No.	Vessel.	Captain.	Reported by—
1	Albano, Ger. S. S.	Kudenhold	II Officer Luhrs.
2	Algeria, Br. S. S	Wards	Officer Booth
3	Almora, Br. S. S.	Turner	Officer McGavin.
4	Amsteldijk, Du. S. S	Baron	Officer de Kup.
5	Annie M. Parker, Br. Schr.	Carter	Master.
6	Arabic, Br. S. S.	Atkin, R. N. R	I Officer.
7	Asama, Br. S. S.	Carr	Officer Myles.
8	Atlanten, Sw. S. S.	Svenson	Master.
9	Baltic, Br. S. S	Smith	Officer Simpson.
10	Bayonne, Ger. S. S.	von Hugo	Officer Frankenbusch
11	Belfast, Br. S. S.	McKee	III Officer Noble.
12	Black Prince, Br. S. S.	Sheppard	III Officer Jackson.
13	Bluecher, Ger. S. S.	Reessing	IV Officer Bauer.
14	British Empire, Br. S. S	Riddle	Officer Bender.
15	British Trader, Br. S. S.	Hutchinson	Officer Williams.
16	Brooklyn City, Br. S. S.	Bailey, R. N. R	Officer Stoton.
17	Bovic, Br. S. S	Kerr	Officer Harbord.
18	Caledonian Br. S. S	Baxter	III Officer.
19	Campania, Br. S. S.	Ware	Officers Horsburgh & Porley.
20	Canopic, Br. S. S.	Bartlett, R. N. R	Officer Thomas.
21	Cayo Manzanillo, Br. S. S	Winter	Master.
22	Cestrian, Br. S. S	Thomas	Officer Harker.
23	Columbia, Br. S. S	Wadsworth	Officer Paulesen.
24	Contre Amiral Caubet, Fr. S. S.	Degrand	Officer Gallocher.
25	Corfe Castle, Br. S. S.	Nutman	Officer Blanchard.
26	Cornishman, Br. S. S	Thornton	Officer Wormald.
27	Crown Point, Br. S. S.	Wall	II Officer.
28	Dania, Ger. S. S	Bonath	Officer Nachtwey.
29	Deutschland, Ger. S. S	Kaempff	Officer Vimcker.
30	Elise Marie, Ger. S. S.	Stege	Officer Sievers.
31	Elswick Hall, Br. S. S.	Cripsey	Officer Berg.
32	Emilia, Port. Bk	Domingues	Officer Cochat.
33	Excelsior. Ger. S. S	Courtin	Officer Meyer.
34	France Marie, Fr. Bk.	La Croix	Master.
35	Friesland, Bel. S. S.	Rogers	Officer Alford.
36	Furnessia, Br. S. S.	Blaikie	Master.
37	Gallia, Fr. S. S	Bouleuc	II Officer.
38	Georgic, Br. S. S.	Clarke	Officer Browne.
39	Germania, Fr. S. S	Jaubert	Officer Latil.
40	Gibraltar, Br. S. S	Knagg	Officer Pegdenn.
41	Glooscap, Br. Sp.	Spicer	Master.
42	Grenada, Br. S. S.	Murchison	Master.
43	Grosser Kurfurst, Ger. S. S.	Mentz	Officer Siebert.
44	Hainaut, Du. Sp	Jacobs	Officer Schwede.
45	Horta, Azores.		
46	Iberian, Br. S. S	Jago	Officer Harris.
47	Indore, Br. S. S.	Mytton	Officer Stancliffe.
48	Indrapura, Br. S. S	Horne	Officer Barston.
49	Iowa, Br. S. S.	Walters	Officer Jackson.
50	Iris, Bel. S. S	Sytor	Officer Achtergael.
51	Kaiser Wilhelm II, Ger. S. S.	Hogemann	Officer Mahlmann.
52	Knight of St. George, Br. S. S	Stephens	Officer Hogan.
53	Koln, Ger. S. S.	Konemann	Officer Werther.
54	Konigin Luise, Ger. S. S.	Volger	Officer Elsner.
