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THE FIRST TRANS-ATLANTIC FLIGHT.

By WILLIS RAY GREGG, Meteorologist.

[Dated: Weather Bureau, Washington, June 26, 1919.]

SYNOPSIS.—In connection with its trans-Atlantic flight the United States Navy, in cooperation with the Weather Bureau, arranged for meteorological reports from Europe, from the United States, and from ships at sea. These reports were forwarded by radio to the Weather Bureau at Washington, D. C., and to meteorologists, representing the Navy and the Weather Bureau, at Trepassey, N. F. Synoptic charts were regularly prepared, and forecasts furnished for the information of the aviators. Reports on May 16 indicated excellent conditions over the western part of the course, with parallel winds and clear weather; over the eastern part of the course, some cloudiness and possibly showers from low clouds, with little if any assistance from the winds; all in all, as nearly favorable conditions as could be expected for some time. The start was therefore made on that day. Reports of the seaplane commanders indicate that good flying weather prevailed, except near the Azores, where low clouds, fog, and some rain were encountered. The NC-4, however, arrived safely at Horta and later successfully completed its journey to Lisbon and Plymouth. So far as the meteorologist is concerned, the principal points brought out by this first trans-Atlantic flight are: (1) Necessity of greater accuracy in barometric observations; (2) the great value of free-air observations; (3) needed improvement in radio apparatus; and (4) importance of accurate and regular meteorological reports from merchant and other ships at sea for the benefit and information of all marine shipping and aviation interests.

The widespread interest in the United States Navy's attempt at trans-Atlantic flight and the general enthusiasm which greeted the success of that effort make it desirable that as complete a history as possible should be written of the undertaking, not only because of the importance of the lessons that have been learned, but also in order that future generations may have available a record of this epochal event, destined quite likely to assume a significance scarcely less momentous than that of Columbus' voyage across the seas. Official reports of the seaplane commanders will doubtless fully describe the planes themselves and all their equipment, the difficulties encountered, and the improvements necessary to overcome those difficulties in the future. The purpose of this sketch is to outline briefly the preparations that were made for receiving meteorological reports, to discuss the use to which those reports were put and to point out certain lines along which meteorological and aerological observation at sea should be developed.

During the winter months of 1919 plans were made by the Navy Department, in cooperation with the Weather Bureau, for securing as complete and widely distributed meteorological reports as possible. By special arrangement with the British Meteorological Office such reports were to be sent by radio from Carnarvon and were to include observations made in Iceland, the Scandinavian peninsula, the British Isles, Denmark, France, Spain, and Portugal. Similar reports were to be furnished from the United States, Canada, and the Bermudas. In addition, the Aerographic Division of the United States Naval Reserve Flying Corps, under the direction of Lieut. R. F. Barratt, organized a very complete system of observations to be taken on certain of the destroyers that were stationed along the line of flight from Trepassey, N. F., to Lisbon, Portugal, and on five battleships, three of which were stationed some distance north of the line of flight, and two a similar distance to the south of it. The locations of all these observing ships are indicated in figure 7. Their names and geographic coordinates are as follows:

Names.	Latitude, north.		Longitude, west.	
BATTLESHIPS.	°	′	°	′
Texas	46	56	31	01
Utah	50	25	39	40
Florida	36	00	42	00
Wyoming	40	00	52	00
Arkansas	48	00	12	00
DESTROYERS.				
Upshur	45	17	48	44
Walker	43	58	44	27
Meredith	42	38	40	15
Hopewell	41	19	36	08
Phillips	39	59	32	05
Gridley	38	58	29	12
Wilkes	37	58	21	01
Conyngham	38	13	16	46
Ericsson	38	29	12	34
Chew	45	36	7	16

ADDITIONAL "BASE SHIPS."

Baltimore at Halifax, N. S.
Aroostook at Trepassey, N. F.
Melville at Ponta Delgada, Azores.
Shawmut at Lisbon, Portugal.

