Appendix B

NORTH POLE NAVIGATIONAL REPORT, 1926

REPORT OF SPECIAL COMMITTEE APPOINTED BY THE BOARD OF TRUSTEES OF THE NATIONAL GEOGRAPHIC SOCIETY TO EXAMINE THE RECORDS OF COMMANDER BYRD's FLIGHT TO THE NORTH POLE, MAY 9, 1926

The Committee has examined the original records of Commander Byrd and found them to have been carefully and accurately kept. In the opinion of the Committee, these records substantiate in every particular the claim of Commander Byrd that on May 9, 1926, he reached the North Pole by airplane, thus being the first person to reach the North Pole by aerial navigation.

The Committee has had expert assistance in the examination of the records from Mr. Hugh G. Mitchell, Senior Mathematician of the U. S. Coast and Geodetic Survey, Mr. Henry G. Avers, Chief Mathematician of Geodesy of the Coast and Geodetic Survey, and Mr. Albert H. Bumstead, Chief Cartographer of the National Geographic Society. These experienced calculators have verified all of Commander Byrd's computations, devoting five consecutive days to the work; they have also critically examined the sextant used by Commander Byrd.

Their examination began at 10 a. m. on June 23 and was completed at 5 p. m. on June 28. The results of their examination are attached to this report.

Gilbert Grosvenor
Frederick V. Coville
Chester Jones

June 28, 1926

Dr. Gilbert Grosvenor, Dr. Frederick V. Coville, Colonel F. Lester Jones,
National Geographic Society,
Washington, D.C.

Dear Sirs:

We have the honor of submitting the following report of our examination of Lieutenant Commander Richard Evelyn Byrd's "Navigation Report of Flight to Pole". We have carefully examined Commander Byrd's original records of his observations en route to and from the North Pole. These records are contained on two charts on which Commander Byrd wrote his observations, made his calculations, and plotted his positions. We have verified all his computations. We have also made a satisfactory examination of the sextant and sun compass used by Commander Byrd.

The plane left Kings Bay, Spitzbergen, at 00 hour 37 minutes Greenwich Civil Time 9 May, 1926, passed the north end of Amsterdam Island at 1 hour 22 minutes G.C.T. headed north following closely the 11° 04' meridian of east longitude.

The dead reckoning position of the plane is given for hourly intervals, after leaving Amsterdam Island, and also at the times sextant observations were made. Ten sextant observations to determine the altitude of the sun were made, six at various intervals between Amsterdam Island and the Pole, and four while the plane was flying at the Pole. The accompanying chart shows the route and the positions when observations were taken.

Under the conditions of flying it is manifestly impossible to make more than one astronomical observation from any one point. A single astronomical observation does not give a location but only a line passing through the position of the observer. Such lines are called "Sumner Lines". If the latitude or longitude of the point of observation is known or its direction or distance from some known point, the position on a Sumner line may be determined.

In the present case we have both the direction and the estimated distance

from Amsterdam Island to give the position on the Sumner lines resulting from the sextant observations of the altitude of the sun.

The resulting positions obtained by using the direction may differ from those obtained by using the estimated distance. This is to be expected. The distances depend upon estimates of speed and estimates of speed depend upon the altitude of the plane obtained with an aneroid barometer. The barometer readings of altitude depend on the assumption that the sea level atmospheric pressure remains constant over the whole route of the flight, something which in ordinary latitudes rarely happens between points so widely separated. We do not know if these conditions are better in the polar regions. It is our belief, therefore, that estimates of speed may be subject to large errors. But the direction of flight from Amsterdam Island could be known with a comparatively high degree of precision as it depended only on the skillful use of two optical instruments, the drift indicator and the sun-compass, both capable of giving the direction within one degree. When these instruments were used almost continuously, as they were, it seems probable that the route flown followed closely the route planned, the deviations to the right tending to balance the deviations to the left.

Attention is called to the fact that the Sumner line determined at 4 hours 56 minutes, coinciding so nearly in direction with the direction of flight, gives a splendid determination of longitude and check on his steering at a point about midway of the flight; just as the one determined at the Pole and intersecting the course at an angle of about 56 degrees gives a good condition for the determination of latitude. The amount which the plane may be actually off the Sumner line is not affected by inaccuracies of steering, such as

enter into the holding the compass course, or determining and correcting for drift, but are wholly due to errors in the observed elevation of the sun. These elevations were determined with a sextant, in which the bubble supplies the horizon of reference, an instrument developed by Commander Byrd and in the use of which he was most skillful. An estimate of the error attending such an observation may be obtained by fitting the dead reckoning to the Sumner lines and by a consideration of the capacity of the sextant. From this evidence, it is believed that five miles, plus or minus, represents a reasonable estimate of the limits of this error, which is not accumulative, but is the same for all Sumner lines thus determined.

