air navigation

1951

DEPARTMENT OF THE AIR FORCE

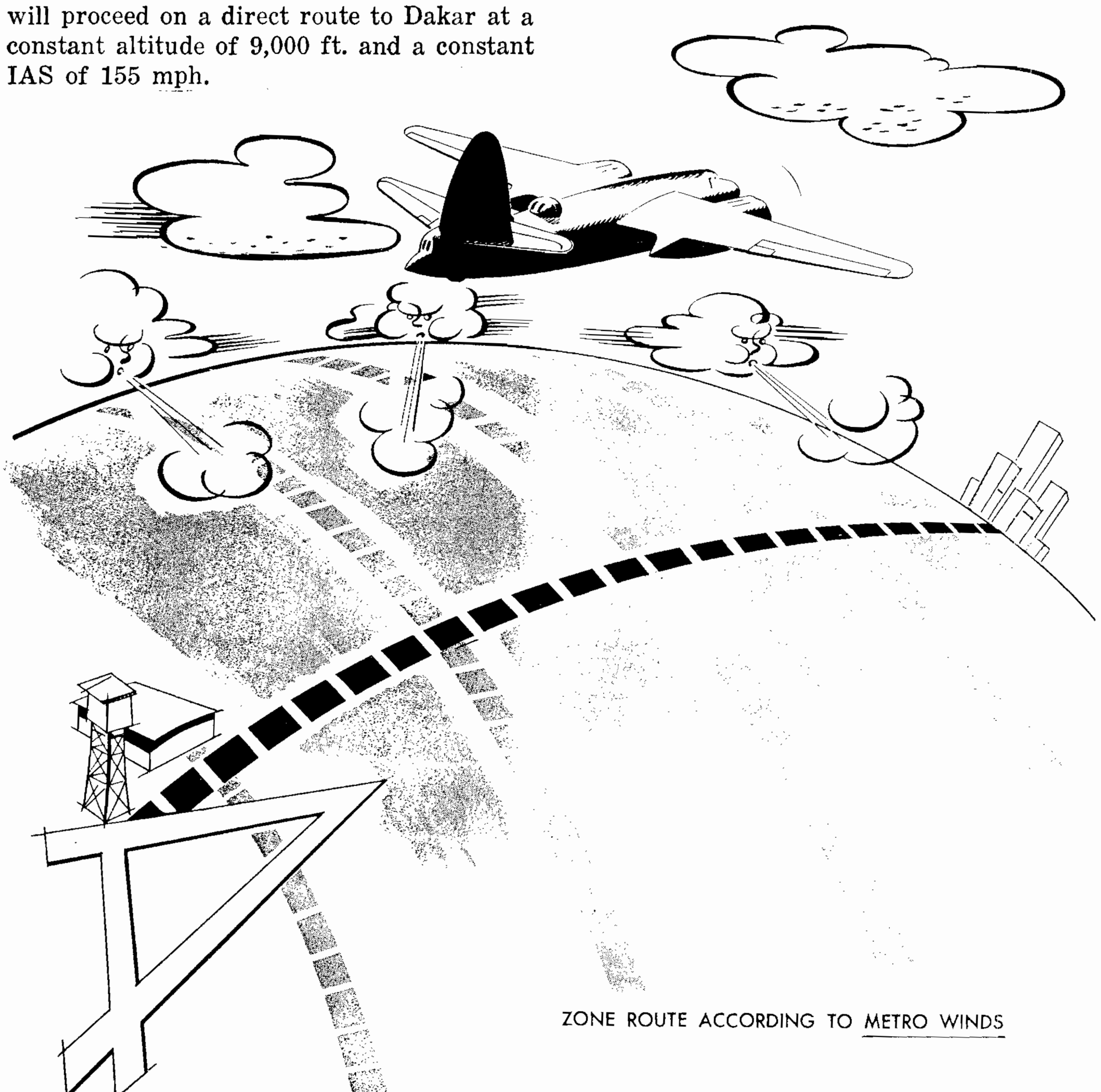
AN OVERWATER MISSION

The basic material of a flight plan has been described. To give an example of the more extensive planning that is required on long missions, the following problem will take up an overwater flight from Natal, Brazil, to Dakar, Africa.

