



THE PRESENT STATE OF THE STUDY OF NAVIGATION AND NAUTICAL METEOROLOGY FOR TRANSOCEANIC AERIAL TRAFFIC

By

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As routes for aerial transport, those between Europe and North and South America should be the first to be considered — the routes which have already been conquered, in a spirit of adventure, in the easterly direction. These sporting exploits which, economically speaking, are worthless, have rendered inestimable service to the science itself by encouraging the collection of and selection from the vast quantity of preliminary material now available for navigation and nautical meteorology. Already, therefore, it is possible to define the line of preliminary research and to inform instrument makers of certain definite requirements as well as to point out to the Nautical Meteorological Observation Service that the observations made every day and even every hour can, and should be used with other than the present ends in view. This will contribute to the achievement of the tremendous task which is stirring the ambition of all the great powers which are interested in transatlantic traffic to succeed in establishing transoceanic aerial communication, which can and ought to be exploited commercially.

A description of all the data obtained from the preliminary work, with which this article deals, will enable a judgment to be formed as to the merits of the various possible routes.

The technical questions of aircraft will not be dealt with here, but it is assumed that a large aircraft only is capable of accomplishing the task, and that it should be big enough to carry the instruments necessary for safe navigation which are described below.

The following subjects are dealt with in succession :—

- I. The determination of position ;
- II. Meteorological principles and their measurements ;
- III. The determination of possible transoceanic routes.

I. To determine the position of aircraft over the sea, advantage is taken of the experience gained by centuries of practical navigation. The advantage

of aviation over navigation in not having to consider shoals is, without doubt, partly the cause of underestimating the advantage of determining the exact position above the sea during flight. In order to attain the goal of the flight towards the East, "Europe", the sporting exploit requires also that the aircraft be relieved to the uttermost limit of all superfluous weight.

A flight made for commercial purposes and which must follow a prescribed route, cannot be made (there is to-day no difference of opinion on this subject) with the navigational methods of a Christopher Columbus, and in any case it is to be hoped that the new German attempt to cross the Atlantic will have at its disposal all available auxiliaries in the way of personnel and technical nautical instruments.

As regards personnel, there should be a flight-captain, with a thorough knowledge of navigation, *i. e.* practical and theoretical aerial navigation; and well-versed in meteorology. He ought to be accompanied by at least one substitute having the same training and experience. The training of these flight captains and aerial navigating officers is undertaken by the "Deutsche Verkehrsfliegerschule G. m. b. H." (D. V. S.), which was inaugurated on 1st January, 1927, and founded with the help of the State. The training of candidates (who must be equipped with a certificate showing that they have passed through the higher branches of school education and must, in addition, have great physical and sporting abilities verified by a psycho-technical examination) for the grade of flight captain, begins by a six-months' course of maritime instruction in the training yacht for navigation on the high seas at Neustadt *i. H.* They must also take a six-months' course at the Aviation School of Schleisheim and at the School of Nautical Aviation at Warnemünde. In order that they may become familiar with the sea and to increase their nautical knowledge, candidates make a six-months' cruise in one of the training ships of the Union of German Training Ships. The summer season of the third year's training is passed in the Maritime Aviation Service at List-auf-Sylt. From there, candidates return to Warnemünde where, during the three months of winter, they receive instruction in all branches of aerial navigation and in meteorology. Their studies are concluded by a practical course in large aircraft and as second pilot in the service of the *Lufthansa*; finally they pass into the upper class of the Warnemünde School of Aerial Navigation. In conformity with the rules laid down for a captain, the candidate is obliged to take a longer course as second pilot in order to obtain his rank of pilot for a transatlantic flight.

Until this training can produce all-round competent pilots, it will be absolutely necessary to resort to mariners on the active or inactive lists who have received instruction in aeronautics, either in the Merchant Service or the Navy. The fact that a "*nautical aviator and a navigator*" is required, must be emphasised.