It may be noted also that in comparing positions determined at 8 hours 18 minutes, 8 hours 38 minutes and 8 hours 59 minutes, it becomes necessary to assume errors of only two minutes in the observed altitudes to bring them into full accord with the average speed between the determined positions. This would indicate that 5 minutes is a very reasonable limit to assign to the uncertainty of an observed altitude.

At 8 hours 58 minutes 55 seconds an observation of the altitude of the sun gave a latitude of 89°55.5' on the meridian of flight. This point is 4.7 miles from the pole. Continuing his flight on the same course and at the speed of 74 miles per hour, which he had averaged since 8 hours 18 minutes, would bring Commander Byrd close to the pole in 5 minutes 49 seconds, making the probable time of his arrival at the Pole 9 hours 3 minutes Greenwich Civil Time.

At the time Commander Byrd was close to the pole he estimated the moment of his arrival there at 9 hours 2 minutes. Our calculations differ from his estimate less than one minute during which time he would have flown about

one mile. From this it appears that he chose the right place to maneuver.

Flying his plane to the right long enough to take two sextant observations he turned around and took two more observations. These four observations confirmed his dead reckoning position of the Pole. He then attempted to fly his plane in a circle several miles in diameter with his pole position as a center.

Flying at and about the Pole at an altitude of 3,000 feet Commander Byrd's field of view was a circle more than 120 miles in diameter. The exact point of the North Pole was close to the center of this circle and in his near foreground and during more than two hours of his flight was within his ken.

Soon after leaving the Pole the sextant which Commander Byrd was using slid off the chart table breaking the horizon glass. This made it necessary to navigate the return trip wholly by dead reckoning. In accomplishing this two incidents should be specially noted. At the moment when the sun would be crossing the 15th meridian, along which he had laid his course, he had the plane steadied pointing directly toward the sun and observed at the same instant that the shadow on the sun-compass was down the middle of the hand, thus verifying his position as being on that meridian. This had an even more satisfactory verification when at about 14 hours 30 minutes G. C. T. he sighted land dead ahead and soon identified Grey Point (Grey Hook), Spitzbergen, just west of the 15th meridian.

It is unfortunate that no sextant observations could be made on the return trip. But the successful landfall at Grey Hook demonstrates Commander Byrd's skill in navigating along a predetermined course, and in our opinion, is one of the strongest evidences that he was equally successful in his flight northward.

The feat of flying a plane 600 miles from land and returning directly to the point aimed for is a remarkable exhibition of skillful navigation and

shows beyond a reasonable doubt that he knew where he was at all times during the flight.

It is the opinion of your committee that at very close to 9 hours, 3 minutes, Greenwich Civil Time, 9 May, 1926, Lieutenant Commander Richard Evelyn Byrd was at the North Pole, insofar as an observer in an airplane, using the most accurate instruments and methods available for determining his position, could ascertain.

Respectfully submitted,

Hugh Mitchell
Albert H. Bumstead
Henry G. Ayers

BYRD ARCTIC EXPEDITION

S. S. CHANTIER

CONFIDENTIAL:

New York, N. Y.,

June 22, 1926

From: Lt. Comdr. R. E. Byrd, U. S. N., ret.

To: Secretary Navy.

Subject: Transmittal of navigation report of flight to the North Pole for the study of the National Geagraphic Society.

Enclosure: Navigation report of flight to the Pole.

1. It is requested that the above mentioned report be transmitted as soon as practicable to the National Geographic Society in order that a study may be made of the navigation done on the flight to the North Pole by Byrd and Bennett May 9.

R E Byrd

- -R. E. BYRD- - -

THE SECRETARY OF THE NAVY.
WASHINGTON.

June 23, 1926.

My dear Dr. Grosvenor:

It is with great pleasure and satisfaction that the Navy Department transmits herewith the report of Lieut. Comdr. Richard E. Byrd, U.S.N., Retired, incident to his recent expedition by airplane to the North Pole.

Very truly yours,

Dr. Gilbert Grosvenor, President,
National Geographic Society,
Sixteenth Street at M, N.W.,
Washington, D. C.

(encl) P/Si

Navigation - Instruments and Methods Used.