The European reports included observations of pressure, wind direction and force, state of the weather, and barometric tendency; those from the United States and Canada, pressure, temperature, wind direction and force, state of the weather, and precipitation; and those from ships at sea, pressure, wind direction and force, barometric tendency, air and sea temperatures, state of the weather, state of the sea, visibility, amount, kind, and direction of clouds and upper-air wind conditions, as observed by means of pilot balloons. The European observations were taken twice daily, at 1 a. m. and 1 p. m., G. M. T.; the American observations, at midnight, noon, and 9 a. m., G. M. T. (8 p. m., 8 a. m., and 1 p. m. Washington summer time); and those at sea at 1 a. m., 7 a. m., 1 p. m., and 6 p. m., G. M. T. In all cases the reports were sent by radio, in accordance with schedules prepared by the Office of Naval Operations, to the Central Office of the Weather Bureau and to the base ship *Aroostook* at Trepassey, N. F. The reports began May 1 from Europe and America; May 7, from the battleships; and May 10, from the destroyers (fig. 2); in all cases continuing until the seaplanes left Trepassey, viz., May 16. Thereafter, reports were sent to Ponta Delgada only from Europe and from ships to the east and northeast of the Azores.

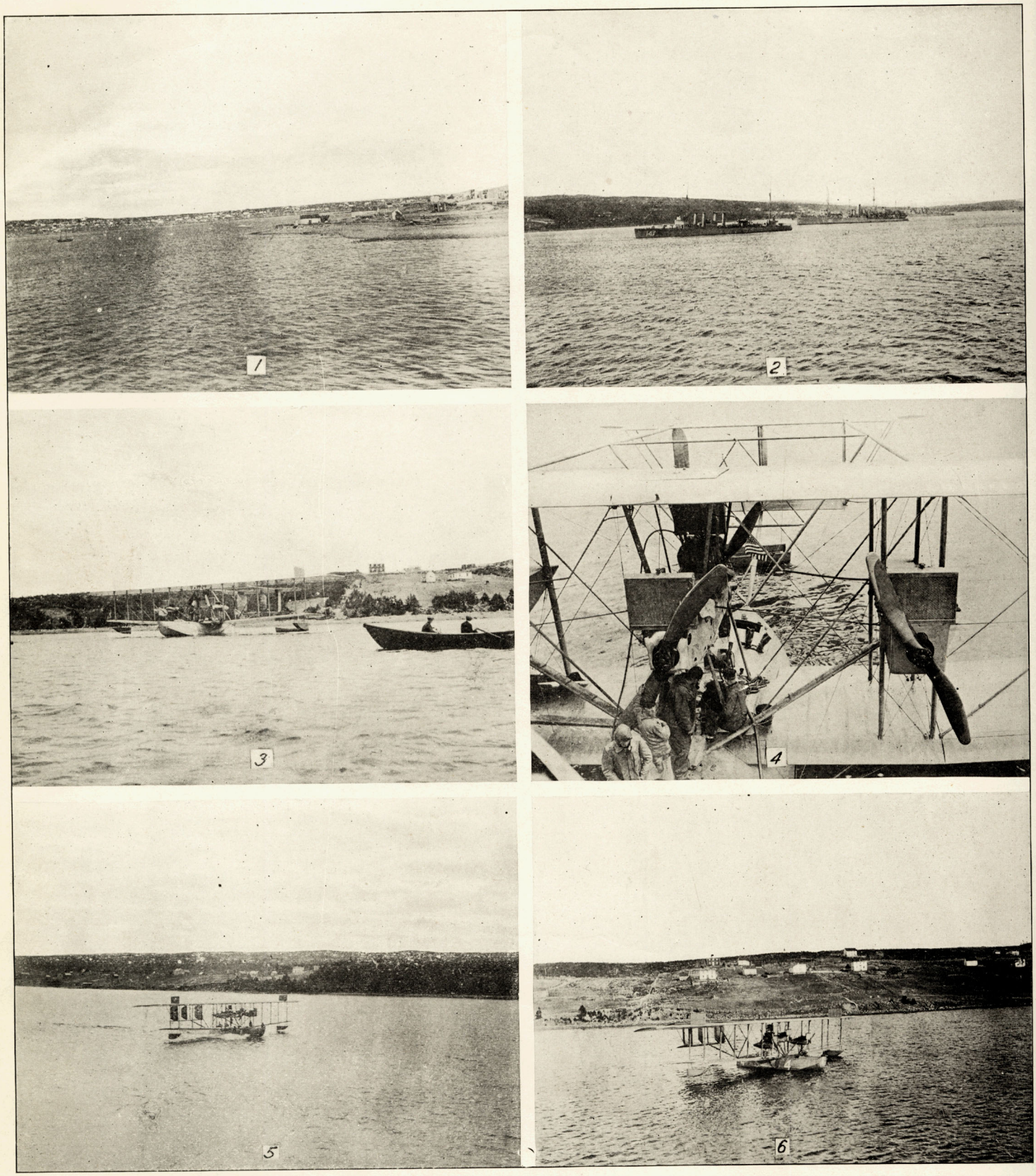

FIG. 1.—Trepassey Bay and village.
FIG. 3.—The NC-3 at her mooring, Trepassey Bay.
FIG. 5.—The NC-1 arrives at Trepassey Bay.

FIG. 2.—Group of destroyers. These, with others, furnished meteorological reports along the course of flight.
FIG. 4.—Close-up view of the NC-3.
FIG. 6.—The NC-4 "taxi-ing," preparatory to "taking the air" for flight to the Azores.

Observations on battleships and destroyers were taken by the enlisted personnel of the Navy. They were charted and studied, in connection with continental reports, by the official forecasters at Washington and by Lieut. Barratt, U. S. N., and the writer at Trepassey, N. F. Others who participated actively in this work, while the planes were at their respective stations, were Lieut. Commander Alexander McAdie at Halifax, Lieut. J. B. Anderson at Ponta Delgada, and Ensign F. W. Reichelderfer at Lisbon.

The reports received at Washington and at Trepassey enabled those engaged in their study to make fairly complete synoptic charts of weather conditions and to follow in detail the changes occurring in those conditions, with special reference to their bearing on the advisability of flight. The relative importance of the various meteorological elements, in determining whether or not conditions are favorable for flight, has already been discussed.[1] In the case of this particular undertaking there were certain special features that required consideration. For example, it was essential, on account of the great weight of the planes, that there should be a wind at Trepassey sufficiently strong to enable them to get off the water; it was essential also that the planes leave at as early a date as possible in order to have the advantage of bright moonlight; moreover, the destroyers would soon necessarily have to return for refueling; and it was desirable, if not essential, that the visibility be good, in order to render observations possible, and that the sea be not very rough, so that in case a descent were necessary the planes might not be wrecked before assistance could be summoned. It can thus readily be seen that a day might be so very favorable as to be absolutely *unfavorable*, for, with very strong winds, even though parallel to the course, the sea would be so rough as to make flying a risky experiment. A good example of this is afforded by a glance at the map showing conditions on May 12, Chart IX. On this date the winds were practically parallel to the course at all points along it, both at the surface and in the free air, yet reports indicated a sea of 3 to 8 meters and thus rendered a flight out of the question.

