

NAVIGATION OF THE AIRSHIP "NORGE" Spitzbergen,
North pole, Alaska , May 11 to 14, 1926.

" Of the navigation equipment which we carried we shall mention the following : Goery sun compass of the same type as used on the 1925 expedition. Outside pilot cabin close to the side rudder wheel were fixed on each side a bracket on which this compass was mounted in order to get no obstructions for the sun. The compass had to be shifted from one side to the other every two hours, a cold job for the navigator who had to hang for quite a time with half of his body out of the cabin.

On principle the sun compass can be described as follows : a picture of the sun is reflected through a periscope down on a glass plate before the rudder man. Connected to the periscope is a clock work which turns the periscope 360 degrees in the same time which the sun uses for the same apparent movements. When correctly set your bow is pointing in the same direction as long as the picture of the sun is kept on the said glass plate. Corrections must be made for declinations and also for the changes in the latitude as the axis of the periscope must be parallel to the axis of the earth. To this comes correction for the ship's drift on account of wind.

270 Of magnetic compasses we had one expensive steering compass and one aperiodic steering compass, both these of English type. Beside this we had one ball aeroplane compass of the German Ludolph type. Both types behaved well and it would be impossible to say which was best. We had the same combination on the 1925 expedition and found then that the safest was to have both types.

For measuring drift and speed we had the Goery instrument for this use, the speed being measured by a four points bearing on an object on the ice passing underneath the ship. As the distance passed over in the measured time is equal to the height of the ship above ground, this requires for exact measurement the correct altitude. Our altimeters were the ordinary aneroid barometers. As these are set after the barometric pressure on the place of departure they will show wrong when this pressure changes as the ship passes along. It would carry too long to hereto describe the different methods of checking the height for correcting altimeters. We carried instruments for this but they could not be used under the special circumstances in the Polar basin.

440 Ordinarily the speed also can be checked by the time the shadow of the ship, which length is known, takes to travel over a certain object on the ground. Neither this method could be used on our flight as the low height of the sun gave a shadow, being too far away from the ship to have sharp contours. However, we used this method, but that gave as it proved afterwards, too big speed for the reason that the shadow just because of unsharpness did not give the full length of the ship.

The speed got in this way corresponded very well with speeds found by the above mentioned instrument and were therefore relied upon. A midnight height of the of the sun gave us correct latitude not as high as expected.

The speed had been less possibly because the barometric pressure had changed and, alimeters thus giving false altitudes , and it can also be said, partly because measured speed always will be too high due to the reason that the rudder men, both at side rudder and ellva, during such observations, try to steer as straight as possible.

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Further we had a splendid German bubble sextant, three pocket chronometers which had been checked daily through a long period beforehand and were kept under the same and constant temperature conditions during the flight. Wireless time signals were also taken during this. Of almanacs we used Nautical almanac and Norwegian Fisherman's almanac, the latter giving Azimuths for high latitudes. Of charts were used Mercator projections up to 85 degrees north Spitzbergen side and 75 degrees North Alaska side, between there we used Gynomonic chart with American map on deviation curves in the Polar basin.

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For the layman(s better understanding of the following we should like to give a short description about one side of the astronomic navigation with respect to the special navigation conditions in the Polar basin. By taking one observation only of the sun, moon, planets and stars, one doesn't get one's exact position in a certain spot. Such an observation tells you only that you stand somewhere on a line, the so-called position line. This line which is perpendicular upon direction of the sun, the Azimuth can be drawn into the chart. To get your exact position it is necessary to get a second position line which crosses your first line at quite a big angle to get a sharp crossing. That is, you must either at the same time take an observation of a second Astral body being far to the side of the first one, or you can if you have only the sun, wait until the direction to this is altered. Had you been standing still and not moved between the observations it is very easy, but if you have been moving between the observations, another calculation comes in. You must then, as is done in maritime navigation, transport or move the first position line parallel to itself in the direction you have moved and with the distance with which you have moved between observations. When you draw also your second position line, the crossing of both these is your exact position at the time of the second observation.

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For air navigation this method will not be correct, taking into consideration the great distance you have moved between observations, as the speed of aircraft is so much bigger, and as will be understood from the above, the exact speed cannot be found in the Polar regions. If you, in addition to this get fog for a considerable time which gives no chance at all for even the finding of approximate speed, you do not know whether you have moved 100 or 200 miles between the observation, beside the indication of speed and direction of the wind with which the meteorologica maps may furnish you, when you have been fortunate to get such reports.

