy. On the 17th they arrived in Tromsø.

A total of 59 trigonometrical signals were erected, of which 38 were permanent. Triangulation was carried out in 49 trigonometrical points, and in 26 points of secondary order. For the detail survey 77 stereophotogrammetric base lines were measured, with a total of 207 pairs of exposures. All the stations could be computed trigonometrically. Tacheometer and depression surveys were carried out from 24 stations, and the latter kind of survey was also executed from a number of the ordinary triangulation points. A levelling line was run from the water gauge in Sørhamna to a bench mark fixed in relation to the trigonometrical net. The base line was run and measured on September 27 and 28th. Its length is 982.358 metres and it is situated along the southwestern edge of Sørlia having a direction of North abt. 12° West. The original plan was to place the base line more centrally in relation to the area to be surveyed, However, when a thorough knowledge of the ground was acquired it was found that no other site than the one chosen was suitable. The extensive and more or less level ground to the west of Miseryfjellet, and also the greater part of the flat ground in the northwest of the island, was either covered with broken stones or consisted of very boggy ground, where it was impossible to fix the base line points or get sufficient support for the tripods without considerable and arduous preliminary work, which could not be undertaken at that time of the year. The chosen site is one of the few places on the island which is reasonably level and dry at the same time. Here, too, the base points have a favourable situation for the development of the trigonometrical net.

Office Work.

The trigonometrical computations were commenced soon after the return home, and were carried out by Miss Marie Nordbye, Solheim and Koller. The latter also worked out the stereophotogrammetric stations. They were finished in January 1923. All the observations proved to be successful, despite the fact that the weather and light conditions were not always favourable. The trigonometrical points were computed with reference to an arbitrarily chosen coordinate system, and the map was constructed with reference to this.[1] As will be seen from Fig. 11 the triangle net is supported by several points situated some distance outside the mapped area. The computation work was finished in 1923. The stereophotogrammetric construction was carried out by *Kartkontoret Stereografik A/S*, Oslo, using a Zeiss-von Orel Stereo-autograph, Model 1914, Nr. 11309. The tacheometer and depression measurements were constructed by Solheim. The office work was finished in June 1923, and the maps were printed (Idal-prints). They embrace the following areas:

Map of the region Laksvatnet-Sørhamna, Bjørnøya, 7 sheets. Scale 1 : 2 000. Contour interval partly 1, partly 2 metres.

Contour interval 1 metre	6.18 sq. kilometres
— — 2 —	6.46 —
Total	12.64 sq. kilometres

Map of Sørhamna with surroundings, Bjørnøya, 4 sheets. Scale 1 : 1 000. Contour interval 1 metre. Area 1.02 sq. kilometres (included in the above figure).

Survey Work in 1923.

In 1923 it was decided that the whole of Bjørnøya should be surveyed on the scale of 1 : 10 000, with a contour interval of 10 metres for the high ground and 5 metres for the low ground. The map was to serve also as a base for the detailed and systematic geological investigations to be commenced for ascertaining the value and extent of the coal deposits. Time permitting, the area around the mine and mining camp, Tunheim, should be surveyed on the scale of 1 : 1 000 with 1 metre contour interval. The Norwegian Svalbard Expeditions were charged with the task of carrying out the survey. To make the survey complete it was also decided to make an astronomical determination of the latitude and longitude of a point on the island.

[1] The coordinate values of 1922 have been subject to quite small corrections according to the results of the triangulation 1923, which net had a better development. The corrections, however, are so small that they are without importance to the construction.

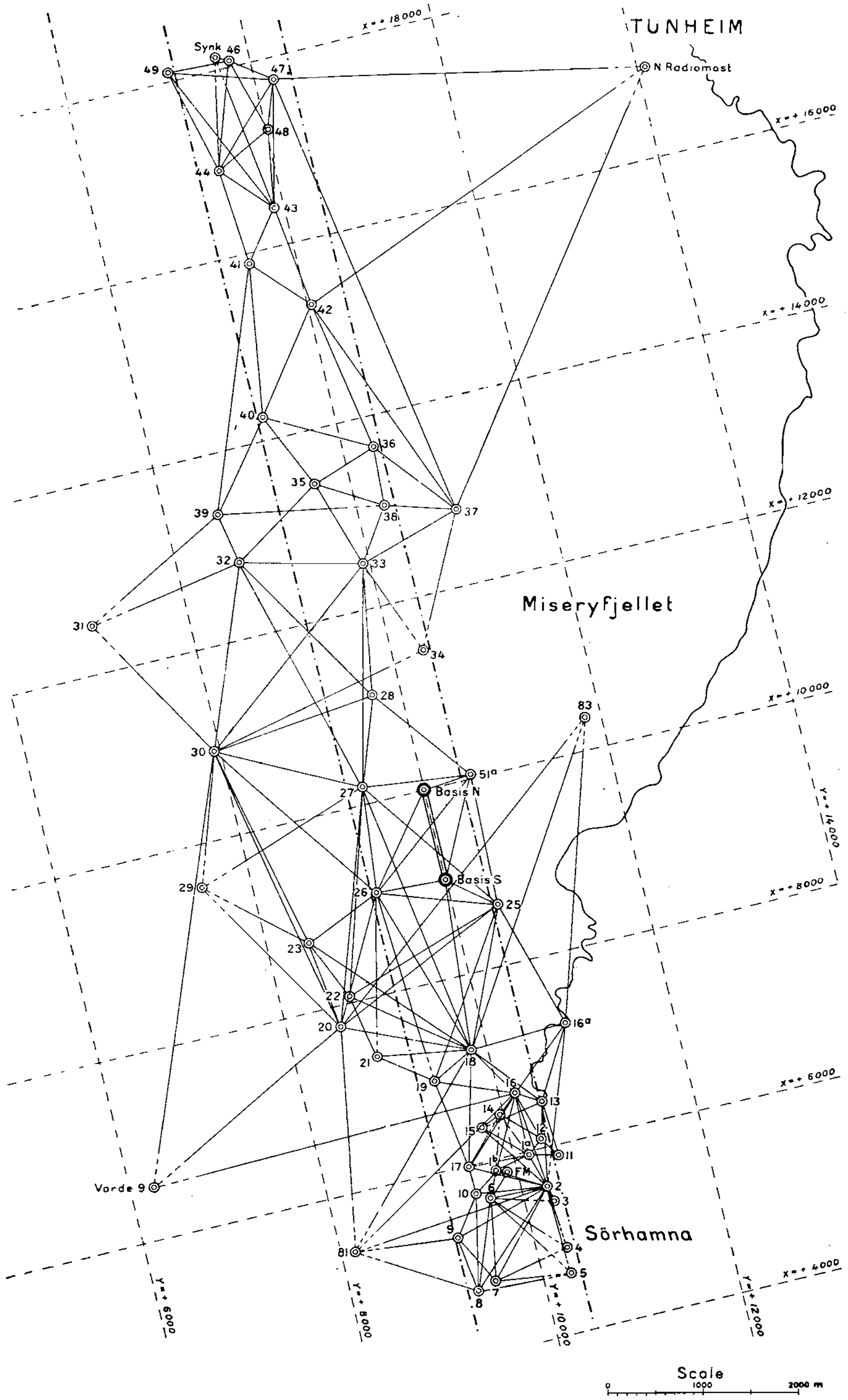


Fig. 11. Base Line and Trigonometrical Net 1922.
—·—·— Trace of aerial ropeway (proposed).

Plan for Field Work.

The plan was worked out by Koller and consisted mainly of the following points:

The trigonometrical net had the same base line and coordinate system as in 1922, and a favourable development of it throughout the island was naturally aimed at. For the triangulation theodolite Nr. 901 is to be used. With regard to the signals in the trigonometrical points, the considerations mentioned in the working plan for 1922 were to apply, but the signals were to be made considerably larger so as to be visible on the photographic plate, for, when surveying stereophotogrammetrically on the scale of 1 : 10 000, one must be able to plot the details at a distance 5 times as great as when surveying on the scale of 1 : 2 000. The signals were to be painted, in order to be as clearly visible as possible. The trigonometrical points should be spread over the island in such a way and in such a number that by trigonometrical resection the position of the stand points for the detail measurements (base lines and tacheometer, stations). As experience has shown that iron corrodes very easily on Bjørnøya, copper bolts are to be used for marking the points. The dimensions of the bolts are 2.5 cm in diameter and their length 15 cm. They are put into holes for two-thirds of their length and fixed with sulphur.

The heights are to be determined trigonometrically and based upon the water level measurements of 1922. The levels of the bench marks of the Swedish water level measurements in Russehamna 1899 to be determined relatively to one of our trigonometrical points, as are the bench marks of Claus Schive, C. E., for the water level measurement at Tunheim in 1918.

The detail survey to be largely carried out by stereophotogrammetry. The high steep cliffs against the sea to be surveyed from photogrammetric sea stations. The rest of the coast is to be surveyed by tacheometry, as are the narrow valleys and those parts of the low country which are difficult to get with stereophotogrammetry. The coast line itself is to be surveyed by direct depression sights from the tacheometer stations.

The work is thus to be divided:

Solheim, topographer, with 1 assistant: triangulation.
Koller, topographer, with 4 assistants: stereophotogrammetric detail survey.
Bernhard Luncke, topographer, with 2 assistants: tacheometric details.
Koller is leader of the work.

Instruments and other Outfit.

The same instruments for triangulation, tacheometry and stereophotogrammetry as were used in 1922, further 1 Goerz camera, size 13×18 cm to be attached to theodolite Nr. 537. 2 stadia rods with 5 cm divisions. The remainder of the outfit was practically identical with that of 1922 with the following additions:

1 rowing boat with 3 pair of oars.

4 dozen ordinary photographic plates 13×18 cm. Exposure meters with light tables, necessary outfit and chemicals for developing plates and printing.

50 copper bolts, diameter 2.5 cm, length 15 cm.

3 kg sulphur.

3 hammers.

(Drill-steel and material for the signals were obtained from *Bjørnøen A/S*).

Grindery material, leather, screws, etc. for repairing boots.

6 mattresses.

By agreement with *Bjørnøen A/S* it was arranged that the provisions should be supplied by the company.

Field Work.

Koller, Solheim, and Luncke, with their assistants, Paul Egede and Jens Eggvin, left Oslo on June 15 for Trondheim, whence they sailed for Bjørnøya in the collier S/S "Thormod Bakkevig". The ship called at Tromsø where the assistants Aksel Åker, Karl Kristiansen, Astrup Kristiansen, and Bertran Johansen embarked. On June 21 the "Thormod Bakkevig" reached Bjørnøya, where the expedition was installed at Tunheim, the mining camp of the company. Various preliminary work was started, and the leaders of the surveying parties made reconnoitring trips on the island, where there was still much snow. All the slopes facing north had huge drifts of snow, and most of the lakes were covered with ice. As the snow-drifts in many places also spread over this ice, the outline of the lakes was invisible. On June 23 the erection of the signals was commenced. Koller and Luncke with 3 assistants covered the northernmost part of the island, and began at Kapp Forsberg. Solheim with 3 assistants erected the necessary signals on Miseryfjellet, and on the higher ground of the central part of the island. The parties brought with them cut boards for the signals, copper bolts, etc. The shape and size of a signal is shown in Fig. 12. They were all supported by 3 stays of wire.

On July 3 Hoel, the leader of the Spitsbergen expedition, arrived to inspect the work and remained on the island until the 7th. During this period the work had advanced so far that it was necessary to

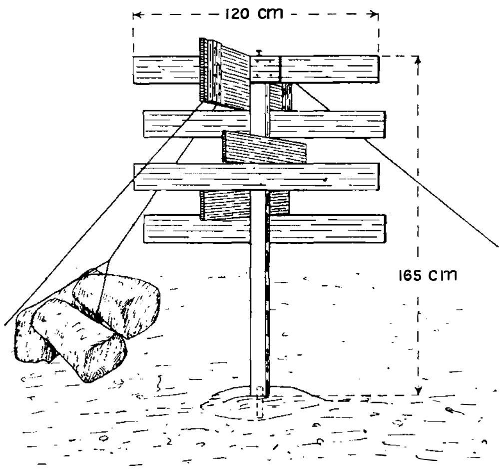


Fig. 12. Wooden Trigonometrical Signal.

erect camps. One tent was placed in a small valley west of Miseryfjellet, and a camp consisting of two tents at Laksvatnet.

A room with three beds in the radio station at Tunheim was placed at the surveyor's disposal for the summer. A dark-room was also arranged here. This proved very useful, for the party leaders could develop and print the plates here during spells of bad weather. In such intervals computation of the series in the observation books was also carried out. Lunckethe photographic expert, developed most of the photogrammes in the course of the summer.

On July 12 all the parties had finished the erection of signals. The snow had now disappeared to such an extent that the survey work proper could commence, but owing to bad weather it had to be postponed until July 15.