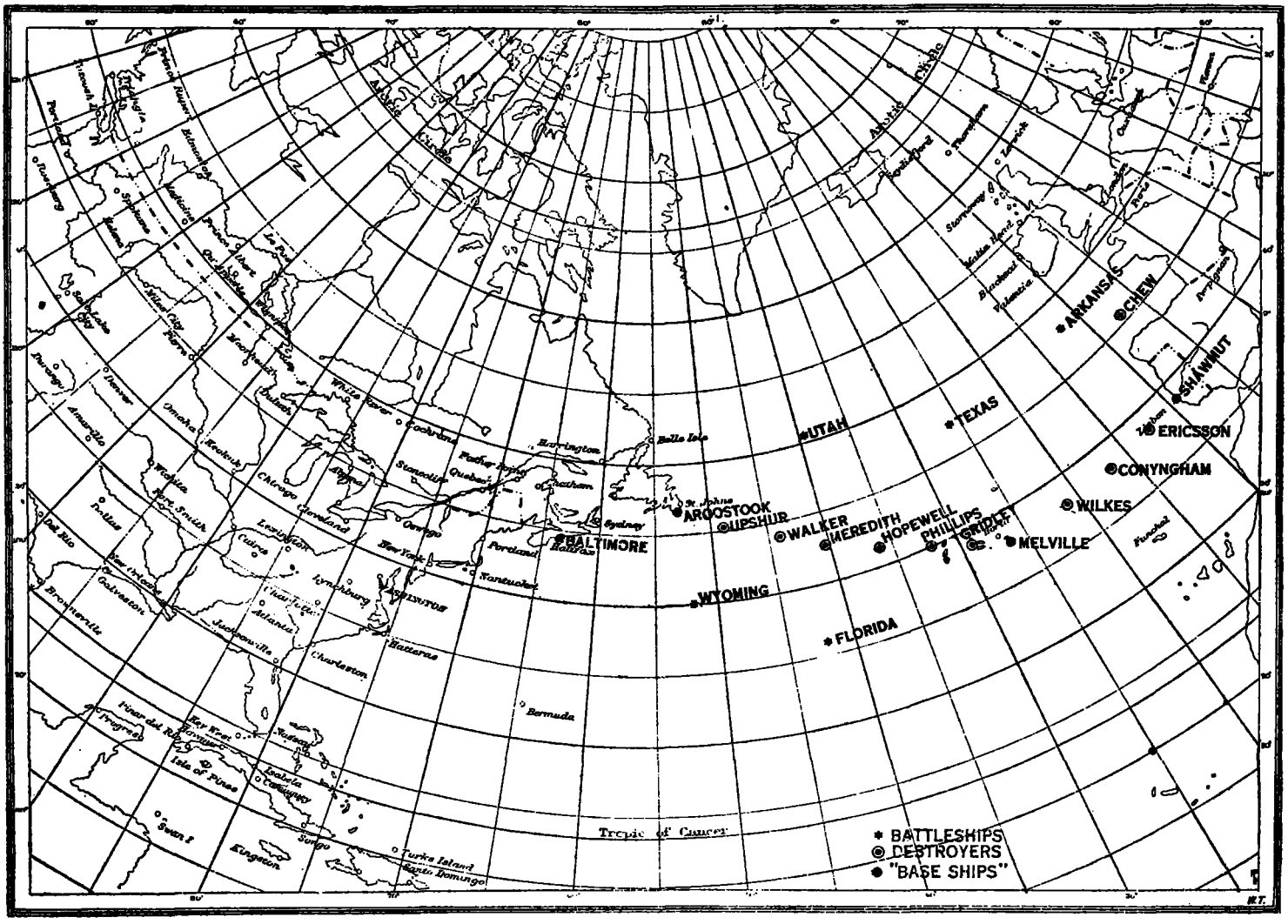

FIG. 7.—Names and positions of meteorological observing ships.

Nevertheless, the two factors that were given closest study were wind assistance and state of the weather, or degree of storminess. The former was necessary, because of the limited cruising radius of the NC planes; and fairly clear weather was desirable, especially at night, in order that observations might be made for the purpose of determining geographic position. It was not expected (nor is it ever to be expected) that ideal conditions would at any one time be experienced over all portions of a course as long as this one. The problem, therefore,

[1] "Trans-Atlantic Flight from the Meteorologist's Point of View." MONTHLY WEATHER REVIEW, Vol. 47, 65-75. See also "Air Navigation," by Maj. H. A. Wimperis, R. A. F., in Aeronautics, May 8, 1919, pp. 482-487, for a discussion of wind and fog, as affecting aviation in general.

was to select a day, as early as possible, on which reasonably favorable conditions would be encountered.

A discussion of the weather changes from day to day, together with forecasts issued from Washington, D. C., is given elsewhere in this REVIEW.[2] We shall now describe in somewhat greater detail the conditions on May 16. Observations at 1 a. m., G. M. T., showed generally unsettled conditions along the course, including light rain, some fog, and variable winds. By 7 a. m. these conditions had greatly improved, particularly over the western part of the course, where clear weather, westerly winds, good visibility, and smooth sea were reported. Still further improvement was shown by the reports at 1 p. m. Conditions were very nearly ideal at and near Trepassey; farther out there was cloudiness, and one ship reported rain. Unfortunately, no observations were received at this time from ships near the Azores, but the battleship *Florida*, lat. 36°, long. 42°, reported fairly high barometer, 30.20 inches, which, however, was apparently erroneous, as indicated by reports later received from that region. (See Chart XIV.) This inaccuracy in barometer readings was also apparent in the case of some of the destroyers' reports, with the result that it was impossible to compute with much certainty gradient wind values. Happily, though, pilot-balloon observations were available, and these indicated approximately the wind assistance that might reasonably be expected. Accordingly, the following statement was prepared at Trepassey and delivered to Commander Towers at 4 p. m., G. M. T.:

"Reports received indicate good conditions for flight over the western part of the course as far as Destroyer No. 12 (about 600 miles out). Winds will be nearly parallel to the course and will yield actual assistance of about 20 miles per hour at flying levels. Over the course east of Destroyer No. 12 the winds, under the influence of the Azores HIGH, recently developed, will be light, but mostly from a southwesterly direction. They will not yield any material assistance.