55	La Lorraine, Fr. S. S	Alix	Officer Guerin.
56	La Savoie, Fr. S. S.	Poirot	Officer Sous.
57	Le Coq, Br. S. S	Peterson	II Officer.
58	Lucifer, Br. S. S.	Prowse	Officer Colvin.
58*a*	Lustleigh, Br. S. S	Bootyman	Officer Cuthford.
59	Mackay-Bennett, Br. S. S.	Schenk	Officer Richardson.
60	Madonna, Br. S. S	Lander	Officer McKay.
61	Manuel Calvo, Sp. S. S.	Castella	Officer Morales.
62	Maranhense, Br. S. S	Casey	Officer Arrowsmith.
63	Martello, Br. S. S	Schekell	Officer Massam.
64	Matteawan, Br. S. S.	Bennett	Master.
65	Mesaba, Br. S. S.	Tubb	Officer Beresford.
66	Mexican, Br. S. S.	Slater	Officer Chirgwin.
67	Michigan, Br. S. S	Stapleton	Officer d'Auquier.
68	Minnehaha, Br. S. S	Robinson	Officer Lewin.
69	Mohawk, Br. S. S.	White	III Officer.
70	Mokta, Br. S. S.	Cooper	Officer Lawson.
71	Mount Temple, Br. S. S.	Forster	Officer O'Reilly.
72	Napolitan Prince Br. S. S.	Eagleton, R. N. R.	Officer Campbell.
73	Noordam, Du. S. S.	Bonjer	Officer Paun.
74	Obi, Br. S. S.	Evans	Officer Jones.
75	Oldenburg, Ger. S. S.	Troitrich	III Officer.
76	Oxonian, Br. S. S.	Dickinson	Officer Lawson.
77	Pectan, Br. S. S.	Daniel	Officer Yeomans.
78	Perugia, Br. S. S.	Johnston	Officer Bewsher.
79	Philadelphia, Am. S. S	Mills	Officer Dorry.
80	Ponce, Am S. S.	Dalton	Officer Mundy.
81	Potomac, Br. S. S.	McKay	Officer MacDonald.
82	Primo, It. Bk.	Gibelli	Master.
83	Quevilly, Fr. Bk	Ladonne	Officer Carpentier.
84	Rappahannock, Br. S. S.	Buckingham	Officer Allman
85	Rhein, Ger. S. S	Rott	Officer Reher.
86	Sachem, Br. S. S	Murdoch	Officer Lowe.
87	Saint Hugo, Br. S. S.	Stabb	Officer Hudson.
88	Santa Cruz, Azores.		
90	Siberian, Br. S. S	Eastaway	Officer Paterson.
91	Sicilia, It. S. S	Sartorio	Officers.
92	Standard, Ger. S. S	Sluiter	Officer Schulte.
93	Sylvania, Br. S. S.	Cresser	Officer Hughes.
94	Templemore, Br. S. S.	Henry	Officer Candlish.
95	Tennyson, Br. S. S.	Ohls	Officer Alexander.
96	Teodoro de Larrinaga, Br. S. S.	Hudson	Officer Carroll.
97	Texan, Br. S. S.	Land	Officer Martin.
98	Traveller, Br. S. S.	Donald	Officer Turgoose.
99	Trebia, Br. S. S.	Hilton	Master.
101	Tuscarora, Br. S. S.	Hollingshead	III Officer.
102	Vera, Br. S. S.	Dunstan	Officer Olsen.
103	Virginia, Br. S. S.	Reid	Officer Lane.
104	Virginia, Ger. S. S.	Rauschenplat	Master.
105	Wells City, Br. S. S	Carey	Officer Brooks.
106	Welshman, Br. S. S.	Kay	Officer Popham.
107	West Point, Br. S. S.	Robertson	Officer Lloyd.
108	Willkommen, Ger. S. S	Lotze	Officer Hollander.
109	Yarborough, Br. S. S.	Turner	Officer Gunn.
110	Zeeland, Br. S. S.	Broomhead	Officer Möller.