Auxiliary instruments of a nautical and technical character are for:—

- a) taking bearings:
- b) checking the position determined by means of terrestrial and astronomical observations;
- c) using, for the flight, the meteorological phenomena encountered.

a) The compass, which is the most important instrument for all kinds of navigation, has been sufficiently perfected to be used in aircraft. In order to economise weight, a magnetic compass should be used such as is made by the instrument-makers ASKANIA A. G. of Berlin, and LUDOLF of Bremen, who work in this sphere in Germany. With a rose approximately 150 $\frac{m}{m}$ in diameter, these compasses are divided into degrees with a precision almost greater than that needed for a lateral rudder worked by pedals, as is still usual to-day. It is to be hoped that this method of pilotage, which is not sufficiently accurate to follow closely a prescribed course, will soon be replaced by hand-steering.

The variation of compasses fitted in large aircraft is not very considerable, for very often it is possible to install the compass sufficiently far from the motor, which is the principal disturbing element. Should still further protection from disturbing elements be desired, use may be made of compasses with repeaters, which have been improved by the Askania factories in the form of pneumatic compasses with repeaters, and of the Pioneer-Brooklyn terrestrial induction compasses, which have been improved in a remarkable manner.

In order to take bearings for determining deviation or to take observations which are essential to Navigation, a bearing plate must be used in conjunction with the compass, or even the periscope which the firm of Zeiss manufactured as an experiment and which has proved satisfactory under trial. When the difficulty as to weight has been overcome, aerial navigation will be conducted with the gyrocompass.

It is only in a flat calm that aircraft in flight, even as ships under sail, make good the exact course indicated by the compass. During a flight, in the same way as during a sea voyage, drift must be taken into account. In this respect the aviator is in a worse position than the seaman, firstly because the drift forces are greater, both absolutely and relatively, than on the sea; secondly because, in the air, they are not so well known and cannot be determined as easily as at sea. From manuals of navigation and by other means, the mariner knows pretty accurately the set and drift of currents. He can at once ascertain the direction of the wind; he has learnt to estimate its force and, from long practical experience, he knows the drift effect of these forces on his ship. The aviator has, indeed, a means of estimating the wind which blows on the surface of the sea, by noting the state of the surface water, from which he is always able to draw fairly accurate conclusions concerning the direction of the wind at the height of his flight but, with reference to the force of the wind which causes the aircraft to make leeway, it is useless to take into account the estimated force of the wind at the surface of the sea. To get over this dilemma, he has recourse to his experience in navigation and, among others to the method known as the "Reel Log". A fixed point is created on the surface of the sea (as is done with the old hand log); the angle of depression of the point is taken twice, noting the times; with these data and the known height of the flight, the distance made good over the ground in the interval between the two observations and, in consequence, the velocity of flight, are calculated. Simultaneously with the angle of depression, a bearing is taken of the fixed point on the water in order to determine the

drift. A certain amount of error is introduced in determining this drift because the point on the water of which the bearing is taken (which is marked by an object dropped from the aircraft), is not exactly astern of the aircraft in the direction of the flight over the ground. It would lead too far to go deeply into the subject here and for a full description of these questions the reader is referred to the work by Captain BOYKOW:- *Treatise on Aerial Navigation*, W. G. L. 1927, Oldenburg Edition, Munich.

The air pilot is not expected to make any calculations to obtain these results. The required values are very easily found in tables with the entries:- "Times and angle of depression or, times and height of flight".

As a result of experiments to find out the most suitable objects to drop, which should, on the one hand, be sufficiently heavy to fall quickly and, on the other, be capable of floating on the surface of the water and should, consequently, become lighter on contact with the water, "fluorescine" was adopted after trials had first been made of chemical products which burst into flame on contact with the water (combinations of calcium). The fluorescine is poured into a hollow, drop-shaped receptacle (for reduction of air-resistance) which breaks on contact with the water and makes a pale green luminous patch visible from a distance. The correct position of the centre of gravity of the receptacle is obtained by means of lead shot. This bomb, used for taking bearings, weighs about 150 grammes ($5\frac{1}{4}$ ozs.) and is intended for day use. Trials are being made to produce a bomb for bearings for night use.