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In the Polar basin you have in the summer only the sun for your observations as the periods when also the moon can be used are very short and did not coincide with the time of our flight. The best thing is to use your navigation only on single observation, not trying to combine the two of them. What you want to know is your longitude and your latitude. If you take your observations at noon and midnight, time reckoned after your meridian, when the sun is due north or south you get a position running east and west and that gives you latitude.

If at the same time a bearing of the sun shows this to be due south or north according to your sun compass and magnetic compass, you know that your longitude is correct or whether you stand east or west of the supposed one.

1265 On the other hand you take observations of the sun when it is due east or west, that is six o'clock a. m. and p. m. and you get a position line running south north giving you your latitude. Apart from this we checked our longitude on several occasions during the flight to the pole by radio bearings on the King's bay wireless station on the meridian of which we navigated.

Finally we want to draw attention, to one among laymen widely spread misunderstanding, namely, that the magnetic compass is completely out of action at the pole. That would have been the case if the magnetic pole had been lying on the geographic pole, but so, fortunately for navigation this is not the case. As will be known the magnetic pole is down on Boothia peninsula on the north coast of Canada. There is thus a certain magnetic force on the geographical pole although it is weak.

Going from Spitzbergen to the pole there is not a great change in the deviation, that is the difference between the magnetic north and true north. At the pole itself the deviation can be said to be everything between 0 and 360° as everything on true south is constant midday. If you should change course you must change so and so many degrees corresponding to the angle between the meridian on which you arrived at the pole and the meridian on which you will proceed.

1513 Going towards Point Barrow difficulties now arise if you must navigate after magnetic compasses alone, because the deviation changes rapidly. Between 89° north and 80° it changes 90°, that is 8' to 15' every hour.

* If your position is wrong you use a deviation with a big error attached to it which gives you shortly a still bigger error in position and so on. In that part of the distance one cannot be too careful enough. *

1715 As the ship passed out of King's bay the navigator set to work on the most interesting piece of work a navigator ever had, the crossing of the Polar basin from Spitsbergen to Alaska via the pole. If we should get clear weather with sunshine all the way it would be comparatively easy, but should the fog much fog occur we should be against quite a problem. We ought to mention here that according to our routine the navigator was quite Souverain (sic) of the whole question of bringing the ship to the destination, unless special meteorological conditions should make a capital change in the route necessary. Such a question should eventually be decided by upon by us and our second in command, who also was the navigator and the captain of the ship. Fortunately this question never arose. As explained in our first article the ship north of Spitzbergen was maneuvered into the meridian through King's bay wireless station after the compasses had been duly checked through bearings.

Approaching the ice edge the wind in our low altitude was blowing out from from ice to the sea reducing our speed to 72 kilometers per hour. Towards 11.56 a.m. all times Greenwich Mean Time, the drift increased to 30' to the port. The altitude was increased from 600 feet to 1600 when we found 14' drift to the same side and an increased speed of 86 kilometers .

Speed and drift operations were taken constantly. If the sun compass amounted to more than 4 degrees the setting of this was altered. For smaller angles than he said the rudderman was only ordered to keep this picture of the sun a corresponding number of degrees out to the side of the center of the glass

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plate the field of this being 5' to either side of the senter. At 1.10 p. m., we got a wireless bearing showing that we stood 6 nautical miles to the east of our meridian. The steering up against the easterly wind was slackened 2' so that we should gradually get back again.

At 5.35 P. M. we got an observation of the sun which said that we now were back on the meridian again. Our latitude was then very close to 85 north. Being that the case, we could use a very simple method for the calculation of the observations of the sun which can be used north of 85. There is namely so little between the Azimuth and hour angle so that all observations can be calculated as midday to midnight observation. That is, the time has got to be taken and the position line drawn perpendicular on the sun's meridian in a distance from the pole equal to the distance of the measured height of the sun and its declination at the moment. With the sun close to the east or west it will be some small error down toward 85 but it is easy to see which way it will work and to take into consideration.

Further wireless bearing in the evening proved that we were sticking to our meridian. These could specially now be relied on as we were so far away from the station that a small error in angle would have given quite and great deflection. Also wireless bearings of Stavanger radio corresponded very good.

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At 9.53 p.m. we took an observation of the sun. According to the position of the sun it could not have given us correct latitude unless our longitude was correct. But that being the case it proved that we were not as far north as expected. As mentioned above we found that the speed at 9 p. m. , we had not been at 87' 40 as anticipated but close to 87', that is 40 nautical miles further south. A little disappointing but what could be expected? At this time we had a bit of breeze reducing our speed to 60 but it soon started to increase again. At 10.30 p. m. we met fog and passed over it at an altitude of 3,300 feet. When we got up to this height the drift was found to be nothing according to observations taken just before we left the ice behind us.