PROBLEM

A B-24 is scheduled to depart from Natal at approximately 2400 GCT on May 1, 1945. From take-off to 9,000 ft., the airplane will climb on course at 450 ft./min. at an IAS of 145 mph. After leveling off, the airplane will proceed on a direct route to Dakar at a constant altitude of 9,000 ft. and a constant IAS of 155 mph.

The **navigator** consults the weather office **and obtains the** forecast winds and other weather information for the flight. So that he will be able to find this information quickly during flight, he records it in the weather section of the flight plan. On his chart he then plots the TC and divides it into **wind zones,** each zone covering a section of the TC in which the wind is almost constant. After establishing the level-off position, as explained presently, the navigator measures the TC and distance in each zone and fills out the balance of the flight plan log.



ZONE ROUTE ACCORDING TO METRO WINDS

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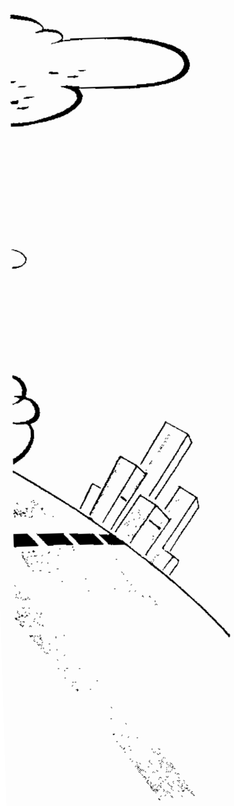
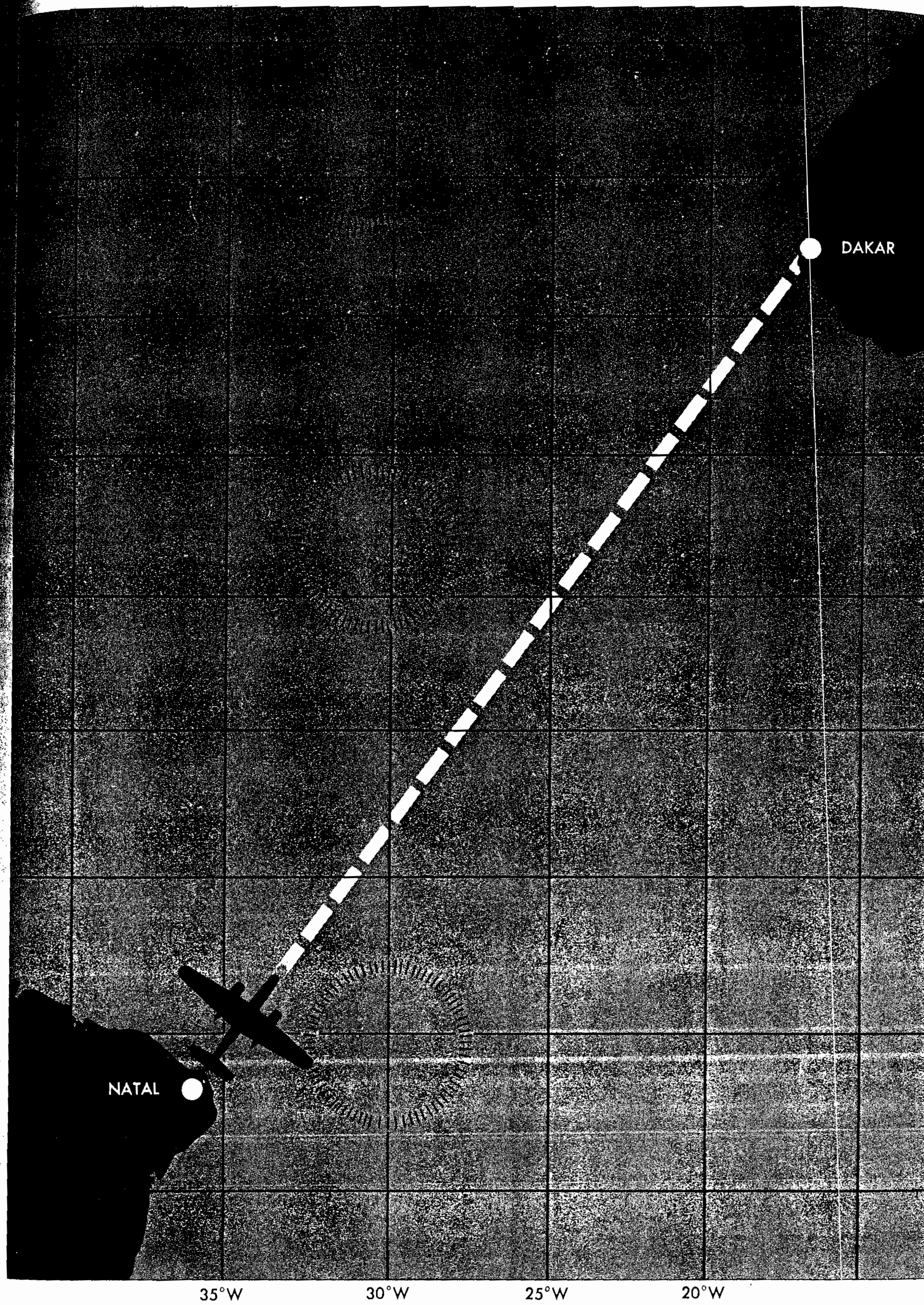