Various instruments for determining speed and drift in the manner above-described, already exist in large numbers. Without doubt the simplest is the Pioneer-Brooklyn instrument. Gadow's *Askania Winspeilscheibe* (*Marineleitung*) also makes it possible to estimate the prevailing wind. The *Ciné-dérivomètre* (*France*) is similar in principle to the Pioneer-Brooklyn apparatus, but more accurate. These instruments are affected by the error of horizontality of the machine; Zeiss has made an instrument in which an attempt is made to eliminate this fault by using a water level. The gyroscope also will mark a decided advance on instruments of this kind. Trials to this effect are now in progress.

It is obvious that, while taking measurements of drift and velocity, it is absolutely necessary to keep the same course and height. The aircraft constructor should take this into account by establishing a proper liaison by signals between pilot and navigator. Nevertheless, it should be noted that experience has shown that it is impossible to obtain sufficiently accurate measurements of velocity and height of flight below 500 metres, since at low altitudes the object passes too rapidly under the eyes of the observer.

Those who use barometric altimeters, affected by actual air pressure, for controlling the height of flight, will find a welcome innovation in the echosounding instruments which, of recent years, have attained an astonishing degree of perfection and which give the captain the means which have not existed up to now, of determining the actual air-pressure — which is of importance to meteorological navigation.

The subject of bearings may now be left and the next subject (*b*):- check-

ing the estimated position by means of terrestrial and astronomical observations, will be dealt with.

First, however, a few remarks on terrestrial navigation. Naturally the aviator, like the navigator, should seize every opportunity to check his calculations and to obtain new data on the prevailing wind by taking observations of terrestrial objects; for this purpose instruments to take bearings are provided.

Astronomical and nautical aerial navigation is based on the same principles and methods as ordinary navigation. Although there is less need for accuracy, the resultant facilities are counteracted by the considerable complications caused by the impossibility of using the horizon for taking the altitude of heavenly bodies. This difficulty may be surmounted, either by descending to heights where the horizon can be used, as was successfully accomplished by the Portuguese Admiral COUTINHO in his flight from Lisbon to Rio de Janeiro, or by using a sextant with artificial horizon with a pendulum or water-level. The firm of C. PLATH of Hamburg has succeeded after many vain attempts in constructing a sextant for the use of aircraft, according to the indications of Admiral COUTINHO. Even in unfavourable weather, sufficiently accurate observations were obtained with this model. Moreover, the firm of LUDOLF of Bremerhaven has constructed a "Coldewey Sextant with artificial horizon" which, according to the reports of J. FEDDERSON, first officer of the N. D. L. S/S *Elster*, gave good results (Compr. HANSA p. 2132). Here also the gyroscope should provide a further instrumental improvement. Experiments carried out in France with the Bonneau system of air-pump gyroscope were not satisfactory. Preliminary experiments, which promise to be crowned with success, are now being carried out in Germany with a gyroscope-sextant using alternating current.

The special conditions pertaining to aircraft necessitate that observations shall be taken only when the aircraft is moving at a constant speed. The pilot should give his assistance — which again demonstrates the necessity of a good liaison by means of signals between the pilot and the navigator. Since the introduction of wireless time signals, broadcasted six times a day a good watch now suffices to take the times; it is even preferable to the chronometer, which is considerably more influenced by the constant vibration of the motor than the much less sensitive watch. (Moreover it is anticipated that, even for navigation, the chronometer, considered an absolute necessity up to now, will soon be done away with). If a sidereal watch be used, all the complicated calculations of the sidereal time are avoided.

With reference to the suitability of observations, it should be noted that the method of meridian and circummeridian altitudes, which is preferred in ordinary navigation on account of its simplicity, can be used in rapid aircraft when the direction of the course is nearly East or West only. It can easily be understood that, on courses covering large differences of latitude, the movement in the direction of the meridian — a movement which directly influences the observed altitude — may be greater than the rate of change in the sun's altitude, so much so that in reality the observer completely loses the moment of culmination of the sun. In these circumstances equal altitude observations, which can always be used, should be taken.

