to the sides of the triangle $A'B'C'$. The maximum displacement to be feared for P is equal to twice the greatest vector.

We must thus try to obtain for each of the points A, B, C an accuracy of sights proportional to the quantities al, bm, cn, or, which comes to the same thing, to a', b', c'

(d) Since the arc $A'B'$, as we have seen in (a), measures $2(\gamma + C)$, the angle formed by $B'A'$ with the diameter passing through B' will measure $\frac{\pi}{2} - (\gamma + C)$, and consequently :

$$c' = 2R\sin(\gamma + C).$$

The expression (1) for the vector PP' may thus be written :

$$PP' = \frac{2Rmn}{ac'}\varepsilon_b = \frac{2Rlmn}{abc}\,\frac{bc}{lc'}\varepsilon_b\,;$$

and as

$$\frac{c}{c'} = \frac{l}{m'},$$

we shall have :

$$PP' = \frac{2\,Rlmn}{abc}\,\frac{b}{m'}\varepsilon_b\,, \tag{3}$$

and similarly the other vectors :

$$\frac{2\,Rlmn}{abc}\,\frac{a}{l'}\varepsilon_a\,, \qquad \frac{2\,Rlmn}{abc}\,\frac{c}{n'}\varepsilon_c\,.$$

These expressions lend themselves more easily than formulae (2) to calculation by logarithms after measuring the lengths by a graphical construction. They show also that the vector corresponding to ε_a can be considered as proportional to $\frac{a}{l'}$ just as to al or a' : a result obtained also from the values of a' given in (a).

P. V.

LOXODROME, ORTHODROME, STEREODROME

by

PROFESSOR W. IMMLER.

(*Annalen der Hydrographie*, Heft VII, 15th July 1935, pp. 275-281).

Professor W. IMMLER shows that the use of Mercator's projection by seamen has been of value to them so long as they found it no disadvantage to follow the straight or "rhumb" line which in this projection joins their point of departure to their point of arrival. But nowadays fast ships and particularly aircraft wish to follow the shortest route, the arc of a great circle; the convenience experienced in following a rhumb line by steering a course on a constant azimuth is rather illusory since changes of variation impose changes of compass course which become more frequent as the speed increases. The stereographic projection, with its great simplicity and its meridians almost rectilinear near the centre, seems to him a suitable one with which to replace Mercator's projection to advantage in such cases, and he proposes the name of "stereodrome" for the straight line joining the points of departure and arrival on the former projection.

This straight line represents an arc of a small circle of the sphere, differing according to the central point adopted for the projection. But the same generally holds good with the other systems of projection. If, for example, one steers by keeping the bearing of a radio-beacon at a constant angle from the course, one describes a rhumb line of a

Mercator projection which had this radio-beacon as pole, and one would approach the radio-beacon without ever reaching it. This is what would happen also if the wind imposed an unknown but constant amount of leeway on an aeroplane steering for this radio-beacon. The rhumb line is only definite if it be specified that the Mercator projection has the axis of the earth as axis, which is the usual condition.

It is however necessary to ensure that the stereodrome differs only from the great circle course by quantities which may be legitimately neglected in practical navigation. If one adopts a stereographic projection containing the points of departure and arrival and having its central point about in the same latitudes, the difference between the great circle line k and the stereodrome s will be very small. As a first approximation we have :

$$s - k = \frac{k^3}{24} \cot^2 \rho,$$

ρ being the spherical radius of the small circle represented by the stereodrome. On this projection, the length k of the great circle track is easily mensurable; merely rotating it round the central point will bring the points of departure and arrival on to the same meridian. After this rotation, the difference of latitude of these points will give the value k, which practically does not differ from s.

We know, besides, that Mercator's projection, though it has many advantages, has the disadvantage of altering lengths to a greater degree than several other conformal projections, such as the stereographic projection.

The author describes an appliance which greatly facilitates the use of this projection. It consists of two concentric rings and a translucent disc bearing a network of meridians and parallels on a stereographic system of projection of which the central point coincides with the centre of the disc. The outer ring is graduated for azimuth. The inner ring to which the net-work is fixed can turn through a small angle within the outer ring in such a way as to bring the desired meridian into the 0 - 180 azimuth of the outer circle (with this object the value of the convergence is printed on each meridian). A rod with a cursor can be moved parallel to a fixed direction. A pencil fixed to the cursor enables the stereodrome to be drawn, its length to be measured and its azimuth to be found at any moment. An arm can be used to join the cursor to the centre of the outer circle. The cursor can be moved at a speed proportional to that of the aeroplane and the whole can be so arranged that the pilot sees his estimated position constantly indicated by a point of light on the transparent card and can read the course to be steered against a lubber's mark.