Solheim started the triangulation in the base line, Koller started north of Laksvatnet, and Luncke at Kapp Forsberg. Good weather prevailed until the 22nd and the work progressed very satisfactorily. At the height of summer it is possible to work day and night on Bjørnøya. This proved particularly fortunate to the triangulation and photogrammetry men, who could then choose the time of day giving the best light conditions for each particular case. Then the field work had to be suspended owing to bad weather which lasted until the 31st. The time was mostly spent in bringing up further supplies of provisions, and repairing boots! The ground on Bjørnøya is largely covered with large and small angular blocks of hard sandstone, and walking on this rough surface meant very hard wear for boot soles. The soles had therefore to be studded with small steel screws or alpine nails, some of which had to be renewed after each day's work. The soles were impregnated with linseed oil. Only in that way was it possible to keep the boots in a fit condition. From August 1 to the 8th the field work could be carried out with brief interruptions. Solheim's party had nearly finished the stations on the high ground, and Koller's party had finished the low ground stations which to the number of 30 are situated from Laksvatnet to Kapp Ruth. In order to secure good control points (*Passpunkte*), especially for the stereoscopic bases on Misery-

B. Luncke phot. 19/8 1923.

Fig. 13. Landing Point on the South Side of Kapp Dunér.

fjellet, 3 cylindrical stone cairns were built, and painted black. A stereo-photogrammetric exposure towards Miseryfjellet is shown on pl. I. A.

On August 8 the party, consisting of Luncke with 2 assistants, walked to Tunheim to get fresh provisions. On the return journey they rowed round the island on the north side and beyond Kapp Dunér. There was a heavy swell from the west, and they tried to land on the south side of the cape. About 30 metres off the shore a breaker capsized the boat, but all the men succeeded in reaching the beach safely. Most of the provisons were saved, but an observation book covering a period of 8 days was lost. Fig. 13 shows the landing point.

The following 3 days gave bad weather and Koller's party spent the time in bringing provisions, photographic plates and outfit to Misery Camp. At the same time Luncke's camp at Kapp Dunér was fixed. On the 9th Solheim levelled the Swedish bench marks in Russehamna. The 12th and 13th gave observation weather, but then followed a protracted period of bad weather which lasted until August 31. The parties of Koller and Solheim had in this period only 2 short days in the field (August 18 and 28). Each day Koller worked a stereoscopic base line on Miseryfjellet. On the 18th Solheim moved to the camp at Laksvatnet, and on the way he made observations in point Nr. 72. On the 28th he was on the west coast and observed in Nr. 5 cairn. Luncke's party, however, was at work the greater part of the time, as only the high ground had fog. They worked in the low country and along the coast in the northwestern part of the island. The astronomer, Dr. Hans Henie, now arrived in the island, and selected as observation point one of the heavy concrete blocks to which the back-stays of the northern radio mast are fixed. A concrete observation pillar with a centre mark was erected here. The astronomical point is thus situated that it can be used as a main point in the trigonometrical net. August 31 and September 1 were fine days and they were also made full use of. Solheim worked in 6 triangle stations, Koller had 6 stereoscopic base lines on Miseryfjellet. One of these, showing the low-lying ground with numerous lakes, is shown on Pl. I. B. Luncke's party, now camping at Ellasjøen in the south, made a big advance on the west coast.

On September 1 Hoel arrived from Spitsbergen, on the way to Norway, and, after having received a report from Koller and Solheim on the work carried out, he left the following day.

Until September 5 weather was favourable for observations. Solheim was particularly fortunate in almost completing his observations. Luncke, too, got much work done, reaching with his tacheometer survey the mountains at Kapp Bull, and then moving his camp to Sørhamna. Koller was hampered on the 2nd and 5th by fog in the elevated parts of the island, but managed to finish the base lines on Miseryfjellet. One of these covering a considerable part of the hilly ground in the south of the island is shown on Pl. II. A. Then followed miserable weather, rain, fog and storm, which lasted until September 24. The party leaders spent the time from the 7th until the 15th in Tunheim; Luncke developed a number of photogrammes, Koller and Solheim worked up their observation series. During some short spells of clear weather Solheim did some tacheometrical surveying in the vicinity of Tunheim and surveyed the coast as far as Kapp Forsberg. He also started the survey for a special map of the Tunheim-Austervåg area. The scale of this map, by agreement with the manager of Bjørnøen A/S in Bjørnøya, was to be 1 : 2 000 with a contour interval of 2 metres.

On September 16 the weather had improved, and the parties left Tunheim. Luncke camped at Kvalrossbukta. Solheim went to the base line to have some of his previous observations improved; and Koller ascended Miseryfjellet where one stereoscopic base line remained to be taken, but bad weather set in and no work could be done. On the 17th the weather was still worse. From the 18th until the 22nd the air was sufficiently clear for tacheometrical work: Solheim surveyed from Kapp Forsberg to Nordkapp, and then continued his work on the special map of Tunheim; Luncke worked towards Sørhamna. Koller worked from the mountain summits every day, but was not through with his work until the 24th.

At last came the good weather which lasted 3 ½ days. Solheim finished the triangulation. He made fresh observations in the base points, in stations 27, 55, 60, 47, 49 and 63 to connect with the astronomical point, in which observations also were made. Luncke finished the tacheometer work in the southern part of the island, and moved to Tunheim on the 28th. The photogrammetric survey also had the benefit of good weather. Koller went to the southern mountains, Antarcticfjellet and Alfredfjellet, and in the course of two days he finished this part (6 base lines). Another base line was taken on the 28th, but then the work was interrupted by a northeast gale, which in the evening increased to a storm. To save the camp the men had to build high stone walls to the windward side of the tents. The following day the wind had abated, but bad weather conditions prevailed until October 1. On the following day (fine weather) the survey was finished. The vessel which was to take the surveyors home had already left Tromsø, and could be expected at any time. Koller's party finished their work with 3 base lines on the north and northwest side of Miseryfjellet, and had thus practically carried out the whole of their programme. Solheim did tacheometrical work at Tunheim, and Luncke at Nordhamna. The ship, M/C "Blomstersæl", arrived that day, but could not shift to the coal pocket until the following day on account of rough sea. At 6 p. m the ship left Bjørnøya with the surveyors and reached Tromsø on the 5th.

The number of trigonometrical signals used during the summer was as follows:

31	wooden signals above	a	copper bolt in the rock
1	—»—	-	—»— concrete pillar
29	—»—	-	iron bolt in the rock
3	—»—	-	cross in the rock
1	—»—	-	drilled hole in the rock
15	—»—	-	iron pipe in the ground
2	—»—	-	wooden plug in the ground
9	cylindrical stone cairns		
2	smaller stone cairns		
1	radio mast		
1	flagstaff		
1	test pit		
96	trigonometrical signals.		

Triangulation was carried out from 55 stations, with 2 or more series from each. Owing to bad light and weather conditions the observations in 13 stations were repeated with a fresh instrument setting. Points from which no sights were made, were pointed from so many stations that they could be computed with ample surdetermination. For the detail survey 63 stereoscopic base lines were taken, with 184 pair of exposures. All the base lines could be computed trigonometrically.

There were 141 tacheometer stations and from 4 of these were taken photograms to be worked out as ordinary photogrammetry. The edge of the cliff was done with tacheometry, as was the coast line itself whenever there was an opportunity. Otherwise the coast line was surveyed by direct depressions. The tacheometer and depression survey were always supplied with sketches of the ground.

Office Work.

Immediately after the return to Norway the computation work was started.

The base net was computed, using condition equations. The other chief points, spread over the island, were computed by using combined intersection and resection, adjusting according to the method of least squares. The other trigonometrical points were usually computed directly from the chief points with intersection and measurement of all the angles, and adjusting the angular sum of the triangles. Points with no observations, because they were inaccessible, were computed in 2 or more triangles, and an average coordinate value.

Then followed the trigonometrical computations of the elevations, carried out by Miss Marie Nordbye and Solheim.

The computation of the stereophotogrammetric base lines were carried out by Koller and Miss Nordbye. One station (usually the A station) of all the base lines was computed by trigonometrical resection, and check, to 1 or 2 points. The difference between observed and computed direction angle to the check points were, as a rule, below 0.0040^{g}.

The tacheometer stations were usually computed as the usual polygonal traverse connected up with the trigonometrical points. Frequently it was also found expedient to compute some of the points by trigonometrical intersection. The computations were carried out by Luncke and Solheim.

The stereophotogrammetric construction was done by *Kartkontoret Stereografik A/S*, Oslo. The work was superintended by Koller. On the whole, the photographic material was successful as regards the elevated ground, and the map could be drawn. However, the outer part of the low country taken from the long base lines on Miseryfjellet and Oswaldfjellet turned out to be incomplete. One had expected to be able to draw that part of the island from these exposures.

The area tacheometrically surveyed, was constructed by Luncke and Solheim.

In the spring of 1924 the construction work was finished, and preliminary prints were made.

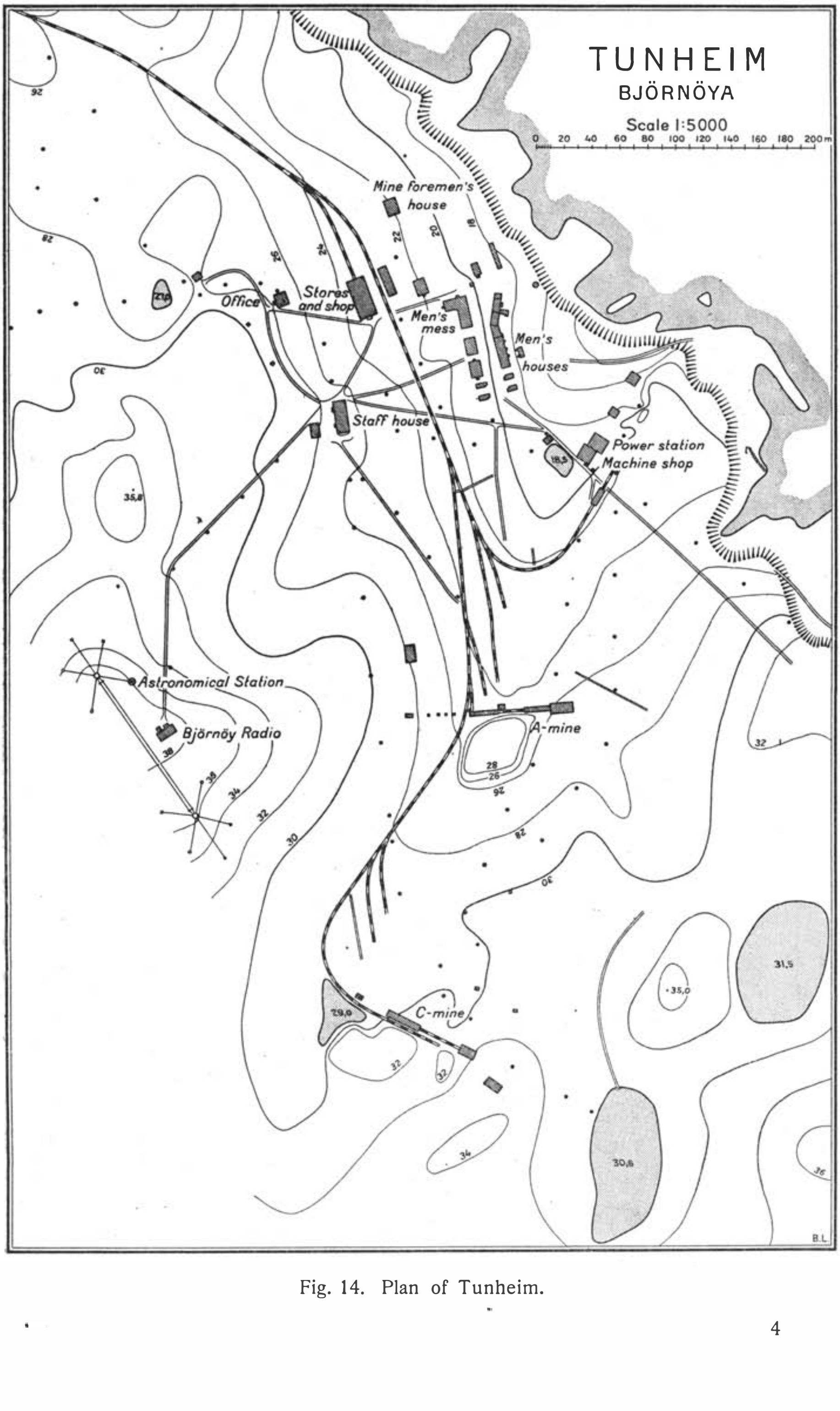


Fig. 14. Plan of Tunheim.

Area surveyed in 1923:	
On the scale 1 : 10 000, and contour interval 5 and 10 metres	120.12 sq. km
On the scale of 1 : 2 000, and contour interval 2 metres (mining area)	0.64 —
Total	120.76 sq. km

Survey Work in 1924.

It now remained to map the steep seaward slopes of Miseryfjellet, the sea-cliffs of Fuglefjellet, Hambergfjellet and Alfredfjellet, together with an area between Laksvatnet and Herwighamna. To this should be added a considerable part of the low country in the northwestern part of the island, which it had not been possible to construct stereo-photogrammetrically.