1. Sextant. We used the artificial horizon bubble sextant in general use in naval aviation. This particular sextant was the one developed by myself for and used by the N. C. Boats on the first transatlantic flight. I also took it to England with me to use to help navigate the ill fated ZR2 back to the United States. I had it with me last year in the Arctic for our flight from Etah. In short I have had it with me for seven years and am very familiar with it and know it to be dependable instrument. I had adjusted it so that it had no error when using the bubble. The instrument has a barrel vernier so that it can be easily and quickly read. The bubble glass has three lines on it so that the sun can be more readily bisected by the middle line. There is therefore no semi diameter to apply. There is a saving of time in not having to apply semi diameter or error.

2. Drift indicator. The instrument we used was a drift angle meter made by the Pioneer Instrument Co., and in general use in the navy. It is a modification of the instrument developed by me from the Crocco instrument for the first transatlantic flight. This instrument is accurate to within a degree and on our polar flight we could get our drift almost exactly. We had a hole cut in the floor of the cabin with three base plates for the indicator so that I could get the drift looking forward or aft. This turned out to be a very excellent arrangement. We had smoke bombs for drift but didn't need them. A stop watch and tables were used for getting the spped over the ground.

3. Chronometers. Used two torpedo boat chronometers which were the best of four. I had been getting their rate for many days and was certain of the time. One chronometer was 9 seconds fast and the other 21 seconds fast and with only a small fraction of a second rate per day.

4. Compasses. For navigating used two sun compasses, one attached to top of a trap door on top of the fuselage and the other movable so that it could be used at the windows of the cabin, where I had fore and aft lines drawn. The navigating magnetic compass was a large one with a six inch card, mounted on the after bulkhead halfway between the ceiling and the floor. In that position it had no deviation, which is important in the Arctic for the deviation sometimes is very large and extremely difficult to compensate for. The pilot had a periodic and an earth inductionscompass.

5. Short method astronomical navigation. Used Saint Hilaire with North Pole as assumed position and picked altitude out of nautical almanac taking advantage of the fact that for any given instant the altitude of the sun at the pole

is equal to the declination. This is a very quick and rather accurate method. When the line of position is long the curvature of the circle of equal altitude must be taken into consideration. When the declination and courtion of time are taken down before the sight, the actual calculations can be made on the line drawn graphically in two minutes. The p and r can be put down ahead of time when the altitude is known approximately. In connection with this graphical solution we used H. O. Publication No.2560. This chart has a cricle around the pole in degrees and minutes marked from the Greenwich. We marked the chart in hours so that the meridian of the true sun could be drawn instantly without changing the time to degrees of arc. We made our chart board amply large for this practice.

6. Our navigating cabin contains four windows and is large enough to navigate in comfort, being about six feet wide and twelve feet long. The drift and altitude could b e taken without exposing the operator to the cold wind stream.

SECTION II

NAVIGATION-REPORT OF FLIGHT

7. Left King's Bay, Spitzbergen for North Pole at 00.37 Greenwich Civil Time May 9, in the Josephine Ford with about twenty one hours gasoline aboard. The weather was clear, barometer steady and temperature on the ground 14 degrees Fahrenheit. Bennett was at the wheel and Byrd navigating.

8. In approaching Danes Island bits of floating ice were seen below. Altitudeabout 2000 feet, a light breeze from the east. As we proceeded north the floating pieces of ice got more numerous.

9. Passed north end Amsterdam Island at 01.22 G.C.T. Altitude 2000 feet. Soon after leaving land we reached the edge of the Polar ice pack. The floes were not broken up to anything like the degree expected, and in several places the solid ice extended to the water's edge. Neither was it thought that the ice pack would end so near Spitzbergen.

10. Western edge of Amsterdam Island and high peak on Hoel Peninsula made excellent true north and south range. Lined the plane up very carefully on this range and checked sun compass and magnetic compass. The sun compass showed true north and the magnetic compass 11 degrees westerly variation. This was easily and quickly read since the compass had no deviation. Noted that the big compass was fairly steady when the plane was steady on a straight course.

11. It will be noted that the latitude of the northernmost point of Amsterdam Island is not correct when taken from the Hydrographic Office Polar Chart No. 2560. The correct latitude taken from a Norwegian and British chart is 79 degrees 48 minutes.

