RECENT DEVELOPMENTS IN POLAR NAVIGATION

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When Admiral Byrd flew over the North Pole in 1926, polar navigation in the air was an uncertain process. Quite naturally, Byrd employed familiar lower-latitude methods with little modification.

During the 20 years following this first attainment of the pole by air there were few flights of aircraft into polar regions, as these were considered too hazardous for regular operations. But the dependable, long range aircraft developed during World War II ushered in a new era in aviation. The possibility of future military operations in these areas became apparent. The probability of routing commercial aircraft along great circles near the poles was discussed. Interest in various commercial activities in the arctic and antarctic increased. Weather stations were established in the far north to increase coverage and improve forecasts.

With increased activity in polar regions, better navigation became necessary. Tables for celestial navigation were extended to the pole and new ones were published. More sensitive magnetic compasses were developed and the astro-compass and directional gyro became available for use in regions where the magnetic field is weak or isogonic lines are uncertain. Charts became better and more numerous. Grid navigation was suggested to simplify the problem of maintaining direction where the meridians come together as spokes of a wheel.

But navigation was still drudgery. Two navigators were a minimum and they were kept very busy. When operational flights in the arctic became routine, time-saving techniques began to be developed.

TWILIGHT

The great fear of polar navigators has been that they might be caught in the long twilight which may last for several days, when neither sun nor stars are available. The reality of this danger is apparent when it is realized that in the polar regions celestial bodies are essential for determination of both position and direction. There are no permanent radio aids and the horizontal component of the earth's magnetic field is so weak over a large part of the polar regions that magnetic compasses are unreliable. One plane headed from the north pole to Alaska and crash-landed on Greenland when the directional gyro changed its wander radically during the long twilight.

Recent developments make it improbable that this incident will be repeated by a properly equipped aircraft with an adequately trained navigator.

First, a more accurate electric directional gyro was developed. The rate of wander of this instrument is generally not more than 4° per hour and is usually quite constant.

Second, the Pfund sky compass had made it possible to determine direction of the sun during twilight, by means of polarized light from the sky. Only four of these instruments have been made thus far, to permit testing and evaluation. One of these was sent to the Air Weather Service 375th Reconnaissance Squadron, V.L.R. (Wea.), operating regular polar flights from Eielson Air Force Base near Fairbanks, Alaska, where a mount for the instrument was devised, as shown in fig. 1, and technique for use of the instrument was developed. The results to date are promising, making this instrument one of the principal contributions to navigation during recent years. The sky compass, developed for the U. S. Navy by the Bureau of Standards, is based upon the work of the later Dr. A. H. Pfund of Johns Hopkins University, Commander T. D. Davies, U. S. N., first recognized the application to navigation of the principle discovered by Dr. Pfund.

Better directional gyros and the sky compass have gone far to solve the problem of determining direction during twilight. But conquest of the twilight bugaboo will not be complete until it is possible to accurately determine position during this period.

In the meantime, it is still wise to carefully plan each trip so as to avoid a lengthy crossing of the twilight zone. Such planning was often difficult when the almanac was the usual source of information. It has been made very simple by the recent development of a twilight computer. Several versions of this instrument have been suggested, the same idea apparently having occurred to various persons at about the same time. The only version known to be in actual use was developed by Lt. Nervik, navigator for the 375th Reconnaissance Squadron, V. R. L. (Wea.). As shown in fig. 2, this consists of a polar chart surrounded by a compass rose with 0° at the Greenwich meridian. An index is provided at the left. A piece of plastic material 6° of latitude wide (to the scale of this chart) and properly labelled as the horizon and twilight limit is constrained to move along a horizontal base, graduated in declination to the latitude scale of the chart. To use the instrument it is necessary only to set the horizon edge of the plastic to the sun's declination and rotate the chart until the sun's G.H.A. as shown on the compass rose is opposite the index. The part of the chart covered by the plastic strip is then twilight. Knowing the approximate travel time between various points along his route, the navigator can quickly and easily determine conditions at each part of his trip, or adjust the take-off time to obtain most favourable conditions.

DIRECTION

The principal problem in polar regions is still the determination of direction. This problem is not limited to the twilight period, discussed above. The usual method is by means of the directional gyro, checked frequently by an astro-compass. The process of using the astro-compass and keeping the gyro log formerly occupied much of the time of one navigator. Three recent developments have rendered this an almost incidental part of his work.