Science is working incessantly to assist the navigator in taking his observations and to produce instruments for this work as simple, compact and practicable as possible. It would seem advisable that the matter of economy of space should not be pushed too far. In large aircraft the necessary space should be allowed to facilitate the conduct of navigation as, next to the means of propulsion, this is the most important consideration. The "*Marineleitung*" has compiled tables to replace long calculations. In order that they be not too voluminous and to make them as practical as possible, the calculation is not based on the assumed position of the vessel, but on a fixed point. In this manner, altitudes are obtained with only two arguments. The tables are entitled :- *Altitudes and azimuths of stars between 20°N and 30°S declination*. They are compiled for six latitudes viz : 70°, 55°, 50°, 45°, 35° and 25°. Supplementary tables of *Altitudes and azimuths of brilliant stars, down to the 3rd magnitude, the declination of which is over 30°N*, are also calculated for the same latitudes. The chart on Mercator's projection is unsuitable for this method since the curvature of the curves of latitude, which stretch over very great distances, is no longer negligible. On the other hand, the stereographic projection is suitable, since all circles of the globe appear thereon as circles. These charts are conformal and, therefore, the courses can be referred directly to the meridians. Tables compiled for navigation, but which are too detailed for aerial navigation, can be reduced to $\frac{1}{3}$ of their actual size without impairing their utility.

The study of these questions leads to the subject of radiogoniometry. This latest aid to navigation is becoming more and more popular, and promises to be of exceptional value to nautical aviation, since it can be used at times when the aerial pilot has no means of making optical observations. The TELEFUNKEN instrument for taking bearings on board, *i. e.* bearings in their literal sense (which are the only ones discussed here) has been successfully reduced to a form adaptable to large aircraft; disturbances in the reception, produced by the ignition spark of the motors, are eliminated by taking the caps off the magnetos and connecting the ignition cables to Earth. It should be remembered that the deviations of hertzian waves, as may compass deviations, can be determined. All the necessary data for taking bearings by wireless are given in the "*Nautische Funkendienst*". The book "*Funkpeilungen*" by Leib-Nitsche, published by E. S. MITTLER & Son, contains detailed information on this subject.

In conclusion, mention should be made of a further aid to navigation — the solar compass — a new instrument with which, *in the vicinity of the terrestrial pole* and by means of a watch, the image of the sun can be held on an almost constant bearing. This instrument, since it can be used only in the proximity of the pole, need not be considered for ordinary transoceanic passages.

(c) *Meteorological Navigation*. Here the maritime aviator is obliged to pass considerably beyond the limits of knowledge expected of the navigator. A flight over solid ground may avoid the dangers of inclement weather since, as a last resort, it may be stopped at any moment; but a forced descent in a hydroplane will be made only when all other possibilities have been exhausted. These possibilities can be realised only by the acquirement of a profound

knowledge of all the meteorological phenomena and their utilisation for the continuation of the flight. "What for the mariner and for the aviator who makes long flights over the ground, is a desirable addition to his general knowledge, becomes for the pilot of a hydroplane a matter of life and death". (Prof. W. GEORGII, Darmstadt).

Particular attention is paid to this matter in the training, mentioned above, of captains of nautical aircraft. Flight captains who have not taken this course of preparation for nautical aerial navigation, should undergo a thorough instruction in meteorology. When the initial indispensable knowledge of an air pilot has been acquired (*i. e.* to be both seaman and maritime aviator) he should, in addition, be instructed in *meteorology*. Stimulated by the requirements of navigation, the science of meteorology has made such marked progress during recent years that it has begun to take its place among the exact sciences. The most important aid to meteorological navigation is the meteorological chart; and for this a great international organisation for publishing information on atmospherical conditions is now preparing bases which can already be considered sufficient for transoceanic flights. The flight captain should be able to draw a chart of this description at any moment during his flight. Although welcome progress has been made in the study of meteorology, the real causes of meteorological changes have not yet been accounted for (probably they must be sought in the variations of pressure at very great altitudes) so as to enable a sufficiently accurate forecast of the weather to be given for more than 12 hours. Consequently, for a transatlantic flight, which takes several days, it is only possible to foretell in a general sense whether it is advisable or not to set out on the flight. The flight-captain should be able to receive further information during his flight and, for this reason, should be able to receive and transmit messages. Such a possibility, even if it were not necessary for other purposes, is a *sine qua non* for meteorological navigation in every transatlantic flight.