12. Wind continued from East but did not retard speed of plane which was making 77 nautical miles per hour over the ice. It was found that object could be found on the snow below to sight on as readily as over the land. Freshly frozen over leads, hummocks, pressure ridges, etc. On the transatlantic flight of the N. C. Boats we had been able to get the drift to within a degree on white caps below. Conditions on the Polar Sea were far better for sighting. I found that I could get the drift almost exactly and going north (when not piloting) I never let three minutes go by without getting the speed and drift. I felt entirely confident that, not considering the personal steering error, as long as we had the sun we could make good an almost exact course, and even a more exact course than a ship in a current for the drift can be obtained from instant to instant in a plane but a ship

cannot get its leeway in an ocean current except by astronomical observation. Then there is the error the surface ship has from swinging of the compass and some sluggishness. In an aeroplane that swinging is accentuated, but in the polar regions there is a far greater tendency for the magnetic compass to swing and the sluggishness is greater and it takes excellent steering to settle it down; and the course steered by it (even with the deviation and variation accurately known) may be in the general direction of the objective but it will not be an exactly straight one. The sun compass however swings only when the course is changed and the shadows on the pin, of course, responds instantly.

13. I checked Bennett on his course every few minutes with the sun compass and if I found him even slightly off his course I brought him back on it. Of course there is a tendency for steering errors to even up in the end but we did not want to take the chance of it not doing so. It was fortunate that we had two sun compasses for at times the shadow from the wings made the sun compass on the trap door useless.

14. There was another great aid to navigation. The re was not a "bump" in the air over the Polar Pack. The air was smooth and the plane gave a steady platform.

15. At 2^h-22^m G.C.T. an hour north of Amsterdam Island our dead reckoning position was lat. 81°-05' North long. 11°-04' East. We could still see the land clearly and as I had been able to check on our range for a long distance we were sure of this dead reckoning position. Our speed for this hour had been 77 miles per hour. I will use only sea miles in this paper.

16. I navigated during the next hour with all the care I was capable of. Bennett showed a tendency to keep toomuch to the right and I had to keep constantly after him but he soon settled down and steered with astonishing accuracy.

17. At the end of the second hour from Amsterdam Island, 3^h-22^m G.C.T. our dead reckoning position was lat. 82°-22.5' North long. 11°-04' East, average speed for hour 77.5 m.p.h.

18. The figures that follow in this paper were taken from my working chart but the descriptive letters preceeding the figures were largely left out on the chart to save time. I want to call attention to the fact that the length of some of the degrees of latitude marked on the chart are inaccurate. This has a bearing on graphical solution of position.

At $3^h-56^m-24^s$ Greenwich Civil Time took sextant observation. Sun 14° ½57'-07". The sextant had no error. Took altitude sun's centre. Therefore had no semidiameter to apply. Used North Pole as assumed position and worked out graphically by Saint Hilaire method.

G.C.T.	= $3^h-56^m-24^s$	Sext Alt.	=	14°-53'-08"
Eqt.	= 3 -36.6	p & r	=	(+)33-28
G.A.C.T.	= $4^h-00^m-00.6^s$	True Alt.	=	15°-53'-41"
		Dec.	=	17 -08'-12"
		Alt.Diff.	=	2'-14'-31"

True altitude is less than computed altitude therefore 2'-14'-31" is laid off from the pole away from the direction of the sun on the bearing of the sun at the instant of sight, which was easily located by the G.A.C.T. 4^h-00^m 00.6^s. The line of position was drawn at right angles to the end of the intercept.

The dead reckoning position at time of sight $3^h-56^m-24^s$ G. C.T. was long 11°-04' East, lat. 83°-10' North.

The line of position in this case was long enough to require applying the curvature of the circle of equal altitudes. This was done and the line crossed our line of flight a few miles ahead of the dead reckoning position. Of course I could not get a fix with the one line, but I knew that Bennett had steered three or four miles to the right off his course so I assumed that our true position was to the right and ahead of our dead reckoning position so I corrected for this roughly for I expected to get a true position by crossing the first line with a second one.

19. The average speed for the hour from 3^h-22^m G.C.T. to 4^h-22^m G.C.T. was 82.5 m.p.h. We were losing some altitude dueing this hour which increased our speed.

20. Our dead reckoning position at the end of the third hour from Amsterdam Island was 83°-45' lat. North long. 11°-04'East.

21. At $4^h-56^m-27^s$ took sextant altitude of sun. Atl. 16°-43'-20".

G.C.T.	= $4^h-56^m-27^s$	Sext Alt.	=	16°-43'-26"
Eqt	= (+) 3 -38	p & r	=	(-) 3 -02
G.A.C.T.	= $5^h-00^m-05^s$	True Alt.	=	16°-40'-24"
		Dec.		17 -08'-54
		Alt Diff	=	28'-30?

to be laid off away from sun since dec. or computed alt.

is greater than observed altitude.