In order to complete the survey two parties consisting of the topographers Luncke and Kåre Gleditsch, with Karl Kristiansen and Bertran Johansen as assistants, were sent to the island. Luncke was the leader of the field work. The instruments used were: Theodolite Nr. 537 and 539 from *Sigurd Baalsrud*, Oslo. Theodolite Nr. 539 had a camera, Nr. 7793, size 9×12 cm, which camera could also be used for instantaneous photographs. Along with Zeiss aerial camera Nr. 4783, size 13×18 cm it was used for the photogrammetric sea stations (fig. 15).

Field Work.

The topographers Solheim and Gleditsch with 4 assistants arrived at the island by S/S "Thormod Bakkevig" on July 5, and at once commenced to build signals along the coast for the support of the sea stations. Luncke joined H. M. S. "Farm", which called at the island on July 10 on her way North with the Spitsbergen expedition, on a trip along the Bjørnøya coast. On this trip photogrammetric sea stations were taken on the stretch Miseryfjellet — Fuglefjellet, where the work had to be stopped on account of fog. The photographer was Koller. The same night "Farm" left for Spitsbergen. Koller and Solheim were then also on board.

The area north of Laksvatnet was first surveyed, then the flat country westwards around Nordhøgda and Tverrsjøen and farther southwards. Thence some blanks on the map at Oswaldfjellet, Ellasjøen, Ymerdalen, Fauskevika and Kapp Levin. The special map of Tunheim was considerably extended. Some surveying in the mine was done by Luncke.

On July 27, the mining company placed S/S "Geir" at the disposal of the party for a trip around the island, enabling Luncke to take the

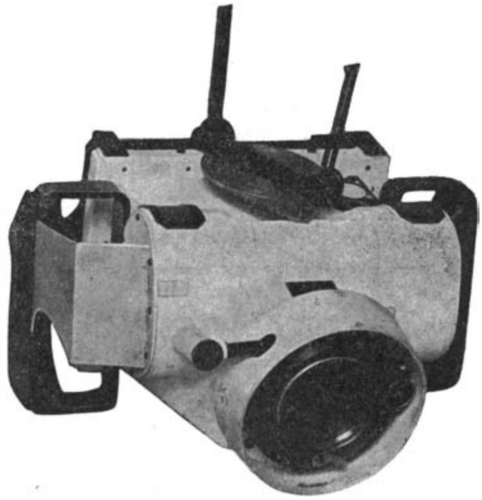


Fig. 15. Air Survey Camera.
Size 13 × 18 cm.

remaining photogrammetric sea stations on the stretch Landnørdingsvika—Stappen. One of these panoramas is shown on Pl. II. B.

There were 116 tacheometer stations, of which 3 also served as photogrammetric stations. The mining area of Tunheim was surveyed, with 6 new bench marks on the surface and 4 in the mine. The computations of the latter were carried out on the spot, and the results handed to the manager of the mine, Fr. Theting, on September 16. From the sea 11 photogrammetric stations were taken with a total of 35 photogrammes. As check points for these stations 2 new cairns and 3 signals were built, and also a few signals in old points.

The field work at Bjørnøya was thus completed and the survey of the island brought to an end.

Office Work.

The maps were constructed during the winter of 1924—25. The tacheometry was computed and constructed by Luncke, and Jakob Sartorius, Solheim, and Luncke constructed the results of the photogrammetric sea stations.

Area surveyed in 1924:

On the scale 1 : 10 000, and contour interval 5 and 10 metres	43.69 sq. km
On the scale 1 : 2 000, and contour interval 2 metres (mining area)	0.98 —
Total	44.67 sq. km

Below follows a summary of surveying methods, surveyed areas, and published maps.

1922. Stereophotogrammetry, scale 1 : 1 000 and 1 : 2 000 (aerial ropeway track)	12.64 sq. km
1923. Stereophotogrammetry, scale 1 : 10 000	91.88 —
Tacheometry, scale 1 : 10 000	28.24 —
Tacheometry, scale 1 : 2 000 (mining area)	0.64 —
1924. Photogrammetry from the sea, scale 1 : 10 000	3.61 —
Tacheometry, scale 1 : 10 000	40.08 —
— — 1 : 2 000 (mining area)	0.98 —
Total area of Bjørnøya	178.07 sq. km

The island has about 700 lakes and ponds[1], mostly situated on the flat ground, the total area of which is 18.8 sq.kilometres, or 10.6 per cent of the total area of the island.

In addition to the maps mentioned on p. 40: Trace of the proposed aerial ropeway, and Sørhamna with surroundings, come the following: Special map of the Tunheim area. 2 sheets. Scale: 1:2000. Contour interval 2 metres. Area 1.62 sq.km ("Idal" print).

The following two topographical maps were printed:

1. Bjørnøya, 6 sheets in 3 colours. Scale: 1:10000. Contour interval 5 and 10 metres. Reproduced and printed by *Ing. Dahls Opmåling*, Oslo 1925.
2. Bjørnøya, printed in 4 colours. Scale 1:25000. Contour interval 5 and 10 metres. Reproduced and printed by *Norges Geografiske Oppmåling*, Oslo 1925.

On p. 69 will be found a list of the maps surveyed and printed (published) by *De Norske Svalbardekspedisjoner* 1922—1925, and by *Norges Svalbard- og Ishavs-undersøkelser* 1928—1943.

Weather Conditions 1922—1924.

It was soon found that the reports of extremely bad weather conditions on Bjørnøya were not exaggerated.

During the season of 1922, lasting from August 16 to October 24, i. e. a total of 70 days, observation weather prevailed only for 38 per cent of the period. Most of the time there was rain, sleet, fog, and storm. Frequently it was only possible to work continuously half a day or even less.

In 1923 the survey was carried out during the better part of the summer, but the weather was just as bad as in the previous year. In the period July 15—October 2 (79 days), when the survey proper was carried out, weather conditions suitable for the photogrammetric method prevailed only for 29 per cent of the period, triangulation "weather" for 35 per cent, and tacheometer "weather" for 42 per cent. The photogrammetric method suffered most from the weather, demanding, as it does, clear air. This method was also chiefly used in the higher parts of the island where the foggy weather is much more frequent than over the low ground. Triangulation here could in part be carried out when the high ground was fog-bound.

In 1924 the survey work was done in the period July 14—September 16 (65 days) with observation weather during 44 per cent of the time.

[1] Skipper Peder Evensen of *Bjørnøen A/S* carried out soundings in 1925 of Haussvatnet, Stevatnet, Laksvatnet, Lomvatnet, Haabethvatnet, Holmevatnet and Ellasjøen

Measurement and Computation of the Base Line.

The measurement was carried out by Koller and Solheim with 4 assistants. The base points are situated in Sørlia on two natural projections of the ground, on either side of a small depression. The marking was done with iron bolts in large blocks of stone, securely embedded in the ground, and the head of the bolts had a fine cross.

The base line was pointed out with theodolite, and marked for every 50 metres with 1 metre long poles.

The invar wire used for the measurement was purchased by Captain G. Isachsen from the firm of *Gottschalk*, Stockholm. The length of the wire was determined in October 1921 by *Norges Geografiske Oppmåling* and found to be:

$$24\,000 \text{ mm} - 7.05 \text{ mm at } +15^\circ \text{ C.}$$

The wire was compared with two wires of *Norges Geografiske Oppmåling*, whose length was determined at *Bureau International des Poids et Mesures* in Sèvres. During the measurement the wire was strained to the extent of 10 kilogrammes by means of a spring balance. The scale of the wire was read on a measuring tripod. This scale — in each end of the wire — has a length of 10 cm, divided into millimetres. The reading was estimated to one-tenth of a millimetre. The base line was measured twice, forwards and backwards, and the difference amounted to 8.2 millimetres. The position of the top of the tripods was determined by levelling as the measurement proceeded. The difference in elevation between the ends of the base is 18.48 m, being the average of levelling both ways, the difference between the two measurements amounting to 10 mm. The average temperature during the measurement was $+ 4^\circ$ C. In computing the base the same coefficient of expansion was used as for the *N. G. O.* invar wires Nos. 46 and 48, giving a correction per wire length of — 0.210 mm at $+ 4^\circ$ C.

The reduction of the wire length to the horizontal was taken from a diagram, drawn according to the formula:

$$\text{reduction} = 2 \text{ r } \sin^2 \frac{\alpha}{2}$$

where r = length of wire, α = angle of inclination of direction between the top of the two tripods.

Base at Sørlia.

Forwards

Tripod	Readings mm +	Readings mm —	Difference in height m	Reduction mm
Base N— 1	1.8	-	0.988	20 35
1— 2	1.8	-	0.845	14.90
2— 3	6.5	-	0.829	14.35
3— 4	0.4	-	0.003	0.00
4— 5	-	14.8	1.191	29.52
5— 6	4.3	-	0.627	8.18
6— 7	0.0	-	1.000	20 80
7— 8	3 9	-	0.642	8.55
8— 9	10.1	-	0.392	3.18
9—10	7.5	-	1.634	55.69
10—11	-	1.9	0.602	7.55
11—12	-	10.9	1.000	20 80
12—13	0.5	-	1.418	41.93
13—14	0.6	-	1.266	33.30
14—15	-	5.9	1.214	30.72
15—16	9 0	-	1.021	21.70
16—17	-	5.1	1.754	64.18
17—18	-	4.3	1.681	58.95
18—19	-	0.4	0.938	18.35
19—20	-	2.1	1.547	49.91
20—21	0.2	-	1.040	22.74
21—22	14.7	-	0.736	11.26
22—23	2.1	-	0.571	6.80
23—24	-	2.1	0.482	4.86
24—25	7.0	-	0.588	7.22
25—26	5.5	-	0 157	0.52
26—27	6.8	-	0.643	8.60
27—28	2.7	-	0.381	3.00
28—29	-	10.7	0 630	8.24
29—30	-	5.9	0.820	14.00
30—31	-	1.9	0.632	8.27
31—32	4.7	-	1.965	80.58
32—33	4.0	-	1.504	47.17
33—34	-	3.8	0.569	6.74
34—35	7.6	-	0.320	2.10
35—36	1.5	-	0.108	0.23
36—37	1.2	-	0.789	13.00
37—38	0.3	-	0.677	9.54
38—39	3.8	-	0.486	4.94
39—40	0.7	-	0.662	9.06
40—41	-	12.0	0.736	11.30
41—S[1]	49.0	600.0	0.007	0.00
	158.2	681.8		803.08

Backwards

Tripod	Readings mm +	Readings mm —	Difference in height m	Reduction mm
Base S— 1[1]	49.0	600.0	0.008	0.00
1— 2	-	12.4	0.743	11.50
2— 3	0.7	-	0.659	9.02
3— 4	3.6	-	0.485	4.92
4— 5	1.4	-	0.694	10.02
5— 6	12.9	-	0.789	13.00
6— 7	18.7	-	0.125	0.34
7— 8	1.7	-	0.359	2.67
8— 9	-	22.6	0.568	6.73
9—10	2.7	-	1.495	46.61
10—11	4.3	-	1.974	81.32
11—12	-	9.4	0.635	8.36
12—13	15.1	-	0.790	13.17
13—14	2.4	-	0.616	7.88
14—15	4.6	-	0.353	2.60
15—16	-	8.6	0.658	9.00
16—17	-	1.9	0.230	1.10
17—18	-	10.0	0.600	7.50
18—19	0.7	-	0.521	5.68
19—20	1.0	-	0.568	6.75
20—21	8.9	-	0.815	13.84
21—22	0.6	-	0.987	20.27
22—23	-	23.2	1.580	52.07
23—24	-	18.6	0.900	16.90
24—25	12.5	-	1.551	50.17
25—26	-	4.4	1.905	75.72
26—27	14.7	-	0.988	20.34
27—28	7 1	-	1.234	31.70
28—29	10.7	-	1.282	34.13
29—30	6.4	-	1.404	41.10
30—31	3.0	-	1.011	21.28
31—32	2.9	-	0.587	7.16
32—33	8.3	-	1.680	58 87
33—34	6.4	-	0.325	2.20
34—35	-	13.7	0.670	9.35
35—36	-	6.2	1.017	21.52
36—37	-	7.9	0.599	7.50
37—38	3.7	-	1.115	25.90
38—39	4.0	-	0.068	0.12
39—40	0.0	-	0.782	12.72
40—41	-	1.5	0.878	16.10
41—N	4.4	-	0.975	19.77
	212.4	740.4		806.90

Forwards

41 spans of 24 000 mm . . .	984 000.0 mm
Correction for wire 7.26·41	— 297.7 »
	983 702.3 mm
Difference: + and —	— 523.6 »
	983 178.7 mm
Reduction	— 803.1 »
Forwards	982 375.6 mm

Backwards

41 spans of 24 000 mm . . .	984 000.0 mm
Correction for wire 7.26·41	— 297.7 »
	983 702.3 mm
Difference: + and —	— 528.0 »
	983 174.3 mm
Reduction	— 806.9 »
Backwards	982 367.4 mm

[1] Measured with a checked steel tape.