TRO WINDS



NAVIGATOR'S LOG

	DUTY	NAME AND ORGANIZATION	RANK	DUTY	NAME AND ORGANIZATION	RANK	ALTIMETER SETTING	
							DEPT.	
Navigator							DEST.	

PLANE NO. 2930 TYPE B-24J DATE 1 MAY

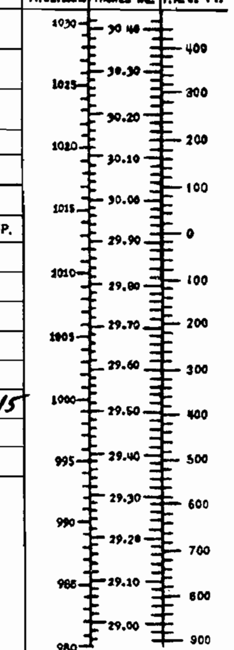
DEPARTURE NATAL

DESTINATION DAKAR

MISSION ORDERS

WINDS	FORECAST ZONE 1			FORECAST ZONE 2			FORECAST ZONE 3			FORECAST ZONE 4		
From	Natal			30° W			25° W			20° W		
To	30° W			25° W			20° W			DAKAR		
ALTITUDE	DIR.	SPEED	TEMP.	DIR.	SPEED	TEMP.	DIR.	SPEED	TEMP.	DIR.	SPEED	TEMP.
0	60	14	+30									
2000	70	14	+27									
4000	70	16	+23									
6000	60	16	+20									
8000	80	16	+17									
9000	90°	21K	+15	60	26	+15	20	28	+15	10	22	+15
Clouds Visibility Weather	CAVU			CAVU			CAVU			CAVU		

MILLIBARS | INCHES HG. | P.A.V. FT.



MEMORANDA

Gross weight — Pounds
Fuel — Gallons
Fuel — Pounds
Fuel reserve — Gallons at destination.
Fuel reserve — Gallons at alternate.