Dead reckoning position lat. 84°-30' North; long. 11°-04'E. Curvature of line had to be applied. This fix put the true position of the plane about a mile or two to the left of the course.

22. During the hour ending 5^h-22^m G.C.T. made average speed of 78.5 m.p.h. Position 85°03.5' lat. North and long. 11°-04 East.

23. During the hour ending 6^h-22^m G.C.T. made average speed of 80.5 m.p.h. Position at 6^h-22^m G.C.T. by D. R. was lat. 86°-24' North long. 11°-04' East. Light wind from east.

24. At 7^h-07^m-10^s G.C.T. took altitude sun's centre 18°-18'-18".

G.C.T.	=	7^h-07^m-10^s	Sext Alt.	=	18°-18'-18"
Eqt	=	(+)3 -37	p & r	=	(-)2 -46
G.A.C.T.	=	7^h-10^m-47^s	True Alt.	=	18°-15'-32"
			Dec	=	17 -10 -18
			Alt. Diff	=	1°-5' -14"

to be laid off towards sun since computed altitude is less than observed.

Dead reckoning position at time of sight lat. 87°-25' long 11°-04'East.

This sight indicated that the plane was about five miles to the left and ahead of the course. Brought plane back on course during hour ending at 8^h-22^m G.C.T.

25. During hour ending at 7^h-22^m G.C.T. made an average speed of 81 m.p.h. Dead reckoning position lat. 87°-45' North long. 11°-04' East.

26. At 8^h-18^m-26^s took sextant altitude. Sun centre 17°-56'-31".

G.C.T.	=	8^h-18^m-26^s	Sext Alt.	=	17°-56'-31"
Eqt	=	(+)3 -38	p & r	=	(-) 2 -55
G.A.C.T.	=	8^h 22^m 04^s	True Alt.	=	17°-53'-36"
			Dec	=	17 -11'-06
			Alt Diff.	=	42'-30"

to be laid towards the sun.

Dead reckoning position at time of sight lat. 89°-01'-40", long. 11°-04' East. This altitude showed the plane on the course and very near the dead reckoning position.

27. The average speed during the hour ending at 8^h-22^m G.C.T. was 8l½ m.p.h. The position at 8^h-22^m was lat 89°-06.5' N. long 11°-04'E. The wind had shifted towards the north and was freshening.

28. At $8^h-38^m-25^s$ G. C.T. took sextant altitude, sun's centre 17°-37'-18"

G.C.T. =	$8^h-38^m-25^s$	Sext Alt.	= 17°-37'-18"
Eqt	(+)3-37	p & r	= (-) 3
G.A.C.T.=	$8^h-42^m-02^s$	True Alt.	= 17°-34'-18"
		Dec.	= 17 -11'-18
		Alt. Diff	= 23'-00"

to be laid towards the sun.

It is important to note that the length of the 89th degree on the meridian 15 degree East from Greenwich is notaccurately marked on the chart. This has a bearing when working graphically.

Dead reckoning position lat 89°-28'-35" long. 11°-04' East. This sight indicated alsothat the plane was still on the course and near the dead reckoning position and about thirty one and a half mile from the pole. The wind had gotten stronger and still shifting towards the north. The sun was shining brightly and the visibility was unusually good.

29. At $8^h-58^m-55^s$ G.C.T. took sextant altitude. Sun's centre 17°-18'-35".

G. C. T.	$8^h-58^m-55^s$	Sext Alt.	= 17°-18'-35"
Eqt	= (+) 3 -37	p & r	= (-)3
G.A.C.T.=	$9^h-02^m32^s$	True Alt.	= 17°-15'-35"
		Dec.	= 17 -11'-36"
		Alt. Diff	= 3'-59"

to be laid off towards sun.

Dead reckoning position lat. 89°-56' long. 11°-04'. This sight indicated that the plane was still on the course and a little over four miles from the pole. This sight andnd and the two preceeding sights had been taken with the utmost care and the platform was steady and by manoeuvring the plane the sight couldbe taken through the cabin window out of the wind stream. I found that I could sit down and bxxee myself for some of the sights.