Average of both measurements: 982 371.5 mm $\pm$ 4.1 mm.
The average height of the base line above mean sea-level: 87.68 m.
Reduction of base line to sea-level according to the formula:

$$k = \frac{B \cdot h}{r}$$

k = reduction, B = length of base, h = elevation above sea-level,
r = earth radius

$$k = \frac{982.37 \cdot 87.68}{6\,395\,680} = 0.0135 \text{ m}$$

$$\begin{array}{r} 982.3715 \\ -\,0.0135 \\ \hline \end{array}$$

Base line reduced to sea-level $\underline{\underline{982.3580 \text{ m}}}$

Triangulation and Trigonometrical Computations.

For the triangulation a repeating theodolite Nr. 901 from *Sigurd Baalsrud*, Oslo was used (Fig. 16).

Magnifying power used	28 ×
Free objective opening	41 mm
Focal length of objective	244 »
Length of telescope	260 »
Sensitiveness of the levels 15 to 20 sec. per ...	2 »
Magnifying power of circle microscope	32 ×
Diameter of horizontal circle	150 mm
Both circles have 400^g divison.	
Weight of theodolite with foot plate	6.8 kg
Weight of box	8.0 »
Weight of tripod	5.2 »
Total weight	20.0 kg

The theodolite is of the transit type. The horizontal circle is divided into $\frac{1}{2}{}^g$, and the readings take place with a monocular screw reader giving directly 0.001^g. The vertical circle is divided into $\frac{1}{10}{}^g$, and by using a vernier microscope can be read 0.01^g. The theodolite has a level on the horizontal circle and one on the vertical circle. On the telescope itself are fixed two levels.

Whenever possible the trigonometrical points were marked with copper or iron bolts, or crosses made in the rock. At 9 points cylindrical cairns of stone were built, and at the others wooden signals 1.65 m in height (Fig. 12). Cairns and wooden signals were painted black.

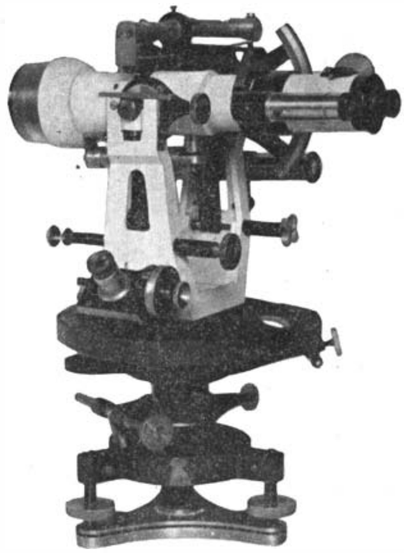


Fig. 16. Triangulation Theodolite Nr. 901.

The triangulation was carried out in series. The minimum number of observations in one point was 2 full series, 3 or 4 series were frequently taken. Each series included 6 points at the most. The vertical angles were taken in one series.

A rectangular coordinate system was chosen with X-axis along the base line, and coordinate values for the northern end of the line ("Basis N") y = 10 000 m and x = 10 000 m. Thus all the coordinates become positive. The base net was computed as a square with all the angles measured and the directions adjusted, using conditional equations. The computation is given below.

The other 25 chief points were computed through a combined intersection and resection adjustment according to the method of least squares. The average error my and mx of the chief points is less than 1 dm, except as regards point Nr. 75. The average error, m, of the adjusted directions averages ± 0.0014 ^{g}.

The less important trigonometrical points are usually computed directly from the chief points through intersection with measurement of all the angles, and with check pointings forwards and backwards to one or several points, but without computing the average error. The computations are carried out entirely in plane geometry. With the small extension of the area no appreciable error will arise.

Adjustment of the Inner Base Net.

Measured Directing.

Base N	Point 26	Base S	Point 51
(1) = 0.0000	(4) = 0.0000	(7) = 0.0000	(10) = 0.0000
(2) = 97.7848	(5) = 28.3224	(8) = 96.6458	(11) = 16.3799
(3) = 139.8251	(6) = 61.3139	(9) = 150.6243	(12) = 48.2324

(9)—(8) = 53.9785	(8)—(7) = 96.6458	(9)—(7) = 150.6243
(2)—(1) = 97.7848	(3)—(2) = 42.0403	(11)—(10) = 16.3799
(12)—(10) = 48.2324	(6)—(4) = 61.3139	(6)—(5) = 32.9915
199.9957	200.0000	199.9957
w = — 0.0043	w = 0.0000	w = — 0.0043

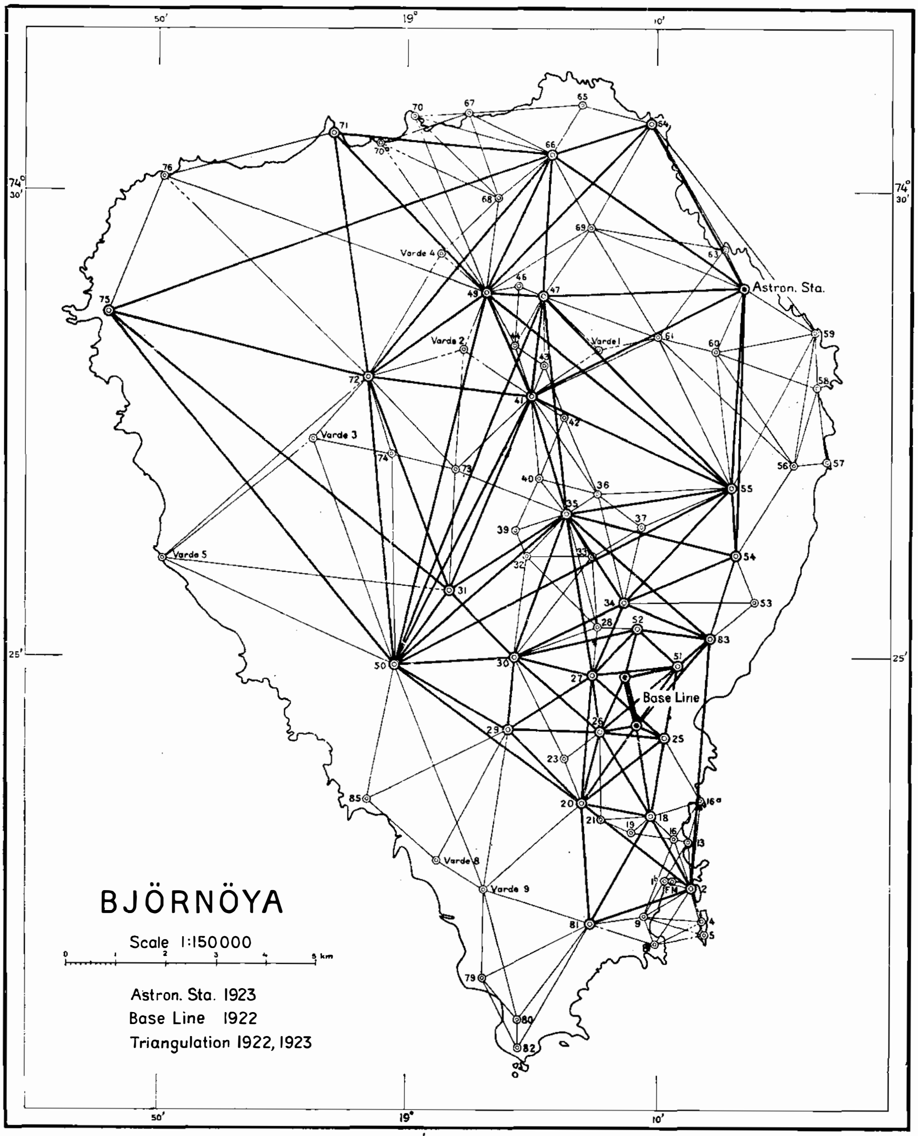


Fig. 17. Complete Trigonometrical Net.

Condition Equations.

$$-v_1 + v_2 - v_8 + v_9 - v_{10} + v_{12} + w = 0$$
$$-v_2 + v_3 - v_4 + v_6 - v_7 + v_8 + w = 0$$
$$-v_5 + v_6 - v_7 + v_9 - v_{10} + v_{11} + w = 0$$

Side Equations.

$$\frac{\sin((3)-(2))\ \sin((12)-(11))\ \sin((9)-(7))}{\sin((8)-(7))\ \sin((3)-(1))\ \sin((11)-(10))} = 1$$

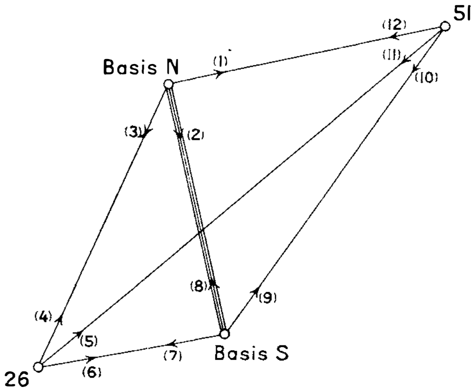


Fig. 18. Base Line Net.

				Diff. for 1 c
(3)—(2) =	42.0403	log sin	= 9.787 748.6	+ 88
(12)—(11) =	31.8525	» »	= 9.680 989.2	+ 125
(9)—(7) =	150.6243	» »	= 9.845 183.8	— 70
		Sum	9.313 921.6	

				Diff. for 1 c
(8)—(7) =	96.6458	log sin	= 9.999 397.0	+ 3
(3)—(1) =	139.8251	» »	= 9.908 822.0	— 49
(11)—(10) =	16.3799	» »	= 9.405 628.4	+ 260
		Sum	9.313 847.4	

Numerator — Denominator = + 74.2

$$-0.49 v_1 - 0.88 v_2 + 1.37 v_3 + 0.73 v_7 - 0.03 v_8 - 0.70 v_9 + 2.60 v_{10} - 3.85 v_{11} + 1.25 v_{12} + 74.2 = 0$$

Coefficients of Condition Equations.

	1	2	3	4	5	6	7	8	9	10	11	12	w
a	— 1	+ 1						— 1	+ 1	— 1		+ 1	— 43
b		— 1	+ 1	— 1		+ 1	— 1	+ 1					0
c					— 1	+ 1	— 1		+ 1	— 1	+ 1		— 43
d	— 0.49	— 0.88	+ 1.37				+ 0.73	— 0.03	— 0.70	+ 2.60	— 3.85	+ 1.25	+ 74.2

[aa] = + 6
[ab] = — 1 — 1 = — 2
[ac] = + 1 + 1 = + 2
[ad] = + 0.49 — 0.88 + 0.03 — 0.70 — 2.60 + 1.25 = — 2.41
[bb] = + 6
[bc] = + 1 + 1 = + 2
[bd] = + 0.88 + 1.37 — 0.73 — 0.03 = + 1.49
[cc] = + 6
[cd] = — 0.73 — 0.70 — 2.60 — 3.85 = — 7.88
[dd] = + 0.24 + 0.774 + 1.876 + 0.533 + 0.49 + 6.76 + 14.82 + 1.563 = + 27.05

Normal Equations.

	a]	b]	c]	d]	w	
[a	$+ 6.0\ k_1$	$— 2.00\ k_2$	$+ 2.00\ k_3$	$— 2.41\ k_4$	$— 43$	$= 0$
	[b	$+ 6.00\ k_2$	$+ 2.00\ k_3$	$+ 1.49\ k_4$		$= 0$
		[c	$+ 6.00\ k_3$	$— 7.88\ k_4$	$— 43$	$= 0$
			[d	$+ 27.05\ k_4$	$+ 74.2$	$= 0$

Solution of Normal Equations.

+ 6.00	— 2.00	+ 2.00	— 2.41	— 43	$k_1 =$ + 6.25
	+ 6.00	+ 2.00	+ 1.49	0	
	— 0.67	+ 0.67	— 0.80	— 14.38	
		+ 6 00	— 7.88	— 43 00	
		— 0.67	+ 0.80	+ 14.33	
			+ 27.05	+ 74.20	
			— 0.97	— 17.27	
	+ 5.33	+ 2 67	+ 0 69	— 14.33	$k_2 =$ + 1.633
		+ 5.33	— 7.08	— 28.67	
		— 1.34	— 0.35	+ 7.18	
			+ 26.08	+ 56.93	
			— 0.09	+ 1.86	
		+ 3.99	— 7.43	— 21.49	$k_3 =$ + 2.51
			+ 25.99	+ 58.79	
			— 13.83	— 40.00	
			+ 12.16	+ 18.79	$k_4 =$ — 1.546

Computation of Corrections v.

	1	2	3	4	5	6
k_1 a	— 6.25	+ 6.25				
k_2 b		— 1.63	+ 1.63	— 1.63		+ 1.63
k_3 c					— 2.51	+ 2.51
k_4 d	+ 0.76	+ 1.36	— 2.12			
v	— 5.49	+ 5.98	— 0.49	— 1.63	— 2.51	+ 4.14
		0.00			0.00	

	7	8	9	10	11	12	— w k
k_1 a		— 6.25	+ 6.25	— 6.25		+ 6.25	+ 268.75
k_2 b	— 1.63	+ 1.63					0 00
k_3 c	— 2.51		+ 2 51	— 2.51	+ 2.51		+ 107.93
k_4 d	— 1.13	+ 0.05	+ 1.08	— 4.04	+ 5.95	— 1.93	+ 114.71
v	— 5.27	— 4.57	+ 9.84	— 12.80	+ 8.46	+ 4.32	+ 491.39
		0.00			— 0.02		

Table of Adjusted Directions.