It is sufficient to give a few examples, chosen from among many available to demonstrate the use of the meteorological chart, rather than to give more detailed descriptions. From a glance at the trend of the isobars, a seaman can estimate the distribution of the winds; for the nautical airman it is even easier since, at the altitudes at which he flies (generally not below 500 m.), the deviating action on the wind, due to friction against the surface of the water, is negligible. At these altitudes, the winds blow almost exactly in the direction of the isobars. The gradient of the atmospheric pressure (distance apart of the isobars) gives a sufficiently accurate indication of the force of the wind. Finally, by noting in what direction the wind tends to shift, the observer can estimate on which side of the minimum pressure he is situated.

Temperature conditions also enable the airman to obtain important information. He knows that the movements in the atmosphere, particularly the vertical movements so unpleasant to the airman, are accompanied by a rapid fall of temperature in relation to the altitude. The visible signs of this state of things are a pile of clouds which often rises to a great height, and it causes storms which, if possible, the aviator avoids. On the other hand, clouds which are in strata form usually form in the layer separating air mas-

ses in which conditions are different. Usually it is easy to fly over these strata of clouds as their surfaces may be compared to a second surface of the earth.

The cosmic relations of meteorological conditions are better understood since the theory of gradual transitions in the atmosphere is no longer accepted, while a study is made of the separate air-masses which differ from each other in temperature or humidity, or in both; and they are studied in their relationship one to the other. Cold air is heavier than hot air. If the equilibrium of two different air-masses is broken by a collision, it may happen that the cold air glides under the hot air. According to the results of experience, this incident occurs in pulsations. It is accompanied by rainstorms and showers but of short duration. Otherwise the hot air rises and escapes above the cold air by sliding along it. This lasts a relatively long time. The strata of clouds, mentioned above, are the phenomena which usually accompany this occurrence.

A thorough training and increasing experience will enable the transoceanic airman to profit by all these phenomena for his flight. For instruments he would require (apart from a wireless outfit and barometer, in conjunction with an echo-sounding machine) a thermometer and hydrometer only; they occupy little space and do not weigh much.

This appreciation on the nautical and meteorological technique of transoceanic flight will be concluded by stating that sufficient progress has been made in the preliminary work in this sphere to make certain that a flight-captain, who has been well instructed both theoretically and practically, will be able to find his way over the Atlantic in a large aircraft. It will be the concern of the organiser of transoceanic flights of this kind to select and prepare suitable personnel.

If the question of determining the position and of navigating the aircraft can be considered as solved, the problem remains of ascertaining on what track the opposing forces of nature are least to be feared. This leads to:-

III. — THE ANALYSIS OF POSSIBLE TRANSOCEANIC ROUTES.

The flights of LINDBERGH, CHAMBERLIN and BYRD have led to much research work in this direction. All the statistics concerning this subject suffer from the lack of observations on air conditions at great altitudes. This must be remedied as soon as possible and it can only be done by sending up many more test balloons during regular steamship voyages.

Existing statistics enable the following table to be compiled:-

Four routes may be considered as suitable for transoceanic traffic: the most northerly (I) passes over Scotland, Iceland and Greenland to Labrador, is approximately 3650 km. (1970 sea-miles) in length and consists of three stages of 900, 1400 and 1300 km. The direct route (II) Ireland-Newfoundland is about 3100 km. (1670 m.) in length, and is not much shorter than Route (I). Route (III) goes from Lisbon to the Azores (about 1600 km.) and from the Azores to Newfoundland (about 2400 km.), giving a total distance of 4000 km. (2160 m.) Finally, the longest route (IV) adds an intermediary station, the Bermudas, to Route (III) making the distance from the Azores to the Ber-

mudas 3400 km. (1835 m.) and finishes near Hatteras, a distance of 1100 km. (590 m.).