the rear of the preceding depression during the afternoon and night of October 10, entering the system of winds surrounding the succeeding depression at 4 a. m. of October 11. At this hour the wind, hitherto moderate from NW., freshened from NE., with overcast sky and falling glass; at 8 a. m. a strong NNE. gale prevailed, with rough sea; at 4 p. m. a whole gale set in, blowing with violent squalls, and accompanied by a high and dangerous sea. Similar weather and conditions prevailed until 2:45 a. m. of October 12, at which hour the wind backed to north, gradually declining in force until 8 a. m., when it sank to a moderate gale (see fig. 4).

Subsequent to midnight of October 12, the storm seems to have diminished materially in energy, although no reports have been received from vessels in the immediate vicinity of the center on that date. Several, however, among them the *Caledonian* (18), the *Columbia* (23), and the *Arabic* (6), crossed the track at no great distance from the center without experiencing especially severe winds.

The reports furnished by the vessels and island stations named in the list preceding have been utilized in the preparation of the present account of the storm. The numbers attached to the observations shown on the daily synoptic charts (figs. 1, 2, 3, 4) agree with those given in the preceding list.

IMPROVED METHODS FOR FINDING ALTITUDE AND AZIMUTH, GEOGRAPHICAL POSITION, AND THE VARIATION OF THE COMPASS—SECOND ARTICLE.[1]

By "X."

The widespread movement to abolish calculation in determining a ship's place at sea from observations of the altitude of celestial bodies is making progress. It is necessary also to provide methods which, by being rid of restrictions as to the situation of the observed body in the firmament that were involved in the old routine of calculating morning and evening spherical triangles, are capable of meeting the need for such frequent determinations of both geographical position and true bearing as are now requisite in consequence of the increased speed of ships. As a further evidence of progress in these efforts, attention must be called to the tables of Victor Fuss, who until his recent retirement was director of the Imperial Naval Observatory at Kronstadt, and also to the abacus, or diagram, constructed by MM. Favé and Rollet de l'Isle, hydrographic engineers in the naval service of France.

In remarking upon the principles of some tables that he had computed for the purpose of relieving the tedium of numerical and logarithmic computation in finding the Sumner line at sea, Sir William Thomson, now Lord Kelvin, long ago said:[2]

When we consider the thousands of triangles daily calculated on all the ships at sea, we might be led for a moment to imagine that everyone has already been solved, and that each new calculation is merely a repetition of one already made; but this would be a prodigious error, for nothing short of accuracy to the nearest minute in the use of data would thoroughly suffice for practical purposes. Now, there are 5400 minutes in 90°, and therefore there are 5400^3, or 157,464,000,000 triangles, to be solved for a single angle. This, at 1000 fresh triangles per day, would occupy above 400,000 years. Even with an artifice such as that to be described below, for utilizing solutions of triangles whose sides are integral numbers of degrees, the number to be solved (being 90^3, or 729,000) would be too great, and the tabulation of the solutions would be too complicated. * * *

A recent article in the MONTHLY WEATHER REVIEW, entitled "Improved methods for finding altitude and azimuth, geographical position, and the variation of the compass," takes occasion to point out that Mr. Littlehales, hydrographic engineer of the U. S. Hydrographic Office, has constructed and is now about to publish graphical tables in which the solutions of the spherical triangle for values varying from minute to

[1] The first article on this subject by "X" will be found in the Monthly Weather Review for June, 1905.