	Measured Directions	v	Adjusted Directions	v^2
Base N				
(1) =	0.0000	— 5.5	— 0 00055	30.30
(2) =	97.7848	+ 6.0	97.78540	35.76
(3) =	139 8251	— 0.5	139.82505	0.24
Point 26				
(4) =	0.0000	— 1.6	— 0.00016	2.66
(5) =	28.3224	— 2.5	28.32215	6.30
(6) =	61.3139	+ 4.1	61.31431	17.13
Base S				
(7) =	0.0000	— 5.3	— 0.00053	27.76
(8) =	96.6458	— 4.6	96.64534	20.88
(9) =	150.6243	+ 9.8	150.62528	96.80
Point 51				
(10) =	0.0000	— 12.8	— 0.00128	163.80
(11) =	16.3799	+ 8.5	16.38075	71.55
(12) =	48.2324	+ 4.3	48.23283	18.65
				[vv] = 491.83

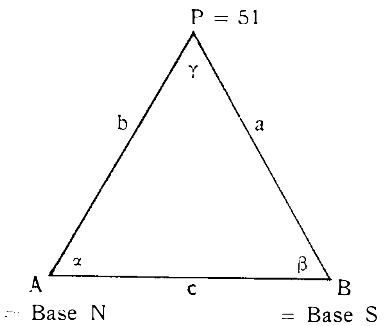
Check of Side Equations.

(3)—(2) =	42 03965	log sin = 9.787743	(8)—(7) =	96.64587	log sin = 9.999397
(12)—(11) =	31.85208	» » = 9.680984	(3)—(1) =	139.82560	» » = 9.908819
(9)—(7) =	150 62581	» » = 9.845173	(11)—(10) =	16 38203	» » = 9.405684
		Sum 9.313900			Sum 9.313900

Average Error.

$$m = \pm \sqrt{\frac{[vv]}{r}} = \pm \sqrt{\frac{491.6}{4}} = \pm 11.1^{cc}$$

Base N	Y = 10 000.000 m	X = 10 000.000 m
Base S	Y = 10 000.000 m	X = 9 017.642 m



Adjusted Angles.

α = 97.78595
β = 53.97994
γ = 48.23411

200.00000

$(AB) = 200.00000$
$\alpha = 97.78595$

$(AP) = 102.21405$

$\log b = 3.030177$
$\log \sin (AP) = 9.999737$

$\log \triangle Y_A = 3.029914$

$Y_A = 10\,000.000$
$\triangle Y_A = +\ 1\,071.307$

$Y = 11\,071.307$

$\log c = 2.992270$
$\log \sin \gamma = 9.837097$

$\log (c : \sin \gamma) = 3.155173$
$\log \sin \beta = 9.875004$

$\log b = 3.030177$
$\log \cos (AP) = 8.541220$

$\log \triangle X_A = 1.571397$

$X_A = 10\,000.000$
$\triangle X_A = -\ 37.273$

$X = 9\,962.727$

$(BA) = 0.00000$
$\beta = 53.97994$

$(BP) = 53.97994$

$\log (c : \sin \gamma) = 3.155173$
$\log \sin \alpha = 9.999737$

$\log a = 3.154910$
$\log \sin (BP) = 9.875004$

$\log \triangle Y_B = 3.029914$

$Y_B = 10\,000.000$
$\triangle Y_B = +\ 1\,071.307$

$Y = 11\,071.307$

$\log a = 3.154910$
$\log \cos (BP) = 9.820561$

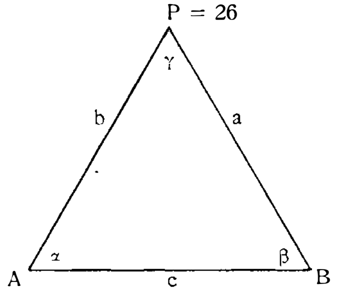
$\log \triangle X_B = 2.975471$

$X_B = 9\,017.642$
$\triangle X_B = +\ 945.085$

$X = 9\,962.727$

Point 51 $\quad Y = 11\,071.307$ m $\quad X = 9\,962.727$ m

P = 26



= Base S $\qquad$ = Base N

Adjusted Angles.

$\alpha = 96.64587$
$\beta = 42.03965$
$\gamma = 61.31448$

200.00000

$(AB) = 0.00000$
$\alpha = 96.64587$

$(AP) = 303.35413$

$\log b = 2.865681$
$\log \sin (AP) = 9.999397$

$\log \triangle Y_A = 2.865078$

$Y_A = 10\,000.000$
$\triangle Y_A = -\ 732.957$

$Y = 9\,267.043$

$\log c = 2.992270$
$\log \sin \gamma = 9.914332$

$\log (c : \sin \gamma) = 3.077938$
$\log \sin \beta = 9.787743$

$\log b = 2.865681$
$\log \cos (AP) = 8.721499$

$\log \triangle X_A = 1.587180$

$X_A = 9\,017.642$
$\triangle X_A = +\ 38.653$

$X = 9\,056.295$

$$\begin{aligned} \log\,(c:\,\sin\gamma) &= 3.077938 \\ \log\,\sin\alpha &= 9.999397 \\ \hline \log a &= 3.077335 \\ \log\,\sin\,(BP) &= 9.787743 \\ \hline \log \triangle Y_B &= 2.865078 \end{aligned}$$

$$\begin{aligned} Y_B &= 10\,000.000 \\ \triangle Y_B &= -\ 732.957 \\ \hline Y &= 9\,267.043 \end{aligned}$$

$$\begin{aligned} (BA) &= 200.00000 \\ \beta &= 42.03965 \\ \hline (BP) &= 242.03965 \end{aligned}$$

$$\begin{aligned} \log a &= 3.077335 \\ \log\,\cos\,(BP) &= 9.897502 \\ \hline \log \triangle X_B &= 2.974837 \end{aligned}$$

$$\begin{aligned} X_B &= 10\,000.000 \\ \triangle X_B &= -\ 943.706 \\ \hline X &= 9\,056.294 \end{aligned}$$

Point 26 $Y = 9\,267.043$ m $X = 9\,056.295$ m

Determination of Mean Sea Level.

In order to determine the average level of the sea, and also the height of the water level at spring and neap tide, a staff gauge was erected in Sørhamna 1922. The staff consisted of a board (2 ½×7 in) 3 metres long and graduated into decimetres. It was fixed as shown in Fig. 19 firmly secured at both ends. In the rock near the staff gauge an iron bolt was placed, the elevation of which in relation to the staff was determined; this bolt became the first bench mark. The levelling was carried out by Solheim and gave the following result:

From the bench mark to the zero mark on the staff	— 3.593 m
From the zero mark on the staff to the bench mark	+ 3.589 »
Average	3.59 m

The height of the staff above the zero point on the staff was thus 3.59 m.

The reading of the gauge was done by the party that charted Sørhamna. On account of the swell the opportunities for connected observations were few. The gale on September 10th damaged the gauge, and from that time the sea was usually so rough that no readings could be made. The results are shown in Fig. 20. From this it will be seen that the mean sea-level corresponds practically to a reading on the staff of 0.88 m. As the accuracy of the reading was only to the nearest decimetre, the reading is rounded off to 0.9 m. The elevation of the bench mark in Sørhamna is thus:

3.59 — 0,90 = 2.69 m above mean sea-level.

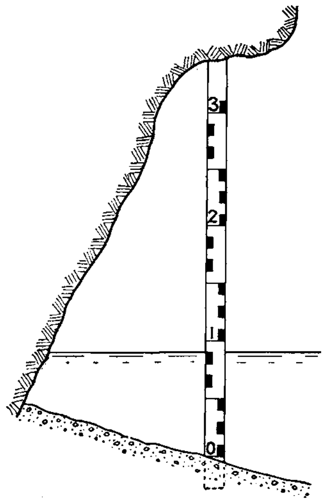


Fig. 19. Water Level Staff in Sørhamna.

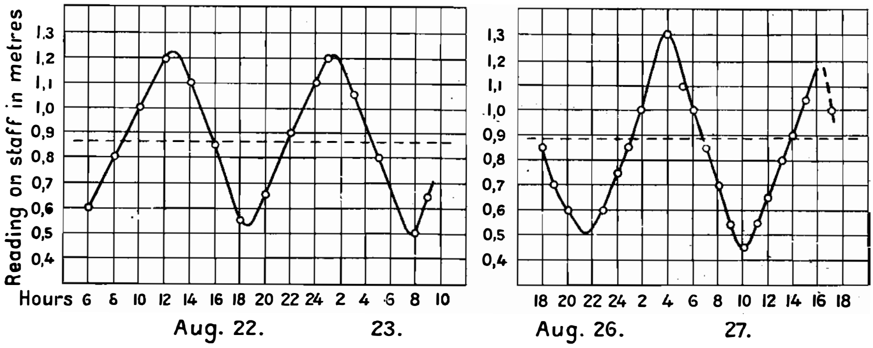


Fig. 20. Water Level Curves. 1922.

Later water level measurements are dealt with in *Skrifter om Svalbard og Ishavet Nr. 14:* Kjær and Fjeldstad. Tidal Observations in the Arctic. Oslo 1934.

Computation of Heights.

Mean sea-level is chosen as zero point for the heights. The bench mark in Sørhamna is also a trigonometrical point, and consequently the starting point for the computation of the elevation of the trigonometrical points. Levelling has only been carried out between the ends of the base line (Base N and S). Otherwise the elevations of the trigonometrical points have been determined by measuring the vertical angle and computation according to the formula

$$h = a \operatorname{tg} \alpha + \frac{1 - k}{2r} a^2$$

h = difference in height, a = distance, α = vertical angle, k = koefficient of refraction, r = earth radius.

Except in a few cases, when the points were inaccessible, the points have always been reciprocally pointed. Thus the following value was found:

$$\log \frac{1 - k}{2r} = 2.83\,110 - 10.$$

It fits very well, except in the low flat area in the northwestern part of the island, where the sight lines, which are longer here, follow the surface in their entire length. The refraction is here more irregular, and the found value appears somewhat too great. The heights have been computed in closed polygons with the shortest possible sides. In adjusting, regard has been paid to the length of the sides, the weight assigned being proportional to the squares of the length of the sides. The average error has not been worked out, but the average correction in the altitude polygons is 15 mm per km. In the summer of 1923 an opportunity arose of getting a comparison between our appointed value of the mean water level of the sea, and a water level measurement in

Russehamna carried out in 1899 by a Swedish expedition led by J. G. Andersson (Forsberg 1900). Two of the Swedish bolts were refound and levelled to the trigonometrical point 16 a, whose height then becomes 27.290 m above mean water level. According to our measurements the height is 27.386 m, a difference of 0.096 m or roughly 0.1 m to which extent the Swedish water level is higher than ours. As mentioned, the carrying out of the tidal measurements in Sørhamna was hampered by many difficulties, as there was always some swell, necessitating interpolation between crest and trough of the waves.

Check was obtained at Austervåg by levelling to an iron bolt, the height of which was determined from systematic tidal observations carried out by Claus Schive on behalf of the *Bjørnøen A/S* in 1918:

Schive's elevation of the bolt	28.2 m
Our —»—	27.7 »
Difference	0.5 m

Our height is thus 0.5 less, which tallies very well, as the height from 1918 refers to an assumed low water 0.5 m below mean water level.

Coordinates and Heights of the Trigonometrical Points.