FLIGHT PLAN

From / To	WIND USED	T-C	DRIFT CORR. / T-H	VAR. / M-H	ALT. FT.	T.	IAS / CAS	TAS	GS	DIST.	TIME INTERVAL	TOTAL TIME	~~CALS.~~ / ~~AIR~~ E.T.A.	FUEL USED ON LEG	FUEL USED TOTAL
NATAL / L.O.	75°/16	041	+4 / 045°	+20 / 065°	CLIMB	+23	147 / 128	141	128	42½	0020	0020			
5°16S 34-45W / 30°W LONG	90/21	041	+6 / 047	+21 / 068	9000	+15°	155 / 134½	160	145	435½	0301	0321			
30°W. LONG / 25°W LONG	60/26	041°	+3 / 044	+21 / 065°	9000	+15°	155 / 134½	160	136	462	0325	0646			
25°W LONG / 20°W LONG	20/28	041°	-3½ / 37½	+20 / 57½	9000	+15°	155 / 134½	160	134	458	0325	1011			
20°W LONG / DAKAR	10°/22	041°	-4 / 037	+18 / 65°	9000	+15°	155 / 134½	160	141	230	0138	1149			

The Flight Plan Log

The log illustrated shows how the navigator has used a separate line of the log for each zone as well as for the climb on course.

Regarding the latter, mission orders stated that the pilot will climb immediately after take-off to 9,000 ft. at 450 ft./min. Therefore, the navigator knows that the entire climb phase will consume 20 minutes. In order to get a level-off position, he mathematically averages the predicted wind velocities in zone from the surface to 9,000 ft. He computes a mean altitude and temperature in the climb; then he determines TAS and finally GS. Applying this GS (138K) for 20 minutes, he calculates that he will fly 42½ n.m. during the climb. He measures this distance along the TC and arrives at the coordinates of the level-off position (05°16′S—34°45′W).

After the climb, the airplane will remain at 9,000 ft. and maintain a constant IAS of 155 mph. Consequently it is no longer necessary for the navigator to average winds. Instead, he uses the forecast wind in each zone for 9,000 ft.

Note that average variation is not the same in all zones. These differences from zone to zone, coupled with wind shifts, produce variable changes in MH.

Also note the ETA column at the extreme right, which the navigator has left blank. He will complete it when he records the time over departure point. Then it's a simple task to add the time en route during climb to departure time and to continue the process by adding time en route in subsequent zones to the time in the ETA column. For example, if the airplane departs from Natal at 0003, it will reach the level-off position at 0023; by adding to 0023 the predicted time en route in zone I (0301), the navigator can calculate that the airplane will reach the end of zone I at 0324, etc. Thus, the navigator calculates an ETA at Dakar.

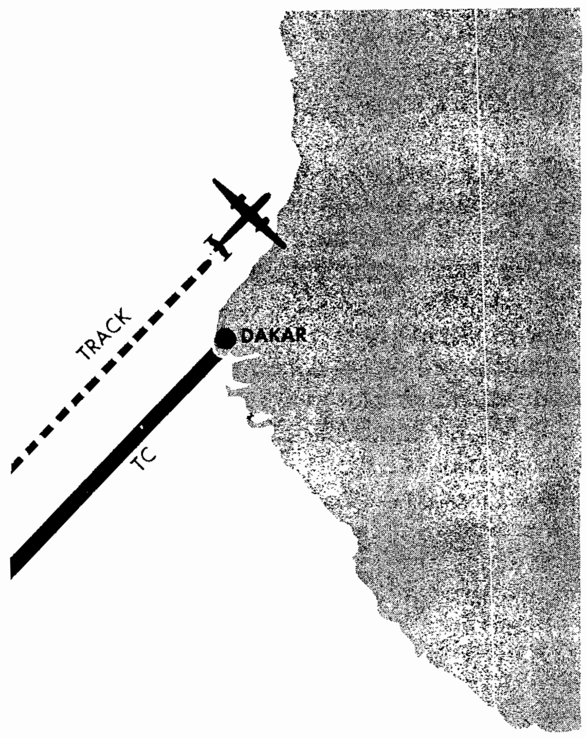
The navigator might list radio information in the following manner:

Station	*Latitude*	*Longitude*
Natal, Brazil	**05°53′S**	**35°17′W**

Frequency	*Call Letters*
347 KC	**ZWK**

Course Error

In examining the route, the navigator notes that Dakar is located on the west coast of Africa. From Dakar, the coast slopes to the southeast and to the northeast.