First, a plastic L. H. A. computer eliminates the frequent computation of local hour angle. Once the instrument is set up, the L. H. A. can be read by inspection to sufficient accuracy for use with the astro-compass.

Second, the addition of a grid scale to the astro-compass (fig. 3 and 4) makes it possible to read grid heading direct, thus eliminating one arithmetical step—and reducing by one the sources of possible error. Credit for this simple but valuable modification belongs to Lieut. David W. Anderson, U.S.A.F., of the 375th Reconnaisasnce Squadron, V.R.L. (Wea.), Eielson A.F.B., Alaska.

Third, the substitution of a simple graph (fig. 5) for the tedious directional gyro log reduces the paper work by perhaps 75 %. By maintaining a plot of the precession of each directional gyro and auto pilot, the navigator can determine at a glance the average rate over any period and when the rate is constant, he can predict the value for any reasonable time in the future. By this method more accurate dead reckoning can be maintained, and desired tracks can be followed more closely. Also, astro-compass checks can be made less frequently and at irregular intervals, as convenient.

The navigator is thus relieved of his most monotonous and exacting task. The substitution of a graph for the gyro log was suggested by F/Lt. Banks, R.A.F., while visiting the 375th Reconnaissance Squadron, V.L.R. (Wea.) and was developed by the latter organization to its present high state of usefulness.

CELESTIAL

Celestial navigation is little changed, but solution in polar regions has been simplified somewhat by several recent developments. The standard method of solution is by H. O. 218 to latitude 70° and by H.O. 230 between this latitude and the pole. The latter is similar to H. O. 218, but incorporates certain improvements. H. O. 249 is sometimes used in polar regions when stars are available, and Weems' Star Altitude Curves have been used advantageously by a few navigators.

During daylight flights the sun is usually the only body available. It is then customary to obtain a line of position once each hour. Three observations are customarily made at four-minute intervals, the lines adjusted to a common time, and the average used. By using this interval the navigator makes one complete solution and uses it for all three observations, plotting them from assumed longitudes differing by 1°. The altitude is precomputed so that an average line of position is available very soon after the last sight. The solution is shortened by the use of an exact almanac tabulated time (usually the hour or half hour) for the middle of the second sight, and by the use of a second-setting watch set to G.C.T. Greenwich Civil Time is customarily used for all navigation in polar regions. Careful dead reckoning and hourly sun observations are sufficient for reasonably accurate navigation.

The method of obtaining good dead reckoning positions has already been discussed. Two additional points are worthy of mention. Drift and ground speed are usually obtained by means of a gyro stabilized drift meter with provision for measuring trail angle, or by radar tracking of some distinctive feature on the surface. The Bellamy method is also available for obtaining drift and under usual conditions provides an accurate average result over water or sea ice. Ground speeds can often be determined by celestial observations. A single body is adequate if it is nearly dead ahead or dead astern. More accurate dead reckoning and better planning in the arctic are made possible by better weather coverage of this area. This is provided by the weather stations recently established there and by the U.S.A.F. flights to the north pole by aircraft assigned to Reconnaissance Units of the Air Weather Service, M.A.T.S.

CHARTS

Charts of polar regions are still inadequate, particularly for marine navigation. They will remain thus until accurate hydrographic and magnetic surveys of these regions have been made. However, present charts are entirely satisfactory for celestial navigation.

Since many polar flights originate in Alaska, the recent extension of the H.O. V 30-NP-2 chart to include this area makes it possible for a single chart to be used for the entire flight of numerous missions. The principal advantage in this instance is that grid navigation can be started whenever convenient, or it can be used for the entire flight if desired.

With the possible exception of the sky compass, which is hardly emerging from the development stage, improvements of the last few years, although not spectacular, are significant in scope. A number of small contributions have collectively reduced the polar navigator's work by almost 50%. As late as the summer of 1948 two navigators were considered indispensable on all polar flights, and three desirable. Less than a year later one navigator could handle all the requirements for an entirely safe flight. Two navigators are still carried on most weather flights because of the unusual demands on navigators due to the requirements incident to half-hourly weather observations, and the length of the flights. A single navigator is the busiest member of the crew and on long polar flights fatigue is considerable.

Polar navigation has come a long way during the last few years, but there is still no suggestion that the navigator is an unnecessary crew member on polar flights. Nor is there any feeling among polar aviators that celestial navigation has outlived its usefulness. With all the recent improvements, polar navigation still demands the best in the field. The cost of a mistake in this area is too great to rely on anything less.