"Weather will be clear and fine from Trepassey to Destroyer No. 8 (about 400 miles out); partly cloudy thence to the Azores, with likelihood of occasional showers. Such showers, however, if they occur, will be from clouds at low altitudes, and it should be possible to fly above them.

"All in all, I believe that the conditions are as nearly favorable as they are likely to be for some time.

(Signed) "GREGG."

A table indicating in detail the wind assistance to be expected at various points along the route was also prepared and delivered to Commander Towers. Advice to start was likewise furnished at this time by Lieut. Barratt. The planes were then made ready, and definite word to attempt the flight was given by Commander Towers upon receipt of the following forecast from Washington at 6.30 p. m., G. M. T.:

"Surface winds fresh and possibly strong west-southwest and upper winds fresh to strong west over course between Newfoundland and Azores. Some clouds, fair visibility, and rising pressure. Conditions favorable for start.

(Signed) "BOWIE."

As is well known, the start was made that evening. After "taxi-ing" in the harbor for some time in order to warm up the engines and to see that everything was functioning properly, the planes headed into the wind, which was blowing at 15 to 20 miles per hour, and left the water in the following order: NC-3 (figs. 3 and 4), Commander John H. Towers in charge, at 10:04 p. m., G.M.T.; NC-4 (fig. 6), Lieut. Commander Albert C. Read in charge, at 10:05 p. m.; and NC-1 (fig. 5), Lieut. Commander P. N. L. Bellinger in charge, at 10:10 p. m. To those who were privileged to witness it, the event was one of absorbing and dramatic interest. So much time and earnest effort had been spent in preparation that all felt the project *must* succeed, yet the vagaries of fortune play so prominent a part in *all* undertakings that the feeling of pride with which the successful departure was watched was coupled with a feeling of anxiety lest some feature might have been overlooked that would spell disaster. Most of the spectators had played a more or less prominent part in carrying out the details of preparation and therefore realized keenly their proportionate share of the responsibility; perhaps none more so than those to whom the meteorological work was assigned. Knowing full well that conditions were not perfect, they nevertheless believed that these conditions were more nearly favorable than would be encountered for some time at least. An examination of reports later received for the remainder of the month indicates that this belief was well founded.

There were some spectators, however, who felt none of this responsibility but only a sense of keenest interest and expectancy. These were the good people of Trepassey, experts in deep-sea fishing, to whom the events of this period, from the arrival of the *Aroostook*, Capt. J. H. Tomb, commanding, on May 2 to the departure of the planes on May 16, formed a succession of thrills and surprises quite demoralizing to the daily routine of life. Rarely, if ever, has it been given to the inhabitants of a small hamlet (figs. 1 and 2), whose previous history had been of so quiet and retiring a nature (at any rate since the days two or three hundred years ago when the almost land-locked harbor of Trepassey formed a safe retreat for the rugged crews of pirate ships) to become all at once the center of world interest. That they appreciated their good fortune was evident not only in their display of friendly curiosity, but also in the cordiality with which they greeted and chatted with their unexpected and uninvited guests. True, this interest was not entirely impersonal, for business in Trepassey suddenly underwent a very striking transformation. It was reported, for example, that the local telegraph office sent more words during this two-week period than during the previous 20 years or than it was likely to send for the next hundred years.

The three seaplanes, as soon as they had "taken the air," flew seaward down Trepassey Bay, then turned eastward and were soon lost to view. By means of radio, however, information as to their progress was available for the next several hours. At 1:23 p. m., G. M. T., May 17, the NC-4 arrived at Horta, having covered the distance of 1,200 nautical miles (1,380 statute miles) in 15 hours and 18 minutes, at an average speed of 78.4 knots (90 miles per hour). The average airspeed of the machine itself has not been reported, but it was probably not greater than 70 to 75 miles per hour, and it is evident, therefore, that the wind assistance amounted to about 15 to 20 miles per hour. The following references to weather conditions are taken from Lieut. Commander Read's story of the NC-4's flight:

"The NC-3 left the water at Trepassey Bay at 10:04 p. m., G. M. T.; the NC-4 at 10:05 p. m., and the NC-1 some time later (10:10 p. m.).