1. *Main Points.*

Nr.	Position	Coordinates in metres				Height in metres		Kind of marking
		Y	±	X	±	Ground	Top bolt	
Base N	Sørlia	10 000.000	-	10 000.000	-	96 80	96.92	Iron bolt permanent
Base S	»	10 000.000	-	9 017.642	-	78.33	78.44	— —
26	Blåsen	9 267.043	-	9 056.295	-	100.44	100.58	— —
51	Miseryfjellet	11 071.307	-	9 962.727	-	364.65	364.72	Copper bolt —
25	Sørlia	10 480.38	0.03	8 636.29	0.03	89.74	89.87	Iron bolt —
27	Blåsen	9 375.81	0.02	10 183.85	0.02	123.42	123.50	Copper bolt —
52	Miseryfjellet	10 466.45	0.01	10 874.33	0.01	350.62	350.71	— —
18	Blyhatten	9 843 52	0.01	7 198.51	0.03	122.70	122.81	Iron bolt —
20	N. Antarcticfjellet	8 564.67	0 01	7 773.78	0.01	169.03	169.10	Copper bolt —
83	Urd	11 827.56	0.04	10 335.65	0.03	534.68	-	Iron tube temporary
81	Antarcticfjellet	8 151.18	0.04	5 388.15	0.06	336.77	336.91	Iron bolt permanent
2	Sørhamna	10 276.99	0.03	5 594.95	0.04	89.06	89.21	— —
29	Skurven	7 482.39	0.03	9 546.75	0 02	127.77	127.83	Copper bolt —
30	W. Langen	7 939 56	0.04	10 916.39	0.04	111.31	111.38	— —
34	Galdernebben	10 337.63	0.04	11 437.48	0.03	325.80	325.88	— —
35	E. Mjogsjøen	9 618.07	0.06	13 444.58	0.09	134.44	134 55	Iron bolt —
50	Oswaldfjellet	5 569.68	0.07	11 342.65	0 03	162.80	162.88	— —
54	Skuld	12 702.47	0 08	11 829.48	0.09	446.78	-	Iron tube temporary
55	W. Jutulsetet	12 939.40	0.03	13 157.11	0.06	232.46	232.54	Copper bolt permanent
31	E. Skruvledalen	6 991.69	0.04	12 534.41	0.03	123.52	123.62	— —
41	Steinflya	9 494.39	0.03	15 880.54	0.04	83.15	83.27	Iron bolt —
47	N. Spelvatnet	10 196.14	0.03	17 765.77	0.07	48.88	48.94	Copper bolt —
49	N. Stevatnet	9 114.38	0.03	18 096.84	0.02	47.44	47.51	— —
Astr. pt.	Tunheim	14 138.05	0.02	16 944.36	0.02	38.42	39.13	— —
66	Kikutkollen	11 034 69	0.03	20 471.84	0.04	52.31	52.40	— —
72	E. Tverrsjøen	6 416.13	0.06	17 042.44	0.05	47.64	47.71	— —
75	Kapp Dunér	1 637.65	0.18	19 535.70	0.12	33.12	33.19	— —
71	Kapp Kjellström	6 877.24	0.06	21 916.86	0.07	25.76	25.82	— —
64	Kapp Forsberg	13 116.43	0.06	20 614.33	0.03	44.38	-	Wooden peg temporary

2. *Auxiliary Points.*

Nr.	Position	Coordinates in metres		Height in metres		Kind of marking
		Y	X	Ground	Top bolt	
FM	Sørhamna	9 905.19	5 845.51	2.69	2.69	Iron bolt permanent
1a	—	10 168 87	5 965 25	36.07	36.23	— —
1b	—	9 796.70	5 874 35	43.09	-	Iron tube temporary
3	Kapp Heer	10 296 59	5 432.36	71.18	-	— —
4	Måkeholmen	10 324.27	4 911.42	-	-	Iron bolt permanent
5	—	10 313.99	4 633.16	-	-	— —
7	W. Sørhamna	9 510.92	4 735.13	45.21	45.33	— —
8	—	9 312 89	4 680.64	129.51	-	Iron tube temporary
9	—	9 248.47	5 272 04	137.06	137.21	Iron bolt permanent
10	—	9 529.50	5 683.03	117.61	-	Iron tube temporary
11	Kapp Nilsson	10 473.97	5 885 80	34.10	34.23	Iron bolt permanent
12	Kvalrossbukta	10 337.94	6 101.60	27.73	-	Iron tube temporary
13	—	10 433.62	6 487.14	43.25	43.45	Iron bolt permanent
14	—	9 969 82	6 451.79	56.73	56.88	— —
15	—	9 770.34	6 353.07	78 24	78.36	— —
16	—	10 181.29	6 646.18	78.93	79.07	— —
16a	Borgmesterporten	10 872.14	7 254.91	27.39	27.51	— —
17	W. Sørhamna	9 526 89	5 985.17	125.13	-	Iron tube temporary
19	E. Grøa	9 392.46	6 966.25	122.83	-	— —
21	N. Antarcticfjellet	8 873.22	7 374.83	121.64	-	— —
22	—	8 733.06	8 064.25	120.93	-	Cross in rock permanent
23	E. Gåsvatna	8 447 62	8 699.31	91.59	-	— —
28	N. Blåsen	9 701.58	11 102.94	128.82	-	Iron tube temporary
32	W. Mefarhaugen	8 649.15	12 818 98	114.25	-	— —
33	Mefarhaugen	9 912.96	12 493.69	157.90	158.00	Iron bolt permanent
36	E. Trihyrningen	10 320.09	13 679.34	140.30	140.39	— —
37	E. Sigjorddalen	11 012.50	12 826.85	155.02	155.11	Copper bolt —
39	S.W. Mjogsjøen	8 551.35	13 374.41	107.37	-	Cross in rock —
40	Steinflya	9 251.25	14 254.77	96 52	96.64	Iron bolt —
42	—	10 038.14	15 308.82	89.38	89.48	— —
43	N. Lygna	9 894.59	16 408.29	61.99	62.13	— —
44	E. Stevatnet	9 403.81	16 939.16	57.17	57.30	— —
Test pit	S.E. Hellevatnet	9 671.6	18 139.2	-	-	Test pit —
46	—	9 795.33	18 061 08	45.90	46.04	Iron bolt —
48	E. Spelvatnet	10 020 58	17 253.51	50.23	-	Drilled hole in rock permanent
51a	Sørlia	10 497 68	10 027.07	-	-	Iron tube temporary
53	Verdande	12 865.79	10 820.96	462.30	-	Small cairn permanent
56	Gygrenova	14 252.05	13 293.95	193.76	193.84	Copper bolt —
57	Kapp Levin	14 910.10	13 208.85	19.33	19.43	— —
58	Evensenhamna	15 083.83	14 690.71	29 94	30.03	— —
59	N.W. Framnes	15 303.05	15 763.27	30.02	30.10	— —
60	E. Lonene	13 275.62	15 861.57	58.41	58.49	— —
61	N.E. Holmevatnet	12 231.14	16 426.21	54.71	54.79	— —
N. Radio-mast	Tunheim	14 114.05	16 954.55	39.12	89.73[1]	Iron mast —
63	Austervåg	13 929.78	17 796.55	27.31	27.38	Copper bolt —
65	W. Titrebekken	11 864.03	21 298.40	35.23	35.29	— —
67	Kapp Posadowsky	9 617.01	21 674.03	24.70	-	Wooden pole temporary
68	Myggrabben	9 794.19	19 873.02	44.29	44.36	Copper bolt permanent
69	E. Laksvatnet	11 447.39	18 857.39	45.53	45.60	— —
70	Gravodden	8 520.85	21 866.75	-	-	Flag staff —
70a	Nordhamna	7 728.24	21 493 45	20.05	20.12	Copper bolt —
73	Gygreurda	7 677.73	14 836.27	84.37	84.45	—
74	N. Øyangen	6 507.43	15 432.50	42.37	42.43	— —
76	Nordvestbukta	3 361.11	21 869.91	32.55	32.61	— —

[1] Top mast.

2. *Auxiliary Point* (continued.)

Nr.	Position	Coordinates in metres		Height in metres		Kinds of marking
		Y	X	Ground	Top bolt	
79	Hambergfjellet	5 797 91	4 851.62	439.99	-	Iron tube temporary
80	Fuglefjellet	6 290.49	3 851.95	410.55	-	— —
82	S. Fuglefjellet	6 139 75	3 288.01	372 90	373.80[1]	Small cairn permanent
85	Kapp Kåre	4 405.72	8 882 43	107.46	107.52	Copper bolt —
Varde 1	E. Lygna	11 014.13	16 455.22	60 97	62 17[1]	Cylindrical cairn permanent
» 2	E. Haussvatnet	8 405.73	17 107 83	53.37	54.67[1]	— —
» 3	Vardehaugen	5 052.86	16 094.30	38 20	39.50[1]	— —
» 4	N. Haussvatnet	8 407 56	19 057.30	38 05	39.35[1]	— —
» 5	Kapp Hanna	1 527.63	14 502.44	23.85	25.15[1]	— —
» 6	Kollerskardet	10 076.80	12 197.55	160 00	161.44[1]	— —
» 7	Skuld	12 892.10	11 693.49	454 08	455.23[1]	— —
» 8	N.W. Alfredfjellet	5 463 64	7 358.00	292 32	293.38[1]	— —
» 9	Alfredfjellet	6 255.58	6 568.31	420.14	421.69[1]	— —

[1] Topp cairn.

Computation of the Meridian and Parallel Net Work.

The astronomical point at Tunheim, fixed by Henie, is connected up with the trigonometrical net and is the foundation for the computation of the graticule. The cross points of the graticule were computed in the conformous Gaussian projection with the meridian 15° East of Greenwich as an axis. Later the points were transformed (using plane trigonometry) into the coordinates of the triangle net. These computations were carried out by the geodecist Jacob Schive of *Norges Geografiske Oppmåling*. See table next page.

Hydrographic Survey of Sørhamna in 1922.

The task of one party was to take soundings for an accurate plan of Sørhamna in order to find out, *inter alia*, whether this harbour could be used for shipping coal. The party consisted of Eilif Iversen, Engineer, with 5 assistants: Nikolai Antonsen, Kristian Larsen, Johannes Mortensen, Alfred Olsen and Alf Hammerø, and arrived at the island on August 13th. They camped in Kvalrossbukta. The following day the harbour was explored and temporary marks were put in places which might be used as station points for the ray measurements, and as points between which a base line for offset sections could be put. These 6 main points (A—F, Fig. 21) were determined trigonometrically by the topographers in the course of the summer. The method of offset sections was employed as much as possible and in agreement with this the base lines A—B and C—D were run the following days.

No place could be found for more straight lines to serve as a base for the sounding sections. The points E and F were chosen as

Coordinates of Meridian and Parallel Net Work.

Point		Coordinates, metres		Point		Coordinates, metres	
Lat. N.	Long. E.	Y	X	Lat. N.	Long. E.	Y	X
74° 20′	18° 44′	— 4 206.9	4 330.0	74° 27′	18° 45′	— 547.2	16 835.1
» »	» 50	— 1 282.2	3 597.0	» »	» 50	1 872.4	16 229.1
» »	» 55	1 156.0	2 989.6	» »	» 55	4 292.8	15 626.4
» »	19° 0′	3 595.0	2 386.0	» »	19° 0′	6 714.2	15 027.1
» »	» 5	6 034.8	1 785.8	» »	» 5	9 136.4	14 431.2
» »	» 10	8 475.4	1 189.4	» »	» 10	11 559.4	13 838.7
» »	» 15	10 916.8	596.0	» »	» 15	13 983.2	13 249.5
» »	» 20	13 359.2	6.1	» »	» 20	16 407.8	12.663.8
74° 22′	18° 50′	— 380.9	7 206.2	74° 30′	18° 44′	330.0	22 368.3
» »	» 55	2 052.3	6 600.0	» »	» 45	812.3	22 247.2
» »	19° 0′	4 486.3	5 997.6	» »	» 50	3 224.3	21 643.1
» »	» 5	6 921.1	5 398.6	» »	» 55	5 637.2	21 042.3
» »	» 10	9 356.7	4 803.4	» »	19° 0′	8 050.9	20 444.9
» »	» 15	11 793.1	4 211.2	» »	» 5	10 465.4	19 850.9
» »	» 20	14 230.4	3 622.4	» »	» 10	12.880.9	19 260.3
				» »	» 15	15 297.1	18 673.0
74° 25′	18° 44′	— 1 938.5	13 349.2	» »	» 20	17 714.1	18 089.1
» »	» 45	— 1 453.7	13 227.4				
» »	» 50	971.0	12 620.1	74° 32′	18° 44′	1 237.4	25 976.1
» »	» 55	3 396.5	12 015.8	» »	» 50	4 125.7	25 252.3
» »	19° 0′	5 822.9	11 415.3	» »	19° 0′	8 942.1	24 056 6
» »	» 5	8 250.1	10 818.2	» »	» 5	11 351.5	23 463.9
» »	» 10	10 678.0	10 224.9	» »	» 10	13 761.8	22 874 6
» »	» 15	13 106.9	9 634.6	» »	» 15	16 172.9	22 288.6
» »	» 20	15 536.5	9 047.6	» »	» 20	18 584.8	21 705.9

stations for the ray measurements and they were both marked. The sounding work started at point A, but was frequently interrupted for half a day, or even a day, owing to dense fog, rain, or heavy sea.

The soundings were made from a rowing boat, and for this purpose 2 signals (staffs with flags) were put up at a distance of min. 10 metres. Until August 22 the work proceeded satisfactorily with a few interruptions. On that date a gale sprang up, lasting 4 days, and the tide gauge was wrecked. On August 26—27 regular readings of the tide gauge were again taken and used for the construction of a curve which may be considered fit for the reduction of the measured depths. It should be mentioned that the net depths computed in the observation books have been reduced as a matter of caution to the 0.30 contour, despite the fact that the lowest measured water level is 0.40.

From August 27 the work was continued with only slight interruptions till September 6 when a strong gale made work impossible until September 14. In this period only one day gave "working weather". Then stormy weather set in again with sleet and rough sea. On September 18th it was again possible to put in a day's work, the last one.