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As there was no drift we should now be heading due north and the last minute before 1 o'clock King's bay meridian time were rather exciting as we at that moment should have seen the sun right ahead. To our great satisfaction that was also the case. Our latitude according to an observation of the sun was (88 $\frac{1}{2}$ ' 30). Through openings in the fog and later on when the fog in the vicinity of the pole cleared away we could ascertain that there still was no drift.

This was also a great satisfaction as we knew that we were heading directly for the pole, it was only left to find out when we were there.

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According to our speed with a certain reduction taken in consideration we should be at the pole about 1. 30 A. M., May 12. The sun would at that moment still have a position giving a good crossing between a position line and our meridian. The height that the sun should have at the pole at 1. 30, namely its declination at that moment was set on the sextant, the corrections taken into consideration. At 1. 10 a. m. the navigator lay down on his knees starting his observations through the windows. The sun rose quite slowly, partly because of the declination, and partly because we sailed against it. The sun started to cover up the bubble, that is having the height it should have at that moment.

2546 The speed was slowed down and the ship brought to a low altitude. After the flags had been dropped, a circle was made during which the setting of the sun compass was corrected for a change of course 12' to the left. Full speed was given and the sun brought into the sun compass, the bow now pointing for Point Barrow. At the same moment we had passed the pole our time should be reckoned after Point Barrow time. We had to put the watch 11 hours back. It was not any longer 2.30 p. m. the 12th of May, Norwegian time, but 3.30. p.m. on the 11th of May. * That is we had to repeat 11 hours which we had just lived, but got two evenings in succession with no day between and Ellsworth who had just had two hours of his birthday and had been congratulated, had to wait some hours and then start afresh upon the new 24 hours. This had never happened to any one before.*

At 4.20 p. m. a longitude observation indicated that we were a little west of Point Barrow meridian. As we now were not steering for a geometrical point the North Pole any longer, but for a big part of the continent, Point Barrow not being our destination if we could reach farther south, we did not take the trouble to get the ship back to that meridian. We just carried on, steering after the sun compass which would take us along a line parallel to the said meridian.

Until now we had no drift and the speed observations showed a little breeze just astern which had been anticipated by our meteorologist. Up to 7 o'clock we had varying drift angles to the part which slackened down towards 8 o'clock.

2728 The navigator could now sit down for a short hour's rest, which together with half an hour in Bering strait were all he had during 70 hours of constant navigation. A latitude observation at 8.45 a. m. 12/5 indicated a latitude close to 84° 30" showing that speed measured now were very great. We were now over fog and kept a constant lookout for openings which would allow drift observations. It was very fortunate that there were no high clouds above us during this passage towards south with that very rapid change in magnetic deviation. But later on we should have to meet this problem too and had to keep the course after the magnetic compasses. As a chain in the side rudder wire, quite close to steering compass was strongly magnetic with varying influence as the rudder was used to the left or right, this compass for a longer part of this trip was not at all reliable, being after awhile quite useless. The course had therefore to be checked continuously on the standard compasses, keeping the navigator very busy between other observations.

2921 As has been told in another part of our article, later on when the ship commenced to ice down, ice also settled on the sun compass which in a short time turned to an ice block of the most fantastic shape. It is needless to say that the clock work stopped, putting the compass out of action for the rest of the flight.

3030 As the above mentioned simple method for the calculation of sun observation now were not sufficiently correct any longer, all the following observations were calculated over after the St. Hillaire method. In order to discover eventual errors these calculations were checked by Grottwaldt or Horgen.

At 4.24 p. m. a longitude observation proved that we had drifted a little to the east and were now very close to the Pt. Barrow meridian. 8.20 p. m. gave us the last latitude observatin before Pt. Barrow 76° 45". In the thick fog we later got into it was difficult to keep good steering and with frequent slowing down of the speed for long periods, giving a greater drift to the west it was impossible to check the course with any exactness. It was therefore a surprise to find by an observation at 4 a. m. May 13, that we were in a nearly north south position line.