[2] E. H. Bowie, Weather Warnings, p. 347. This also discusses weather conditions during the flights from Rockaway, Long Island, to Trepassey, N. F., and during the flight of the Navy dirigible C-5 from Montauk Point, Long Island, to St. Johns, N. F.

"We were flying over icebergs, with the wind astern and the sea smooth.

"It was very dark, but the stars were showing. At 12:19 on the morning of the 17th the May moon started to appear, and the welcome sight made us all feel more comfortable.

"Each destroyer was sighted in turn, first being located by star shells, which, in some cases, we saw forty miles away; then by the searchlights, and finally by the ships' lights. All were brilliantly illuminated.

"So far, our average speed had been 90 knots, indicating that we had a 12 knot favorable wind. At 1:24 the wind became less favorable and we came down to 1,000 feet.

"At 5.45 we saw the first of dawn. * . * * Messages were received from over 1,300 miles, ——

"At 8 o'clock we saw our first indications of possible trouble, running through light lumps of fog. It cleared at 8:12, but at 9:27 we ran into more fog for a few minutes. At 9:45 the fog became thicker and then dense. The sun disappeared and we lost all sense of direction. The compass spinning indicated a steep bank, and I had visions of a possible nose dive.

"Then the sun appeared and the blue sky once more and we regained an even keel and put the plane on a course above the fog, flying between the fog and an upper layer of clouds. We caught occasional glimpses of the water, so we climbed to 3,200 feet, occasionally changing the course and the altitude to dodge the clouds and fog.

"We sent out a radio at 10:38 and at 10:55 to the nearest destroyer, thinking the fog might have lifted. We received replies to both messages that there was thick fog near the water.† At 11:10 we ran into light rain for a few minutes.

"At 11:13 we sent a radio to the destroyer and could hear Corvo reply that the visibility was 10 miles. Encouraged by this promise of better conditions further on, we kept going. Suddenly, at 11:27 we saw through a rift what appeared to be a tide-rip on the water. Two minutes later we saw the outline of rocks.

"We glided near to the shore and rounded the point. Finding that the fog stopped 200 feet above the water†, we shaped our course for the next destroyer, flying low, with a strong wind behind us. We sighted No. 22 in its proper place at 12 o'clock. This was the first destroyer we had seen since we passed No. 16.

"The visibility then was about 12 miles. We had plenty of gasoline and oil and decided to keep on to Ponta Delgada. Then it got thick and we missed the next destroyer, No. 23. The fog closed down * * *

"At 1:04 we sighted the northern end of Fayal, and once more felt safe.

"We headed for the shore, the air clearing when we neared the beach. We rounded the island and landed in a bight we had mistaken for Horta.

"At 1:17 we left the water and rounded the next point. Then we sighted the Columbia through the fog and landed near her at 1:23.

"Our elapsed time was 15 hours and 18 minutes."

The NC–1 and the NC–3 made practically the same time (and experienced therefore similar weather conditions) as did the NC–4. Near the Azores, however, in order to get their bearings, they descended to the surface, landing at about 1 p. m., G. M. T. The water was too rough to enable the planes to resume the flight, and considerable damage was done to them. Fortunately the NC–1 was able to get in communication with a passing vessel, and the crew were rescued, although the plane itself was lost. Because of a defect in its radio apparatus the NC–3 was unable to inform the destroyers or other ships of its plight and was therefore compelled to make headway as best it could. This was difficult, owing to the southward extension, on the 18th (see charts XV and XVI) of a cyclonic disturbance that had previously been central at about latitude 50° N., longitude 30° W. In spite of the high winds and seas resulting from this storm, the NC–3 succeeded in "taxi-ing" to Ponta Delgada, reaching that harbor on May 19.