The above routes avoid the two principal North Atlantic storm-centres, which are to be found round about 45° N. - 35° W. and 37° N. - 60° W.

W. R. GREGG has prepared comparative statistics of the favourable and unfavourable days for the crossing by routes (II) and (III). He considers as favourable the days marked (+) on which the head and stern winds equalise each other, and as unfavourable (—), those when a contrary wind prevails. This results in the following table :-

	Route II Towards the West.		Route III Towards the East.		Route II Towards the East.		Route III Towards the East.	
	+	—	+	—	+	—	+	—
SPRING.....	12	80	19	73	45	47	48	44
SUMMER.....	14	78	25	67	56	36	45	47
AUTUMN.....	5	86	20	71	44	48	43	48
WINTER.....	4	84	17	73	49	41	47	43
YEAR.....	35	328	81	284	194	172	183	182

The statistics clearly indicate the fact that westerly winds prevail in the North Atlantic. Even during the most propitious period of summer, the favourable days amount to only 18 % for crossing in the westerly direction by route (II) and to 37 % by following route (III). Taking the average for the year, these figures are lowered to about 10 % and 25 %. On the other hand, for the Easterly crossing, more than 50 % of favourable days may be counted on.

The table compiled by Dr W. GEORGI of Darmstadt gives the velocity which the winds may attain, calculated from measurements made during observation cruises undertaken at the instigation of the Deutsche Seewarte and the LINDENBERG OBSERVATORY during the years 1922-25. The data are worked out for an altitude of 500 metres.

AVERAGE VELOCITY IN KM. PER HOUR

	50 - 45 N.	45 - 40 N.
WINTER.....	67	65
SPRING.....	41	38
SUMMER.....	33	22.3
AUTUMN.....	28.4	30

The average wind-velocities, as shown in the table, attain in winter values which demonstrate the impossibility of a flight at this period of the year. In summer the values diminish by 1/2 to 1/3 in comparison with the winter

figures, but they always remain very high keeping in mind the fact that at a speed of 150 km. per hour (80 knots) of the aircraft itself, an average of nearly 20 % of this speed is necessary to overcome the head wind.

It is not only wind force which interferes with flight; bad weather should also be taken into account as one of the disturbing elements. Deep cyclonic depressions bring about bad weather. The following table, also compiled by Dr. W. GEORGII, shows the frequency of these cyclones with an atmospheric pressure of 750 $\frac{m}{m}$ (29.53 inches.).

<i>Latitude N.</i>	70°/65°	65°/60°	60°/55°	55°/50°	50°/45°	45°/40°	40°/35°	35°/30°
WINTER	11.94	31.68	21.08	13.84	16.60	11.00	4.96	1.08
SPRING.....	6.72	23.64	18.92	14.32	13.70	8.63	2.84	0.04
SUMMER	5.92	18.12	19.08	13.76	8.52	2.86	0.20	0.00
AUTUMN	12.28	29.64	21.36	14.60	11.72	7.08	3.24	1.28

The trifling annual fluctuations in the latitudes between 65° and 50° are noticeable. The conditions to the North and South of this zone are much more favourable in Spring and in Summer than during the rest of the year, and to the South of 40° N., deep depressions are very rare. The diminution in the frequency of cyclones to the North of 65° N. should also be noted, as these northern regions closely resemble the 45°/40° zone in respect of the value for the frequency of cyclones. It should be remembered that the fog which appears most often in summer in the region of Newfoundland, rarely exceeds about 300 m. in height and, in consequence, does not present an insurmountable difficulty to flight.