[2] Proceedings of the Royal Society (of London), Vol. XIX, 1870-1871, p. 260.

minute of arc are conveniently provided for, not only within the one quadrant of the sphere to which the above calculation by Lord Kelvin relates, but throughout the whole circuit of the sphere. The same article gives a description of the numerical tables that have been published by Professor Souillagouet, of the French Navy, which are very similar to those proposed by Fuss and described by him in the Proceedings of the Seventh International Geographical Congress at Berlin in 1899, in a communication entitled "Table for determining the altitudes and azimuths of stars."[3]

A comparison between the tables of Fuss and Souillagouet reveals in the former a somewhat greater ease of manipulation on account of superior arrangements of the columns and the presence of tables of differences to facilitate interpolation. Both have adopted the same method of dealing with the problem, viz: by decomposing into two right-angled spherical triangles the triangle of position, in which the known elements are the angle at the pole, the codeclination, and the colatitude, and then solving the two right triangles separately. The method of Fuss depends upon the following formulæ:

$$\text{Sin } a = \cos d \sin t; \ \cot b = \cot d \cos t.$$
$$\text{Sin } h = \cos a \sin B; \ \cot A = \cot a \cos B,$$

where t = angle at pole,
d = declination of star,
h = altitude of star,
A = azimuth of star,
φ = latitude of observer,
a = perpendicular from position of star to meridian of observer,
b = complement of side included between the foot of perpendicular and the pole,
$B = b + 90 - \varphi$.

The first entry in a table, in which t, the angle at the pole, is the upper horizontal argument, and d is the vertical argument, gives a and b. Then having computed B, as indicated by its definition, enter the same table a second time with B as the horizontal argument, and a as vertical argument. The star's altitude and azimuth will be found in the columns, a and b, respectively.

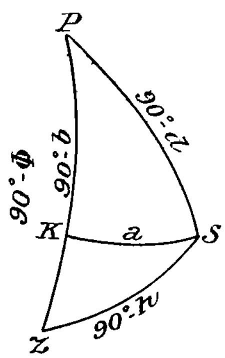

FIG. 1.

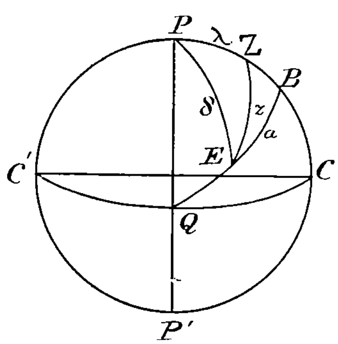

FIG. 2.

The table of Fuss is computed for every whole minute of time in hour angle, and every whole degree of declination, while Souillagouet's table is for every two minutes of hour angle, and every thirty minutes of declination.

The table of Fuss also differ from Souillagouet's in that the latter has the declination for the upper horizontal argument, and the hour angle for vertical argument, and, further, instead of giving finally the azimuth and altitude, it gives the amplitude and altitude.

The abacus of Favé and Rollet de l'Isle (see fig. 6) is also founded upon processes that effect an indirect solution of the astronomical triangle by decomposing it into two partial right-angled spherical triangles.

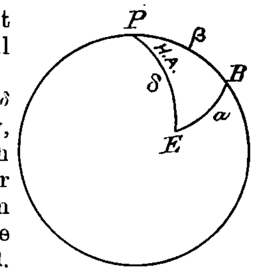

FIG. 3.

Let PZE be an astronomical triangle, δ being codeclination of the observed body, $\lambda = PZ$, the colatitude, $z = EZ$, the zenith distance or coaltitude, and EPZ the hour angle. Drop a perpendicular from E on PZ, produced if necessary, and designate PB by β and EB by a. Then $ZB = \beta - \lambda$.

The abacus (see fig. 4) provides for obtaining the two legs of a right spherical triangle when the hypotenuse and one angle are known, and conversely it provides for obtaining the hypotenuse and one angle when the two legs are known. In the right spherical triangle BPE (see fig. 3) if δ and the hour angle $H. A.$ are known a and β may be found. In the right spherical triangle ZEB, a is now known and also $ZB = \beta - \lambda$. Hence EZ, the zenith distance, may be found.

