"THERE'S NO BLACK MAGIC IN NAVIGATION THESE DAYS!"

HISTORY OF AIR NAVIGATION

by

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adjustment made in maintaining coincidence instead of a limited number of settings picked off mechanically at equal intervals of time; the gain in accuracy, however, is not very much. The next obvious step is to re-arrange the integrator so that at the end of the observation a single reading will give the average without restriction as to the duration of the observation and without any arithmetic. This has been solved, and such sextants are already in course of construction.

What will the future have to show? Up to the present, development has been along the lines of averaging large numbers of measurements made to a continually varying datum.

The alternative is to make a single measurement to an averaged datum.

This averaged datum can be provided by a gyroscopic vertical or gyroscopic horizon as it is usually presented, provided such instruments can be made to perform with sufficient accuracy, which is not yet the case; a satisfactory type of gyroscopic sextant may arrive in a few years' time or not for a long time, if ever, according to the state of progress in constructing accurate gyroscopes which will behave satisfactorily in aeroplanes.

Another factor affecting the design of the air sextant of the future is the pressurizing of the so-called stratosphere aeroplane. If the pressurizing is only extended to the passenger accommodation, it may not have any effect on the navigation and the sextant, but if extended to the crew's accommodation, then it will certainly have an influence on design and possibly will cause the sextant to change to a periscopic form in which the outer end is outside the aeroplane while the eyepiece is inside the pressurized space. Time will show.

POSITION-LINE COMPUTERS

The altitude measured by help of the sextant is useless until converted into a position-line, and the methods adopted at various times have necessarily been drawn from marine experience for the most part and modified to suit the conditions in which the navigator was compelled to work.

The marine navigator utilized tables for this purpose and so did the air navigator at first, but found them very inconvenient in a draughty, open cockpit; slide rules were suggested, the first, by Professor C. L. Poor, being a set of circles with a transparent disc and a radial line, the two latter being free to move separately

or together. The circles were divided to suit the cosine-haversine formulae and the complete slide rule was efficient as a slide rule but very bulky and heavy (weight 9 lb.); the next slide rule was very much simpler and involved only two scales of logarithmic cosines and tangents. These scales were spiralled round two coaxial cylinders and gave much greater accuracy, being of much greater effective length besides permitting the slide rule to be much smaller and lighter (weight under 2 lb.); this was the A.M.L. position-line slide rule of Captain Bygrave.

Nomograms, which give the solution by ruling straight lines on prepared diagrams, have also been used, but are not sufficiently accurate unless drawn inconveniently large; an example is the d'Ocagne nomogram.

Other graphical methods are the use of projections from any point on the instantaneous East-West axis of the earth to convert hour angle and declination into azimuth and altitude by a simple rotation of the grid through an angle equal to the co-latitude.

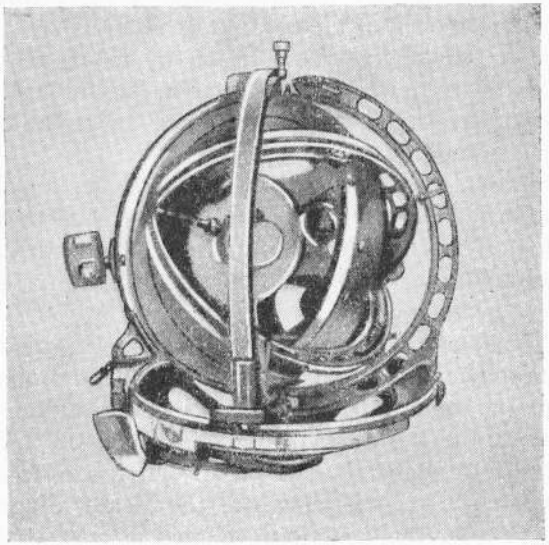
In one special case (when using a Mercator projection with the meridian of the observer as the equator of the projection) the rotation can be replaced by drawing a straight line, with the consequence that the projection can be drawn on a very large scale and cut into moderate sized pieces which can be used more or less conveniently; this is known as the Veater diagram, after Commander Veater, R.N., who developed it.

There is an alternative to having a very large projection, and that is to have a very small projection on glass or other rigid material and work on it by use of microscopes. The Bastien-Morin instrument did this, using an orthographic projection, but the gear is heavy and expensive and has not been adopted to any great extent. Other modifications have been made but the above are good illustrations of the type.

Mechanical models have been made to solve the problem mechanically, but they are all either bulky or heavy or both, besides being expensive. The best of these was the sphero-trigonometer of Nuschak, of Trieste, which was designed for marine use and was accurate to about a minute of arc (same accuracy as the Bygrave position-line slide rule). One of these was actually used on the Graf Zeppelin.

Still another method was found by Captain Baker, R.N., in England and Lieut.-Commander Weems in U.S.A., who both drew altitude curves against co-ordinates of latitude and hour

angle. Baker did this for the sun and various selected stars, while Weems only considered the case of stars. The Baker machine based on these lines was designed for a special purpose and is now an interesting item of history, but the Weems star curves are used to a quite large extent in U.S.A. They suffer from the disadvantage of the navigator being restricted to not more than three stars at any place and time.



SPHERO-TRIGONOMETER

The same system has been developed a stage further in this country by the Royal Air Force, in the form of the astrograph, in which the star curves are projected on to the navigator's chart. The same disadvantage applies and they seem to be falling out of use to some extent.

The greatly increased standard of comfort in aeroplanes (such as it is), due to the abolition of the cockpit and the use of totally enclosed aeroplanes, has removed the objections to the use of tables.

The Air Ministry has therefore produced new and very convenient tables, which are expected to be universally available at the conclusion of the war, which enable the required results to be obtained very quickly and with a minimum of labour.

The necessary data for the objects observed, required before using the calculators or tables, whichever may be adopted, were

given formerly in the Nautical Almanac and nowadays in the greatly simplified Air Almanac, in which part of the standard calculation has been done in advance. The advantage is so marked that many small vessels now use the Air Almanac in order to save time and labour; moreover, it seems extremely probable that the Nautical Almanac will be re-organized on the lines of the Air Almanac after the war.

Just as the air navigator in the early days borrowed from the marine navigator, so the marine navigator will in time adopt some of the improvements made by the air navigator.