The comparatively low frequency of cyclones in high latitudes calls for a more detailed examination of Route I. According to the measurements of wind made by Dr. QUERVAIN for these latitudes, it is evident that on an average for one year, a velocity of wind above 10 to 14 km. per hour must not be counted on. With reference to the direction of the winds, the crossing is favourable in Spring and Summer. At an altitude of 500 m. in the Eastern part of the passage, the easterly and westerly winds are nearly balanced, whereas in the Western part, *i. e.* from Greenland, Easterly winds prevail in a proportion of about 8.5 to 1.5. In addition to these meteorological conditions, which are favourable to a flight towards the West, there is the great advantage that the crossing is divided into three sections by land. Consequently an assured future may be predicted for this route.

With regard to Route IV., which is the longest and the most Southerly, the fact that in 1927 this route was chosen for the German attempts leads to the supposition that, in spite of its length, it presents certain advantages. In Summer it is in the zone of the trade winds, which is characterised by very regular meteorological conditions and winds. As far as the Azores, at average altitudes, East and West winds follow each other with equal frequency.

In higher spheres the West winds predominate and aid the crossing towards the East. On the route Azores-Bermudas-Hatteras, the influence of the trade winds predominates so that, in any case in Winter and in Summer, Easterly winds must be expected. In addition, during Summer the weather is splendid between Azores and Cape Hatteras.

To sum up, it may be said of the four North Atlantic routes that :-

1. At present crossings can be undertaken only in Spring and Summer.
2. Routes II. and III. are unsuitable for regular traffic because of the unfavourable meteorological conditions to be encountered and Route II. is particularly unfavourable.
3. Route I. is worthy of consideration.
4. Route IV. is the one to be chosen for preference.

In conclusion, a few words should be added on the South-America Lisbon-Pernambuco flight. It is necessary to use the Canary and Cape Verde Islands as intermediate stations. These divide the crossing into distances of 1409, 1500 and 300 km. This route differs from the North-Atlantic Route in that there are no seasonable variations of weather. The wind conditions for this flight towards America are most favourable ; Easter winds of average force predominate. Tropical squalls, which are the only dangers to be feared, generally occur at the beginning and end of the West African monsoon, in Spring and Autumn, on the part of the crossing to the South of Cape Verde Islands. Although not very frequent, on account of their intensity it would be necessary to establish a warning service before undertaking regular flights over this route.

Finally it may be said that, thanks to science, the problem of transoceanic flights can be fairly clearly stated in spite of insufficient research. If the demands of science are put into practice, and it is assumed that they can be, the conquest of the Atlantic in an Easterly direction, while always remaining a nautical exploit which calls for very great personal aptitude, will no longer be a foolhardy enterprise as were the attempts of this kind made last year with small and unsuitable craft.

Since writing these lines, the *Bremen* has brilliantly accomplished the flight towards the West. Germany is proud of the success of her countrymen, the more so that the flight was achieved with a totally insufficient meteorological and navigational equipment and at a period of the year when, as has been stated, the enterprise encounters almost insurmountable obstacles. Authentic accounts of the manner in which the flight was carried out are not yet published. Consequently it is only possible to make conjectures on the difficulties which have been surmounted, and which may be imagined to have been as follows :-

The shortest route was chosen, called herein Route II. In the month of April, on an average, a maximum of three favourable days can be counted upon on this route. At an altitude of 500 m. the average winds met with are of 40 km. per hour. It should be noted that these are mean values.

In view of the fact that the cyclonic frequency is about 20, as shown by the tables, it may be assumed, *a priori*, that the *Bremen* encountered a deep cyclonic depression, so that in order to win through it would have had to struggle against even greater wind velocities.

The impossibility of receiving weather forecasts and of determining the position by wireless, the difficulty of fixing the position astronomically in the zone of bad weather near the American coast and, finally, the relaxation of the forces of the aviator after a period of superhuman tension, amply explain the great drift of the aircraft towards the North, which was so nearly fatal to it.

This flight would seem to corroborate the assertion that a transatlantic flight cannot be successfully accomplished unless the pilot is thoroughly acquainted with nautical and meteorological sciences.