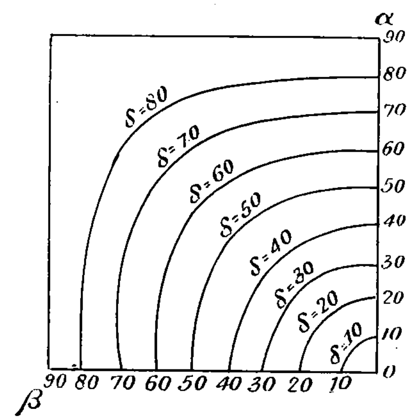

FIG. 4.

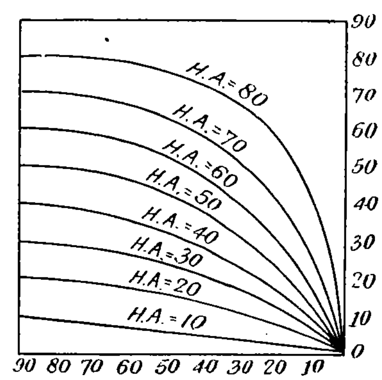

FIG. 5.

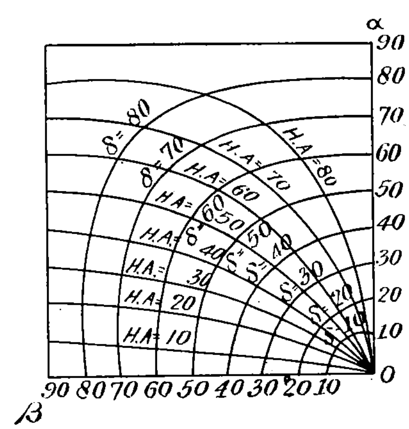

FIG. 6.

[3] We understand that the complete tables by Fuss are being published in St. Petersburg for the use of the Russian Navy.—EDITOR.

From the right spherical triangle *PBE*, figs. 2 and 3, we have—

$$(1)\qquad \text{Cos}\ \delta = \cos \alpha \cos \beta.$$
$$(2)\ \text{Cot}\ H.\ A. = \cot \alpha \sin \beta.$$

Let α and β be two variables in Cartesian rectangular coordinates. Assign δ a constant value and let α and β vary; then from the first of these equations a certain definite curve will be traced as shown in the diagram (see fig. 4), and by assigning arbitrary values to δ, from 0° up to 90°, a family of declination curves will be obtained. In the same manner there will result a family of hour angle curves (see fig. 5) by assigning arbitrary values to the hour angle *H. A.*, and then letting α and β vary. By constructing the two series of curves on the same set of coordinate axes these results follow.

Thus the plane area is divided into a series of curve line quadrilaterals which may be made as small as we please by tracing the curves at sufficiently small intervals.

If one value of δ and one of *H. A.* be given, then by means of these curves the position of a point is fixed in the plane. The rectangular coordinates of this point are the values of α and β corresponding to these values of δ and *H. A.* Conversely, if we know the values of α and β, we are enabled to plot the position in the plane, and we can read off δ and *H.A.* by means of the curves.

By means of this abacus, the azimuth and altitude of a star may be determined when its declination and hour angle and the estimated colatitude are given. Plot the position of the star by means of δ and *H. A.* curves, estimating the minutes by the eye, and read the rectangular coordinates of the point thus plotted, α on the vertical scale and β on the horizontal scale. The *H. A.* curves here represent meridians and the δ curves represent parallels of the celestial sphere. Now make $B = \lambda + \beta$, considering β negative if the latitude and declination are of contrary name. Plot the point which has α and *B* for rectangular coordinates, and, considering now the *H. A.* curves to represent verticals, and the δ curves to represent circles of equal latitude, read off the azimuth by means of the *H. A.* curves, and the altitude due to the estimated latitude by means of the δ curves.

This abacus will also serve to find:

(1) The time of rising and setting of a star and its azimuth in the horizon.

(2) The name of an observed star.

(3) The distance and great circle course between two points.

Through the initiative of Monsieur Eugène Pereire, President of the Administrative Council of the Compagnie Générale Transatlantique, this method has been published in rectangular coordinates on four grand-eagle pages on a scale of $\frac{12}{1000}$ of a meter to the degree, and may be purchased in France.