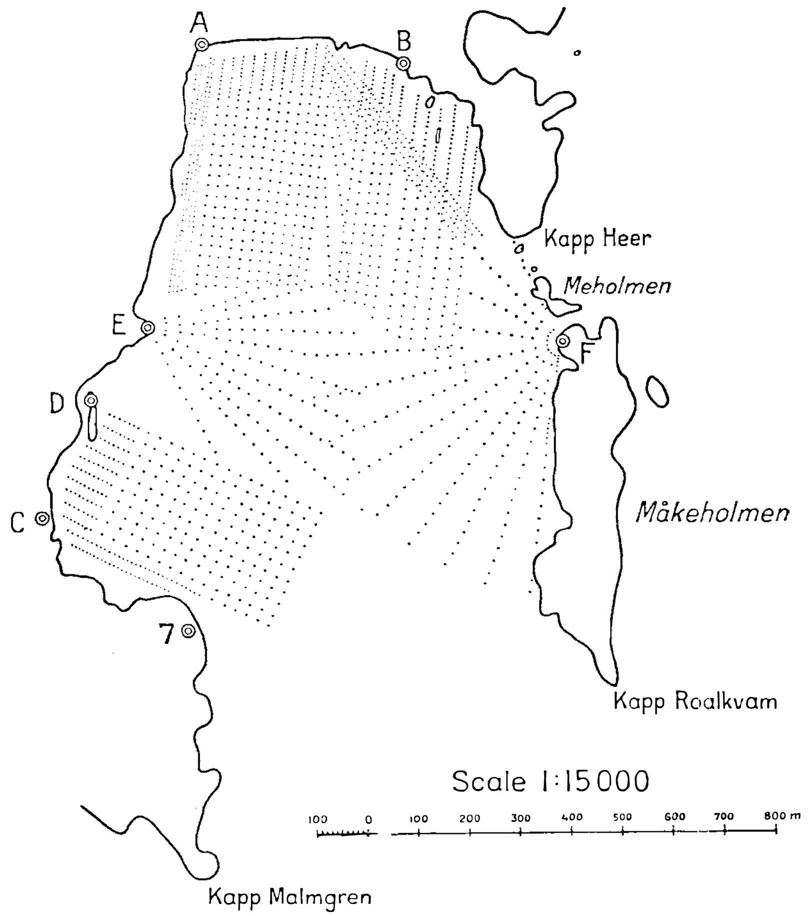


Fig. 21. Sounding Profiles in Sørhamna.

The nature of the bottom of Sørhamna is, generally speaking, favourable, being almost entirely sand with seaweed. Near the rocky shore the sand layer is probably thin. It was possible to find out definitely with the lead the difference between sand and rock bottom.

In the northeastern part of the harbour the bottom is uneven. At small depths the rock is not covered with sand; even at a depth of 6—7 metres there appear to be rocky ledges without sand. There is thus no anchorage here. On the whole it may be said that this part of the harbour is suitable only for rowing boats.

The currents of the harbour are very advantageous. The current line runs in approximately a straight line from Kapp Heer to trig. sta. 7. Inside this line there are no currents; outside the current is quite strong, probably up to 0.5 m/sek. In the passage between Måkeholmen (Gull Island)

and Kapp Heer the water runs in part like a river, the speed being probably up to 2 m/sek. and during a gale there are great breakers here. At the entrance to the harbour — between the two cliffs — a few soundings were also taken and the depth here is 18 metres near the shore and 24 metres in the middle of the entrance.

The soundings were plotted in the winter of 1922—23 by Claus Schive.

Maps and charts surveyed and published by De Norske Svalbard-ekspedisjoner 1922—1925 and by Norges Svalbard- og Ishavs-undersøkelser 1928—1943.

Kart over strekningen Laksvatn —Sydhamna, Bjørnøya. Markarbeider og beregninger utført av den Norske Svalbardekspedisjon 1922 under ledelse av Adolf Hoel. Landmålingen av Alfred Koller og W. Solheim. Målestokk 1:2000. Idalkopi[1], 7 bl.

[Map of the tract Laksvatn—Sydhamna, Bjørnøya. Field work and computations by the Norwegian Svalbard expedition 1922 led by A. Hoel. Topographical survey by A. Koller and W. Solheim. Scale 1.:2000. Idal print. 7 sheets.]

Kart over Sydhamna med omgivelser, Bjørnøya. Markarbeider og beregninger utført av den Norske Svalbardekspedisjon 1922 under ledelse av Adolf Hoel. Landmålingen av Alfred Koller, sjømålingen av Eilif Iversen. Målestokk 1 : 1 000. 4 bl. på kalkerlerret. Ikke offentliggjort.

[Map of Sydhamna with surroundings, Bjørnøya. Field work and computations by the Norwegian Svalbard expedition 1922 led by A. Hoel. Topographical survey by A. Koller, hydrographic survey by E. Iversen. Scale 1 : 1 000. 4 sheets on tracing cloth. Not published.]

Lodninger i Sydhamna, Bjørnøya. Markarbeider og beregninger utført av den Norske Svalbardekspedisjon 1922 under ledelse av Adolf Hoel. Landmålingen av Alfred Koller og W. Solheim, sjømålingen av Eilif Iversen. Målestokk 1:1 000. Idalkopi. 2 bl.

[Soundings in Sydhamna, Bjørnøya. Field work and computations by the Norwegian Svalbard expedition 1922 led by A. Hoel. Topographical survey by A. Koller and W. Solheim, hydrographical survey by E. Iversen. Scale 1 : 1 000. Idal print. 2 sheets.]

Bjørnøya. Spesialkart over Tunheimfeltet. Målestokk 1:2000. Tachymetrert av W. Solheim, Bernhard Luncke, Kaare Gleditsch. De Norske Svalbardekspedisjoner 1923—24. 2 bl. på kalkerpapir.

[Bjørnøya. Special map of the Tunheim area. Scale 1 : 2 000. Tacheometry by W. Solheim, B. Luncke, K. Gleditsch. The Norwegian Svalbard expeditions 1923—24. 2 sheets on tracing paper.

(Part of the map will be found in this paper, Fig. 14, on the scale 1 : 5 000.)

Svalbard. Bjørnøya. Topografisk kart. Målstokk 1:10000. [Optatt av] Dei Norske Svalbardekspedisjonane 1922—24. Oslo 1925. 6 bl. Trykt i Ing. Dahls Opmåling.

[Svalbard. Bjørnøya. Topographical map. Scale 1 : 10 000. [Surveyed by] the Norwegian Svalbard expeditions 1922—24. Oslo 1925. 6 sheets. Printed in Ing. Dahls Opmåling.]

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[1] Special kind of print prepared by *Ing. Dahls Opmåling*, Oslo.

Svalbard. Bjørnøya. Topografisk kart. Uppteke av dei Norske Svalbard-ekspedisjonane under A. Hoel. [1922—24.] Målstokk 1:25000. Oslo 1925. Reprodusert og prenta i Norges Geografiske Oppmåling.

[Svalbard. Bjørnøya. Topographical map. Surveyed by the Norwegian Svalbard expeditions under A. Hoel. [1922—24]. Scale 1 : 25 000. Oslo 1925. Printed in the Geographical Survey of Norway.]

A new edition (dated 1944) of the above map and with soundings accompanies this paper (in pocket).

Nordishavet. Arctic Sea. Svalbard. Bjørnøya. Bear Island. Målstokk [scale] 1:40000. Sjømælingar av [Surveys by] Norges Svalbard- og Ishavs-undersøkelser 1928—1931. Utarbeidt av [Compiled by] Rolf Kjær. Reprodusert og prenta i [Reproduced and printed in] Norges Geografiske Oppmåling. Nr. 501. [Formerly S 1.] Last printed March 9, 1943.

Nordishavet. Arctic Sea. Svalbard. Bjørnøyfarvatnet. Bear Island Waters. Målstokk [scale] 1:350000. Sjømælingar av [Surveys by] Norges Svalbard- og Ishavs-undersøkelser 1928—1931. Utarbeidt av [Compiled by] Rolf Kjær. Oslo 1937. Nr. 502. [Formerly S 2.] Last printed May 23, 1941.

Hydrographic Survey at Bjørnøya 1928—1931 and Determination of the Magnetic Variation in 1931.

By

Rolf Kjær

Hydrographic Work 1928—1931.

1928. The hydrographic survey work carried out at points along the coast of Bjørnøya previous to 1928 comprised detailed soundings, on various scales, of certain harbour areas as already mentioned (p. 35, 38, 66). This applies to Herwighamna, Sørhamna, Norskehamna, Austervåg, and some small "creeks" on the coast at Tunheim and Fugleodden.

When the halibut and cod fisheries in these waters were found to be very remunerative, the Norwegian Storting granted in 1928, for the first time, the necessary funds for the fitting out of an hydrographic expedition to survey the coastal waters of the island, and also to make soundings of the banks surrounding the island.

The first expedition carried out nearly all of the present detailed hydrographic survey of the coast, although it was succeeded by similar expeditions. Only a few of these (in 1930 and 1931) had the opportunity of doing sounding work in the immediate vicinity of the island.

The inspection vessel of the Norwegian Navy, "Michael Sars" was placed at the disposal of the expedition sent out by *Norges Svalbard- og Ishavs-undersøkelser* in June 1928. This vessel, of 207 tons gross, built in 1900 as a fishery inspection vessel, was engaged, during the winter on patrol service on the coasts of Troms and Finnmark. The vessel was old, without any modern equipment such as echo-sounding apparatus and gyro compass, and with small cruising range and low speed (only 8½ knots). Nevertheless, she served the expedition well, having good sea-going qualities and being easy to manœuvre. There were, however, no special arrangements for survey work, and this caused the surveyors some inconvenience.

The expedition in 1928 also had at its disposal a 28′ life-boat fitted with a F.M. 4 H.P. motor, giving it a speed of from 3½ to 4 knots. It was used for the detailed hydrographic work close to the shore.

The preparatory expedition work was carried out in Oslo by the staff of *Norges Svalbard- og Ishavs-undersøkelser*, and Commander A. Hermansen was to lead the expedition and also to do hydrographic survey work. The hydrographic surveyor of the expedition was the author, who had been granted leave from *Norges Sjøkartverk* (Hydrographic Office of Norway), where he was employed. Skipper Peder Evensen, who had previously been harbour pilot to the coal company *Bjørnøen A/S*, was engaged to act as local expert.

The "Michael Sars" left Tromsø for Bjørnøya on June 16. Like most of the expeditions to the Arctic Sea, this expedition, too, was charged with many duties which were to affect its survey work. Geophysical and meteorological work, transport duties and cruises in search of the missing seaplane "Latham" with Roald Amundsen and companions on board, occupied, in fact, so much of the time of the expedition that the original task: hydrographic survey work suffered considerably.

The "Michael Sars" arrived at Bjørnøya on June 18. After the relief staff of the wireless station on the island and some miners had been put ashore, the hydrographic work was started.

The outfit and instruments at the disposal of the surveyors were:

Sounding sheets (4) of the Bjørnøya banks on the scale of 1 : 200 000, and of the island itself on the scale of 1 : 40 000,
Sextants,
Micrometer quintants (type: C. Plaht) for angle measurements,
Range-finder,
Optical square 180° (type: Hydrographic Office of Norway),
Lucas Sounding Machine, Submarine Sentry, Snapper Lead for bottom samples and hand lead of ordinary type.

The sounding sheets on the scale of 1 : 200 000 were constructed on the Mercator projection, and the 1 : 40 000 sheet on the polyconic. On the latter were plotted some of the trigonometrical points fixed in 1922—1924, and also the coast line as measured by tacheometry, photogrammetry, and depression sights in the same period.

For fixing the positions near land a range-finder, 180° optical square, and angular measurement with the quintant were used. To within 7—8 miles of the island the quintant measurements were supplemented by bearings. Farther out ordinary navigation methods with log and compass and also bearings were employed. It should be mentioned that on clear days Miseryfjellet (536 m) could be sighted from a distance of 40 nautical miles.

During the first few days Commander Hermansen, on board the "Michael Sars", carried out some deep-sea soundings, especially in the northwestern area from the 2-mile limit and as far out as the island could be sighted. In the life-boat the author, accompanied by two ordinary seamen from the "Michael Sars" and Skipper Evensen as local expert, started the detailed hydrographic survey between the shore and the 2-mile limit.

After a few days the deep-sea sounding work was interrupted owing to other duties (the search for the missing plane "Latham"), and it was never resumed to any great extent. "Michael Sars" with Commander Hermansen was away from the island for about a month.

The detailed hydrographic survey was carried out entirely by the author, and during the first few days the life-boat was used with the "Michael Sars" as mother ship. In the morning the life-boat with the surveyor and provisions for the day was detached from the ship, which, after having carried out its deep-sea sounding work, returned in the evening to pick up the life-boat party.

When the "Michael Sars" was in the Bjørnøya water the detailed hydrographic work was done at Kapp Bull, then along the northwest coast of the island, later on around Austervåg. When the deep-sea soundings were suspended, the life-boat party had to fall back on the island during the continued work.