30. Immediately after getting the altitude difference and line for the last sight we had according to my calculations reached the pole. That was at 9.02 G.C.T. We headed to the right and took two more sights and turned and took

two sights more. I took these very carefully and they averaged 17°-15'-14 and the altitude seemed to remain constant. Applying p & r of three we get true altitude 17°-12' 14". There were many reasons for believing that we had passed over the pole. We had kept on a straight course, checked our position from time to time with sextant observations and appeared to get some good fixes near the pole. But to make certain that we would not miss passing over the pole, when we completed our observations we followed for several miles the meridian 11°-04' we followed to the pole, circled as near as we could judge with the distance we had gone beyond the pole as a radius and left the pole for the return trip at 9.15 G. C. T. Temperature zero Fahrenheit. Altitude 3000 feet.

31. There was another splendid check on our position. Soon after leaving the pole when I took the wheel to relieve Bennett my sextant which I had inadvertantly left on the c hart board slid off to the floor breaking the horizon glass So it became essential to get back to Spitzbergen without a sextant and by dead reckoning alone. At eleven hours Greenwich Apparent Civil Time (one and three quarters hour after leaving the pole) when the sun would be crossing the meridian we were flying along 15 East. I got Bennett to head the plane as accurately as possible towards the sun. At the same time I checked the sun compass and found the shadow exactly bisected by the line on the hand of the clock. That proved we were exactly on our course-that we had steered a straight course from a known position.

32. The wind which had started freshening before we reached the pole was astern on the return trip and increased the speed considerably all the return flight. The average speeds for the first six hours of our return were 91, 89, 93.5,92.5,92 and 94.5 m.p.h. Of course the plane was much lighter than when we started and was getting lighter all the time.

33. The sun remained bright and visibility was splendid. Sighted land about 14.30 G.C.T. about the time we expected to find it, and found later that we were headed exactly for Grey Point, other evidences that we knew our position at all times. We headed towards Amsterdam Island long before reaching land and when we came to open water we found a strong wind blowing white caps beneath us.

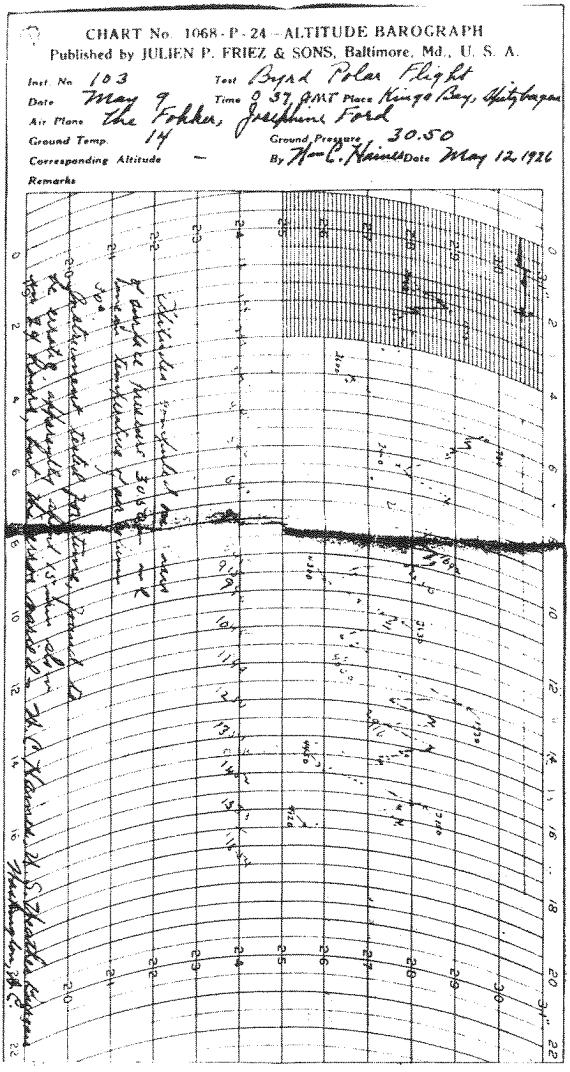
34. We reached King's Bay at 16 hour and 34 four minutes Greenwich Civil Time. Temperature

35. The sun was shining brightly when we arrived just as it had been for the whole trip.

36. We had explored 10,000 square miles of hitherto unseen regions. Visibility in the Arctic is unusually good

on clear days and we had been able to see a great distance. The ice pack was criscrossed all over with pressure ridges and there were many recently frozen over leads but few open leads where a landing could have been made in the water with pontoon as a boat. The chances of landing safely were far better with skiis and I believe we could have landed safely in a number of places.

Respectfully,
R E Byrd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