3209 * It was nearly 12 hours since last longitude observation. The error in the estimation of the drift angle thus amounting to not much more than $1\frac{1}{2}$ miles per hour. Our meteorological chart had been of great assistance, the chances for drift observations being very scarce in the fog.*

253 As we knew that we could proceed down Bering strait it was not any longer necessary to make course for Point Barrow. We therefore steered along the last last mentioned position line which struck the coast well enough to windward that we could be certain enough of not drifting off into Berin Sea.

After the supposed minimum speed and maximum speed since last latitude observation it was announce that we would be in sight of land not before 6 a. m. and not later than 8 a. m. , our speed being not much more than 60 kilometers.

447 At 6.45 a. m. land was sighted ahead an on the port bow by the navigator who had watched for four minutes before he told about it, in order to be quite sure and not disappoint anybody. The course wa altered eastward to come under land as sson as possible in order to make certain where we were. At 7.25 we were over the coast, but snow covered as it was and very flat, it was impossible to make out its contours for comparison with he maps, the visibility being not of the best. The country to the east looked like the vicinity of Point Barrow.

As we had nothing to do in that direction we turned along the coast and toward south west.

At 8.45 we passed over and recognized Wainwright. After the distance sailed out we had been pretty close to Point Barrow when we struck the coast. Later we heard that we were actually sighted from that place. Although navigation across the polar basin was finished with , it may be interest to describe shortly the navigation further on as it arose problems not by any means easier than they which had been surmounted.

3625 Passing along the coast the fog became denser and denser obliging us to go lower and lower in order to be able to see far enough ahead not to run against obstacles. At last abreast of Cape Beaufort it was impossible to proceed any longer and we went up through fog and clouds to bright sunshine. Later on we could see through the openings in the clouds that we had drifted eastwards and were over land. We went down through the opening and tried to proceed southwest to get to the sea again. Thick layers of fog drifted underneath us and only now and then a piece of bare rock was seen, but far too little to enable us to make our our whereabouts. Heavy black clouds swept round the mountain ~~tepe~~ peaks forcing us again to rise above the fog into sunshine. We believed that we were so far south that we couldn't proceed any longer.

3777 We had to try to get down underneath the fog and so do the best to find our way. To go directly down when we did not know our exact position would be very dangerous. A hard gale was blowing and high mountains hidden in the clouds. As the sun now approached a favorable position for a position line pointing north - south out the Bering strait, the ship was maneuvered by sun observations until we got such a line. The course was set along this line which pointed clear of all land and the ship headed into the wind so that she could approach the ice or water or whatever it may be with as slow speed as possible.

We then pointed the nose down and came out over the ice in an altitude of some 300 feet. at the moment Galtwald got a bearing of a station which he, on account of the strong signals meant might be Nome, but he could not say for certain, as he just had picked it up when he was in communication with some other station, without learning its signature. This gave us a position north of the Diomedede islands. But as we were not certain of which station it was, we could not rely upon it. But however set a course from this position for Cape Prince of Wales. Very soon we go out over open water which aroused our suspicion as we did not believe there so early would be open water so high up the strait.

We might just as well be on the south side of the strait and with that course of ours heading for the Aleutian islands. The visibility was very bad. If we did not keep the ship, so to say, dangerously low down, we could not see at all.

4305 The ice crust commenced to jamb again and Nobile announced that the shp had to be brought as quick as possible to the nearest land which ever it was. The ship was consequently headed into the wind making course good east. It lasted very long before we sighted land and when we came over it it was impossible, under the present conditions as to visibility to make out whether we were north of Kotzebue Bay or over the east shore of Norton Sound. There was nothing else to do but to go up above clouds and get a latitude observation, the sun being now nearly south. We got up to sunshine and had to take the observation from the top of the ship as the sun on this latitude was so high that it was hidden by the envelope in which ever direction the ship pointed. The observation gave latitude 67° 30', we were north of Kotzebue Bay. We went down again through the clouds and founf ourselves over land. Passed over the whole of Kotzebue Bay driven by a northern gale of more than 70 miles per hour, in that high altitude.

Heading west to get to the sea again, Gottwald now heard some wireless station giving its signature and he took bearings of it. These bearings, together with the immensely many bends on the serpentine river making it answer properly to its name, gave us means to get our exact position. Shortly after we sailed out over Schischmareff Inlet. We now clung to the beach in such an altitude on account of the visibility, that the antenna which preciously had bumped on the ground, had to be taken in.

At 3.30 a. m. May 14 we rounded Capr Prince of Wales and the navigator was relieved of his duties, having work to do in connection with the coming landing.

Nome, June 10, 1926.

Riizer Larsen

Second in command and navigator of the expedition.

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