You can visualize the navigator's predicament if he approached Dakar left of course with visibility limited to two miles. Then he might miss not only Dakar but the entire African mainland, because he would be flying parallel to the coastline and might never see it. Moreover, he would run the risk of running out of fuel. Bear in mind that even a slight course error accumulates to serious proportions over a distance of 1628 n.m. A one degree error in 1628 n.m., for instance, would put the airplane 27 miles off course.

The advantage lies in being to the right of course. If he is to the right, the navigator can perform a terrestial landfall on the coast of Africa if poor visibility prevails. On overwater flights land may not be sighted until it is only a few minutes away.

Another reason why the navigator should keep to the right is that he will have access to several emergency airfields which have runways long enough for a B-24 and are located along the coast southeast of Dakar. Bathurst, about 100 miles southeast of Dakar, is one of these fields.

With these factors in mind, he decides to remain on course or slightly to the right of it and to alter to get back on course whenever he drifts to the left.

Celestial Preparation

Since take-off time is scheduled for 2400 GCT, the navigator will use night celestial during most of the mission. In preparation for this, he lists the altitudes and azimuths of the visible navigational stars, selecting those stars with greatest magnitude for each hour of flight. It is easy to compile this list with the aid of a current Almanac and a Rude star finder.

First, he establishes hourly DR positions by applying the flight plan GS along the TC. Then, he determines the LHA♈ at these positions. Knowing the LHA♈ he can set up the star finder and, from it, pick off the approximate altitudes and azimuths of the best navigational stars for each hour.

Here is the star list for the first two hours:

The information in this list will simplify the navigator's task of recognizing the stars and constellations, especially if he has been accustomed to viewing the heavens in the northern hemisphere. Knowing a star's altitude and azimuth, he will know where in the sky to look for the star. But the greatest advantage of this celestial preparation lies in the fact that by examining the azimuths of the listed stars the navigator can determine on the ground just what stars will give the best cut of the LOP's. An asterisk (*) follows the stars he has selected for three-star fixes, since the azimuths of those stars are more nearly 120° apart than the azimuths of any other three in the list.

Notice that the navigator listed several stars—not just the three he elected to use. He did this as a precaution, for on the flight some of the preferable stars might be obscured by clouds.

By studying the 0100 list, he finds that Rasalague, Acrux, and Denebola, being about 120° apart will provide the best cut. At 0200 on the other hand, he intends to use three other stars—Vega, Rigil Kentaurus and Regulus. Thus he will retain an azimuth difference of nearly 120° between stars.

Date: May 2, 1945

GCT 0100			GCT 0200		
DR Pos.	4°00′ S 33°40′ W		DR Pos.	2°48′ S 32°37′ W	
LHA♈	199°55′		LHA♈	217°00′	
	Alt.	*Az.*		*Alt.*	*Az.*
Arcturus	63°	029°	Vega*	18°	047°
Rasalague*	25°	075°	Rasalague	40°	070°
Antares	40°	122°	Antares	54°	130°
Rigil Kent.	33°	169°	Rigil Kent.*	34°	178°
Acrux*	31°	188°	Acrux	28°	195°
Regulus	39°	290°	Regulus*	24°	286°
Denebola*	60°	310°	Denebola	46°	297°
Dubhe	18°	343°	Arcturus	66°	354°