On May 20 the NC–4, assisted by strong west-northwesterly winds, flew from Horta to Ponta Delgada, covering the distance of 150 nautical miles (173 statute miles) in 1 hour and 45 minutes, at an average speed of 86.7 knots (100 miles per hour). During the following week the weather between Ponta Delgada and Lisbon was generally unfavorable with head or cross winds and more or less cloudiness. On May 27 winds practically parallel to the course prevailed at all points (see chart XVIII) and the trans-Atlantic flight was successfully completed, this portion of the journey, 800 nautical miles (920 statute miles) being made in 9 hours and 44 minutes, at an average speed of 82.1 knots (95 miles per hour).

The most important lessons drawn from this first successful aerial crossing of the Atlantic, so far as the meteorologist is concerned, are:

1. Decided improvement in marine barometers and greater care in reading them (probably the latter in most cases) is necessary. Inaccurate pressure reports frequently made it impossible to determine the gradient existing at different points along the route, and in one case, previously referred to, indicated a condition the exact reverse of that actually prevailing.

2. The great value of free-air observations, in this case with pilot balloons, was clearly demonstrated. Without these observations it would have been impossible, owing to the inaccuracy of the barometric reports, to have indicated what wind conditions were to be experienced.

In reply to a reporter's question, "Did you find the weather reports important and reliable?" Lieut. Commander Read on his return to the United States said, "We found them very important. The Weather Bureau has a good system of reporting direction and velocity of surface winds, but no facilities for making observations of winds at high altitudes. That is something which might be developed if the Weather Bureau should have the money appropriated." (N. Y. Ev. Post, June 28, 1919, sec. 2, p. 4.)

3. The development of radio apparatus capable of covering greater distances and of avoiding interferences is essential.

4. The maintenance of "station" ships at sea is expensive and perhaps impracticable, but it should be possible to organize on a large scale a cooperative service, whereby all merchant and other ships should at stated times furnish accurate and prompt reports of meteorological conditions at sea, these reports to be received at land stations, where they can be charted and studied for the benefit and information of all marine shipping and aviation interests.

† Technically "fog" rests on the surface, so this was a low cloud.—ED.

[3] This is literally true, but the goal set by the Navy Department was Plymouth, England, and this was reached on May 31. The NC–4 flew from Lisbon to Ferrol Harbor in the northern part of Spain, on the 30th and completed the journey on the following day. Charts XXI and XXII show generally fair weather along the line of flight, with practically no wind, on those two days. On the 31st, however, some fog and local showers were encountered, and it was therefore necessary to fly at a very low altitude, much of the time at about 100 feet.

THE FLIGHT OF HAWKER AND GRIEVE.

On May 18, 1919, at 5.45 p. m., G. M. T., Mr. Harry G. Hawker and Commander Mackenzie-Grieve left St. John's, N. F., for a nonstop flight direct to Ireland. For several days no news of them was heard, but on May 25 the world was electrified to learn that these daring aviators had been rescued at sea by a Danish steamship. Mr. Hawker told his story simply as follows: [1]

"We had very difficult ground to rise from on the other side. To get in the air at all we had to run diagonally across the course. Once we got away we climbed very well, but about 10 minutes up we passed from firm, clear weather into fog.

"Off the Newfoundland banks we got well over this fog, however, and of course at once lost sight of the sea. The sky was quite clear for the first four hours, when the visibility became very bad. Heavy cloud banks were encountered, and eventually we flew into a heavy storm, with rain squalls.

"At this time we were flying well above the clouds at a height of about 15,000 feet.

"About five and one-half hours out, owing to the choking of the filter the temperature of the water cooling out the engines started to rise, but after coming down several thousand feet we overcame this difficulty.

"Everything went well for a few hours, when once again the circulation system became choked and the temperature of the water rose to the boiling point. We of course realized that until the pipe was cleared we could not rise much higher without using a lot of motor power.

"When we were about 10½ hours on our way the circulation system was still giving trouble, and we realized we could not go on using up our motor power.

"Then it was we reached the fateful decision to play for safety. We changed our course and began to fly diagonally across the main shipping route for about two and a half hours, when, to our great relief, we sighted the Danish steamer, which proved to be the tramp *Mary*.

"We at once sent up our Very light distress signals. These were answered promptly, and then we flew on about two miles and landed in the water ahead of the steamer.