The disc can be changed according to the mean latitude of the track or during the course of a very long trip.

The same stereographic network can be used to draw lines of altitude obtained from star sights, if these are worked out with respect to the central point. With this object an azimuth rod has been provided, carrying a bar with the curvature of the curve of altitude.

One could have a series of networks, each with a scope of 10 to 12° of latitude; 10 of them would be sufficient for the whole earth, as the meridians would have no graduation.

It should be noted that special charts on projections other than Mercator's have already been proposed and used for long journeys by aircraft. See *The Hydrographic Review*, Vol. V, No. 2, Nov. 1928, pp. 39-42 and Vol. X, No. 1, May 1933, p. 81.

P. V.

In the December 15th, 1935, issue of the *Annalen der Hydrographie*, Heft XII, pages 489-493, Dr. H. MAURER rises against the expression Stereodrome to designate a curve which is different on the sphere according to the varying central point adopted for the projection, whereas the Loxodrome is a well-defined curve with respect to the Earth's fixed axis of rotation.

Dr. H. MAURER does not believe that seamen will abandon Mercator's projection, which offers so many advantages, in order to adopt a stereographic projection, at any rate as long as the compass remains the main course-indicating instrument.

The airman goes much quicker and can fly both over land and sea; he can thus envisage a more direct route; on the other hand the wind for him is a greater cause of uncertainty. So long as he mainly makes use of the compass, a frequent change of course is a hindrance; experience will disclose whether the use of a radio direction finder must predominate and whether a stereographic projection offers him advantages.

But, as far as aviation is concerned, long journeys must be considered. For a journey over 360 nautical miles, like those which Professor IMMLER has in view, the system of projection is of slight importance; gnomonic or conic projections would be just as good, and even Mercator's projection, if one be not in the neighbourhood of the pole. But if a crossing of the Pacific be considered, then it is no longer possible to carry out, with any precision, on a stereographic map of such size the operations indicated by Professor IMMLER, for the meridians would be circles in it, differing greatly from straight lines.

P. V.

LIMITS OF OCEANS AND SEAS - U. S. S. R.

Decision of the Central Executive Committee of the U.S.S.R. concerning uniformity in the geographical denominations of the Soviet Arctic.

I. The following denominations of the Arctic Ocean and its parts adjacent to the territory of the U.S.S.R. are obligatory for use in all scientific papers, manuals, maps, charts etc. issued in the U.S.S.R.

1. Svernyi Ledovityi okean (*Arctic Ocean*).

2. Parts of the Arctic Ocean: Beloe More (*White Sea*); Barentsovo more (*Barents Sea*); Karskoe more (*Kara Sea*); More Laptevykh (*Laptev Sea*); Vostochnosibirskoe more (*East Siberian Sea*) and Chukotskoe more (*Chuckchee Sea*).

3. The geographcial limits of the separate parts of the Arctic Ocean, adjacent to the territory of the U.S.S.R., to be as follows:

Barentsovo more (*Barents Sea*)

Western limits: North Cape (Norway); Bear Island; South Cape (Spitsbergen); *E* coasts of Western Spitsbergen and eastern shore of North-East Land to Cape Leigh Smith.

Northern limits: Cape Leigh Smith across the islands Bolshoy ostrov (Great Island) Gillis and Victoria; Cape Mary Harmsworth (southwestern extremity of Alexandra Land) along the northern coasts of Franz-Joseph Land as far as Cape Kohlsaat.

Eastern limits: Cape Kohlsaat; Cape Zhelaniya (Desire); W. coast of Novaya Zemlya; Proliv Karskye Vorota (Kara Strait); W. coast of Vaigach Island; Yugorsky Shar (Yugor Strait).

Southern limits: the coast of the mainland from Yugor Strait to Cape Kanin Noss thence to Cape Sviatoy Noss (of Murmansk) and along the coast of the mainland to North Cape.

Pechorskoe more (*Pechora Sea*)

The term Pechorskoe more (*Pechora Sea*) is admitted for the south-eastern portion of the Barents Sea, though it is not to be considered an independent geographical unit.

Western limits: from Cape Chornyi (southern entrance into Kostin Shar); northern extremity of Kolguev Island; E. coast of Kolguev Island to the western end of Plosskie Koshki (Flat Cats); Bugrinskaya kossa (Bugrinsk Spit) and on to Cape Sviatoy Noss (Timan).

All other boundaries coincide with the corresponding limits of this part of the Barents Sea.

Beloe more (*White Sea*)

The basin south of the line joining Cape Sviatoy Noss (of Murmansk) to the north-western extremity of the Kanin peninsula (Kanin Noss), limited by the shores of the U.S.S.R.