STUDIES ON THE THERMODYNAMICS OF THE ATMOSPHERE.

By Prof. FRANK H. BIGELOW.

I.—ASYMMETRIC CYCLONES AND ANTICYCLONES IN EUROPE AND AMERICA.

INTRODUCTORY REMARKS.

The synthetic construction of the correct statement of the mechanical problems involved in the cyclonic and anticyclonic circulations of the atmosphere depends upon the coordination of the data derived from observations of the velocity vectors, the pressures, and the temperatures prevailing in the moving air masses. In my International Cloud Report, 1898, and in the MONTHLY WEATHER REVIEWS for January, February, and March, 1902, the distribution of the velocity vectors for the United States was described; in the REVIEWS for January and February, 1903, the distribution of the pressures corresponding to these velocities was explained; in this present series of papers the results of my studies on the relation of the temperatures to the velocities and pressures will be summarized. It has been shown conclusively for the United States that there are no true local warm-centered and cold-centered cyclones or anticyclones in the atmosphere, and that all the theoretical discussions or theses founded on that basis are misdirected. The observations demonstrate that in the lower atmosphere the actual mechanism consists of rather deep warm and cold countercurrents of air, which underrun the prevailing eastward drift. The centers of gyration are uniformly in the region where these counterflowing currents meet each other, that is to say, on the edges rather than in the midst of the warm and cold regions. About one half of the cyclone is relatively warm and the other half cold, while the opposite half of the anticyclone is warm and its alternate half is cold. Thus, in the United States, the eastern and northern sectors of the cyclone with the western and northern sectors of the anticyclone are warm, while the western and southern sectors of the cyclone and the eastern and southern sectors of the anticyclone are cold. The warm air flowing from the southwest into the east of the cyclone and west of the anticyclone, and the cold air flowing from the northwest into the east of the anticyclone and the west of the cyclone, constitute two currents whose temperatures differ from each other and from the normal temperature of the prevailing eastward drift. These currents seek to equalize their different temperatures by interpenetration, and in so doing the circulating structures known as cyclonic and anticyclonic are established. The heat added to the tropical zones of the earth by the solar radiation is to a considerable extent transported into the temperate zones by long horizontal currents in the lower levels, and is there expended in generating local circulations. These penetrate the upper current of eastward drift and tend to retard its motion, slowing it down to the moderate velocities which have been found to exist within ten miles of the ground. This stratification and interpenetration of currents of different temperatures is the true source of the energy of storms. The heat energy derived from the condensation of aqueous vapor to water, and the energy produced by purely dynamic eddies are entirely secondary in importance to the thermodynamic energy obtained by the counterflow and underflow of warm southerly currents against the cold northerly currents and beneath the eastward flowing drift. In the present series of papers it is purposed to examine somewhat fully the thermodynamic conditions which exist in the atmosphere, especially in cyclones, anticyclones and tornadoes; at present the temperature data are inadequate for a satisfactory consideration of hurricanes and the general circulation, though something may also be done in that direction.

THE SUPPOSED DIFFERENCE IN THE TEMPERATURE DISTRIBUTION BETWEEN AMERICAN AND EUROPEAN CYCLONES AND ANTICYCLONES.

Certain discussions of the available temperature observations made at different levels in cyclones and anticyclones for the United States and Europe indicate that there is a serious disagreement in the results for the respective regions, as if these local circulations might really be different in some important respects. We should not expect to find any such divergence in the thermodynamics of the atmosphere when the observations and the computations have been accurately made, but as it is comparatively difficult to extract the exact truth of the matter from the actual observations, it will be proper to examine these observations carefully before admitting that any important difference in the structures actually exists. A suitable review of the literature may be found in Mr. Clayton's article,[1] from which the following few statements are compiled:

From a study of mountain observations, Professor Hann found

[1] Various researches on the temperatures in cyclones and anticyclones in temperate latitudes. By H. Helm Clayton. Beiträge zur Physik der freien Atmosphäre. Vol. I, pp. 93–106.