When working along the west coast (Kapp Bull—Kapp Dunér), and along the north coast (Kapp Dunér—Austervåg) it became necessary to camp for the night ashore — at one or other of the few points where landing is possible. On some occasions a heavy swell made it necessary to spend the night at sea. A kedge anchor was then used, it being too dangerous to approach the coast. Otherwise the life-boat party tried as often as possible to reach Austervåg, where the boat could lie in comparative safety and accomodation for the men was good. In Austervåg it was also possible to get the boat ashore. With a small hand-winch placed on the old coal pocket, the boat could be lifted out of the water, thus being safe in bad weather.

The surveyor could not follow a definite programme, but had to make his plans from day to day, dependent on the weather and also to a certain extent on the currents. The work had preferably to be done on the leeward side of the island. If, for instance, the wind was easterly one had to go to the west coast and remain there until the weather changed. Provisions and camping outfit were therefore always in the boat so that the party could go ashore and camp at any time. As the life-boat party had no contact with the mother ship, "Michael Sars", and for about a month had to work all by itself, the work was not devoid of danger. The difficult conditions led to very irregular working hours: dead days might alternate with up to 30 hours continuous working periods.

The currents around the island also impeded the survey considerably and had to be taken into account. Soundings were mostly carried out *with* the current. The low speed of the boat (only about 4 knots) made it well-nigh impossible to work against the current, which might have a speed of 3 knots. During spring tide, and when the current was at its maximum, it was not possible to make soundings with the hand lead to a greater depth than about 25 m. Current and wind also made the passing of certain points of the island dangerous, particularly at the south point (Kapp Bull). Framneset on the east coast was also awkward to pass at times.

The survey was also impeded to some extent by winds blowing on shore and by a good deal of fog, but, on the whole, the weather conditions were not bad and permitted the author to finish before the end of July a survey which gives some idea of the depths along the coast of the island, and which have been of good use to later navigators in these waters. At the end of July, when the survey was concluded, the "Michael Sars" sailed northwards to carry out other work in the waters of West Spitsbergen.

1929. No coastal survey work was carried out by this year's expedition to Bjørnøy waters.

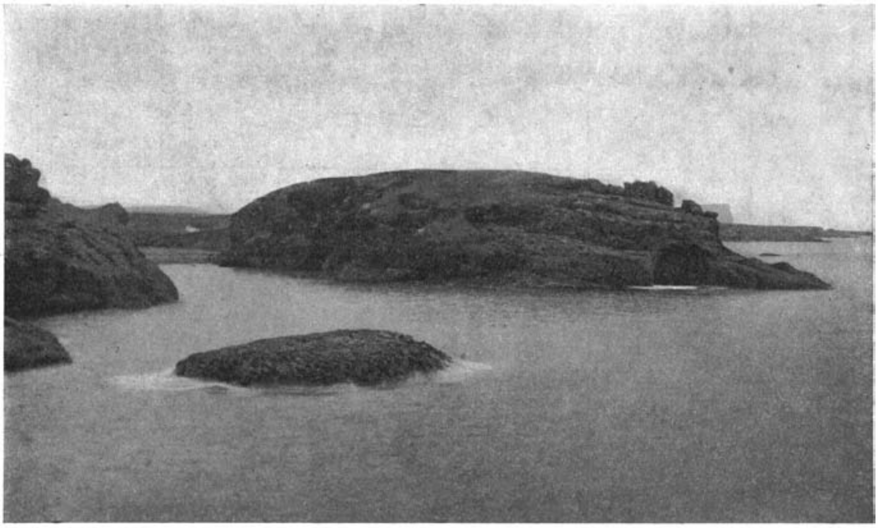
1930. As in the previous two years, the "Michael Sars" was also this year placed at the disposal of the expedition by the Navy. The author was surveyor and leader. The programme included deep soundings of the Bjørnøy banks, and also supplementary soundings off the coast as well as tide measurements.

The vessel left Tromsø on June 2 and reached the island on the 4th. An automatic tide-gauge (purchased in 1929, type Julien Friez, Baltimore) was erected and tested at Austervåg, and three men were then left to look after the gauge while the "Michael Sars" carried out its sounding work on the banks. These watchmen were fitted out with a tent, sleeping bags, and provisions for 30 days; they could communicate with the ship via the Bjørnøy wireless station situated at Austervåg.

During the deep-sounding work a few soundings were also taken near the islands. The tidal observations continued without interruption for 30 days, until July 7, when the gauge was taken down. The ship returned to Tromsø and the expedition was brought to an end (July 9). A detailed account of the tidal work will be found in *Skrifter om Svalbard og Ishavet, Nr. 14*: Kjær and Fjeldstad (1934).

1931. This year's programme of the "Michael Sars" expedition to the Bjørnøy waters again included work to supplement the detailed survey carried out in 1928. The author was again leader and surveyor. His assistent was Alfr. Andersen, late boatswain of the Hydrographic Office of Norway. He had been with the expedition of 1930.

The "Michael Sars" sailed from Tromsø on May 1. The ship was at the disposal of the expedition during the following eight weeks, but owing to various circumstances, such as stormy weather, it was only possible to carry out some revision soundings at Sørhamna and Kvalrossbukta in the days May 19—24. A week later a vain attempt was made to do some soundings off Framneset. For several days the ship was at anchor on the lee side of the island, and during this time



B. Luncke phot. 19/8 1923.
Fig. 22. Kapp Dunér. To the Left, with a Beach, is Teltvika.

signals were built for the benefit of future survey work. Trigonometrical signals along the west coast were also heightened.

On June 21 the expedition returned to Norway and later expeditions have not done any hydrographic survey work in the coastal waters of Bjørnøya.

The results of the work will be found on the Norwegian charts 501 and 502 (see list of maps p. 69).

Determination of the Magnetic Variation in 1931.

During this expedition the author also made a number of determinations of the magnetic variation at Bjørnøya. For this purpose the expedition had borrowed from the Hydrographic Office of Norway an old declinatorium (Bamberg Nr. 1480). The ship chronometer of "Michael Sars" checked by wireless time signals, was used, and the latitude and longitude of the observation points were taken from the topographical map of the island on the scale of 1 : 25 000.

On June 1 the azimuth of the sun was found from 4 observations of the sun, 10 metres WSW of the astronomical point at Tunheim. On the 15th 4 similar observations were taken at Teltvika on Kapp Dunér (Fig. 22) and the following day, June 16, 4 more at Ellasjøen in the south of the island.

Below is given the computation of 2 observations from each of the mentioned observation points. The observations were computed according to the nonlogaritmic formula for α:

$$\operatorname{ctg} \alpha = \frac{\cos t \cdot \sin \varphi - \cos \varphi \ \operatorname{tg} \delta}{\sin t}.$$

Determination of the Magnetic Variation in 1931.

	Tunheim June 1		Teltvika, Kapp Dunér June 15		Ellahytta June 16	
	$\varphi = 74°29'$	$\lambda = 19°13'.5$	$\varphi = 74°28'.6$	$\lambda = 18°46'.75$	$\varphi = 74°23'.75$	$\lambda = 18°59'.8$
	I	II	V	VI	IX	X
1. Chron ⊙	$14^h\ 48^m\ 49^s$	$15^h\ 34^m\ 22^s$	$17^h\ 26^m\ 4^s$	$17^h\ 58^m\ 18^s$	$10^h\ 32^m\ 37^s$	$11^h\ 3^m\ 50^s$
2. Chr. fast	— 53 14	— 53 13	— 58 16	— 58 15	— 57 53	— 57 52
3. G. M. T.	13 55 35	14 41 9	16 27 48	17 0 3	9 34 44	10 5 58
4. Eq. of T.	+ 2 28	+ 2 27.7	— 0 8	— 0 8.3	— 0 17	— 0 17.5
5. G. A. T.	13 58 3	14 43 36.7	16 27 40	16 59 54.7	9 34 27	10 5 40.5
6. △ λ	1 16 54	1 16 54	1 15 7	1 15 7	1 15 59	1 15 59
7. L. A. T.	15 14 57	16 0 30.7	17 42 47	18 15 1.7	10 50 26	11 21 39.5
8. H. A. of Sun in time	3 14 57	4 0 30.7	5 42 47	6 15 1.7	— 1 9 34	— 0 38 20.5
9. H. A. of Sun	48°.737	60°.128	85°.696	93°.757	—17°.392	— 9°.585
10. ⊙ δ	21°.975	21°.980	232°.95	23°.296	23°.325	23°.327
11. ⊙ α (computed)	—54°.56'.4	—66° 47'.0	—92° 27'.9	—100° 8'.1	20° 25'.0	11°.17'.8
12. Reading ⊙	262° 35°.0	274° 26'.3	45° 19'.5	52° 59.8	308° 13'.3	317° 20'.5
13. Reading N.	27°39'.0		132°51'.8		148°38'.0	
14. Reading magn. N.	25° 34'.0	25° 35'.7	130° 26'.1	130° 24'.6	146° 07'.7	146° 07'.4
15. D.	— 2° 05'.0	— 2° 03'.3	— 2° 25'.7	— 2° 27'.2	2° 30'.3	2° 30'.6

The *Nordlysobservatoriet* (Northern Light Observatory) at Tromsø later checked the work. The following mean values (of 4 observations) were obtained:

Tunheim	— 2° 04.5
Kapp Dunér	— 2° 26.7
Ellahytta	— 2° 31.4.

Literature.

Kjær, Rolf. Farvannsbeskrivelse over kysten av Bjørnøya. — Meddelelse. Norges Svalbard- og Ishavs-undersøkelser. Nr. 6. Oslo 1929.

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Kjær, Rolf and J. E. Fjeldstad. Tidal observations in the Arctic. Oslo 1934. — Skrifter om Svalbard og Ishavet. Nr. 14.

Place-names.

The map accompanying this paper contains a total number of 297 place-names. Of these 59 are older names, and 22 are from Svalbard Chart S. 1, 1932. 5 earlier names have not been used. The place-names, with an explanation of their meaning, will be found in: The Place-names of Svalbard. Oslo 1942. Skrifter om Svalbard og Ishavet. Nr. 80.

Alfredfjellet. *Alfreds Fjäll*, Kjellström & Hamberg 1899.
Alkeholmen.
Anderssonøya. *Andersson Øy.* Isachsen 1912.
Antarcticfjellet. *Antarctics Fjäll*, Kjellström & Hamberg 1899.
Arneputtane.
Auma.
Ausa.
Austervåg. *Sørumvaag*, Hoel, Kvalheim, Schive 1918; *Østervaag*, Bjørnøen A/S. 1919.
Avdalen.
Avtjørna.
Beinneset.
Benda.
Bergmesterporten. *Borgmästareporten*, Kjellström & Hamberg 1899.
Bertrandputtane.
Besstjørnene.
Bjørnøya. *T'veere Eylandt*, Barents 1598.
Bjørnøy Radio.
Blautmyrvatna.
Blyhatten.
Blyvika. Svalbard Chart S. 1. 1932.
Blåsen.
Bogevika.
Bollevatnet.
Borgmesterporten. *Borgmästareporten*, Dunér & Nordenskiöld (1867), p. 16.
Brattåa.
Breisiget.
Breiskallen.
Brettingsdalen.
Brødrevatna.
Bråtentjørna.
Bugetjørn.
Båtvika.
Daudmannsvatnet.
Dipilen.
Djupvatnet.
Drangane.
Driplane.
Efuglvika.
Einangen.
Ellahytta.
Ellasjøen. *Ellas sjø*, Kjellström & Hamberg 1899.
Emmaholmane. *Emmas Öar*, Kjellström & Hamberg 1899.
Engelskelva. *Engelsk-Elven*, Keilhau (1831), p. 124.
Engelske Staur. *Engelsk-Stæren*, Keilhau (1831), p. 124.
Evensenbukta.
Evjebukta.
Fagervatna.
Fakstjørnene.
Fallvindsdalen.
Fauskevika.
Femtjørnene.
Flakmyrvatna.
Flaskeskjera.
Flisa. Svalbard Chart S. 1, 1932.
Flyvatna.
Fløyta.
Flåvatna.
Fossåa.
Framnes.
Fuglefjellet. *Fogelfjället*, Dunér & Nordenskiöld 1867.
Fugleodden.
Galdernebben.
Glitra.
Gluggdalen.

Gluggdalsvatna.
Glupen.
Grautauget.
Gravodden.
Grislevatna.
Grunnbukta. Svalbard Chart S. 1, 1932.
Grunningen.
Gruva.
Grytvika.
Grøa.
Grøntjørna.
Gråtedalen.
Gygrenova.
Gygreurda.
Gåsvatna.
Haabethvatnet.
Hamartjørna.
Hambergfjellet. *Hambergs Fjäll*, Kjellström & Hamberg 1899.
Hamnevika.
Handklædet.
Haugenneset.
Haugtjørnene.
Hausselva. *Hauss Fluss*, Kessler 1900.
Haussvatnet. *Hauss See*, Kessler 1900.
Havhestholmen.
Heimvegputtane.
Helin.
Hellevatnet.
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Hira.
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Holmevatnet.
Hornvika.
Hølputtane.
Håsteinen.
Ingebrigtsenøya.
Iversenbukta.
Jacobsenodden.
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Kalven.
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Kapp Dunér. *Kap Dunér*, Kjellström & Hamberg 1899.
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