"The sea was exceedingly rough and despite the utmost efforts of the Danish crew it was one and one-half hours before they succeeded in taking us off. It was only at a great risk to themselves, in fact, that they eventually succeeded in launching a small boat, owing to the heavy gale from the northeast which was raging.

"Altogether, before being picked up, we had been 14½ hours out from Newfoundland. We were picked up at 8:30 (British summer time)."

Commander Mackenzie Grieve, the navigator of the Sopwith, said:

"When but a few hundred miles out a strong northerly gale drove us steadily out of our course. It was not always possible, owing to the pressure of the dense masses of cloud, to take our bearings, and I calculate that at the time we determined to cut across the shipping route we were about 200 miles off our course.

"Up to this change of direction we had covered about 1,000 miles of our journey to the Irish coast. [The landing was made in latitude 50° 21′ N., and longitude 29° 30′ W.]"

During much of the time a straight course could not be steered because of clouds. In this way much time was lost, so it is not surprising that a speed of only about 80 miles an hour (1,050 statute miles in 13 hours) was, on the average, maintained. Very likely, however, this loss in speed was due in no small measure to the fact that cross winds prevailed during the greater portion of the flight. The air speed of the Sopwith machine is not known, but it was probably about 90 miles an hour, and the course of flight was on the average E. 15° N. If we assume that the wind blew approximately at right angles to the course with a speed of 40 miles per hour (and this is a fair assumption, judging from reports published [1]) we find that the machine, in order to follow the desired course, would have to make an angle with it of about 26½°, and the resultant speed would be only 81 miles per hour. Under the conditions of speed above given, i. e., wind 40 miles per hour and airplane 90 miles per hour, what might be called the wind's *critical* angle, or an angle with the course such that neither assistance nor resistance would be offered, is about 78°.[2]

A discussion of Alcock's and Brown's successful nonstop trans-Atlantic flight will appear in the June, 1919, number of the MONTHLY WEATHER REVIEW.—*W. R. Gregg.*

[1] New York Times, May 27, 1919, by courtesy of the London Daily Mail.

[1] See also Charts XV and XVI in this number of the Review.
[2] Cf. MONTHLY WEATHER REVIEW, February, 1919, p. 70.

A NEW EVAPORIMETER FOR USE IN FOREST STUDIES.

By C. G. BATES.

[Dated: U. S. Forest Service, Denver, Colo., April, 1919.]

SYNOPSIS.—This article treats of the subject of evaporation or transpiration from plants, of the factors which influence it, and of the conditions which must be met before water losses from plants can be approximately determined through instrumental evaporation.

It is pointed out that the "evaporation stress" or tendency to evaporate, is produced by a different combination of factors in each body from which evaporation may occur. Because of the fact that the vaporizing process in leaves takes place on the surface of moist cell walls which are not directly exposed to the moving air, the theory would lead us to expect that the effect of wind would be greatly minimized in evaporation from leaves, the rate of diffusion of the vapor being almost completely controlled by vapor pressures in the leaf (inter-cellular) spaces. On the other hand, the leaf is admirably adapted for absorbing the sun rays of all wave lengths; hence evaporation from leaves will be more directly controlled by the supply of radiant energy than perhaps will that from a body which does not absorb so readily and which may obtain considerable heat from the air, especially if a strong wind brings new supplies of air rapidly to the evaporating surface.

The article then describes the efforts which were made to devise an instrument having about the same relation to wind and to radiant energy as do leaves of plants in general. The idea of an "inner cell" for the vaporizing process, rather than a freely exposed moist surface, was the basis for these efforts. The result was a very practical metallic instrument known as the "Type 4 evaporimeter," whose behavior and operation are fully described. The essential feature of this instrument is a moist layer of linen between two metal plates, the upper of which protects the wick from rain, is coated with lampblack and transmits absorbed heat to the wick; the lower plate is thick and contains a number of small perforations simulating the stomata of leaves. Vapor formed in the moist linen escapes through these perforations. The layer of linen is above a well-insulated tank, from which it is fed by a stem wick. Distilled water is used and evaporation losses are obtained by weighing before and after exposure.

It is shown that considering either a large number of daily periods having a variety of weather conditions, or shorter periods at different times of the day, the evaporation from the Type 4 evaporimeter parallels the total transpiration of 12 small coniferous trees more closely