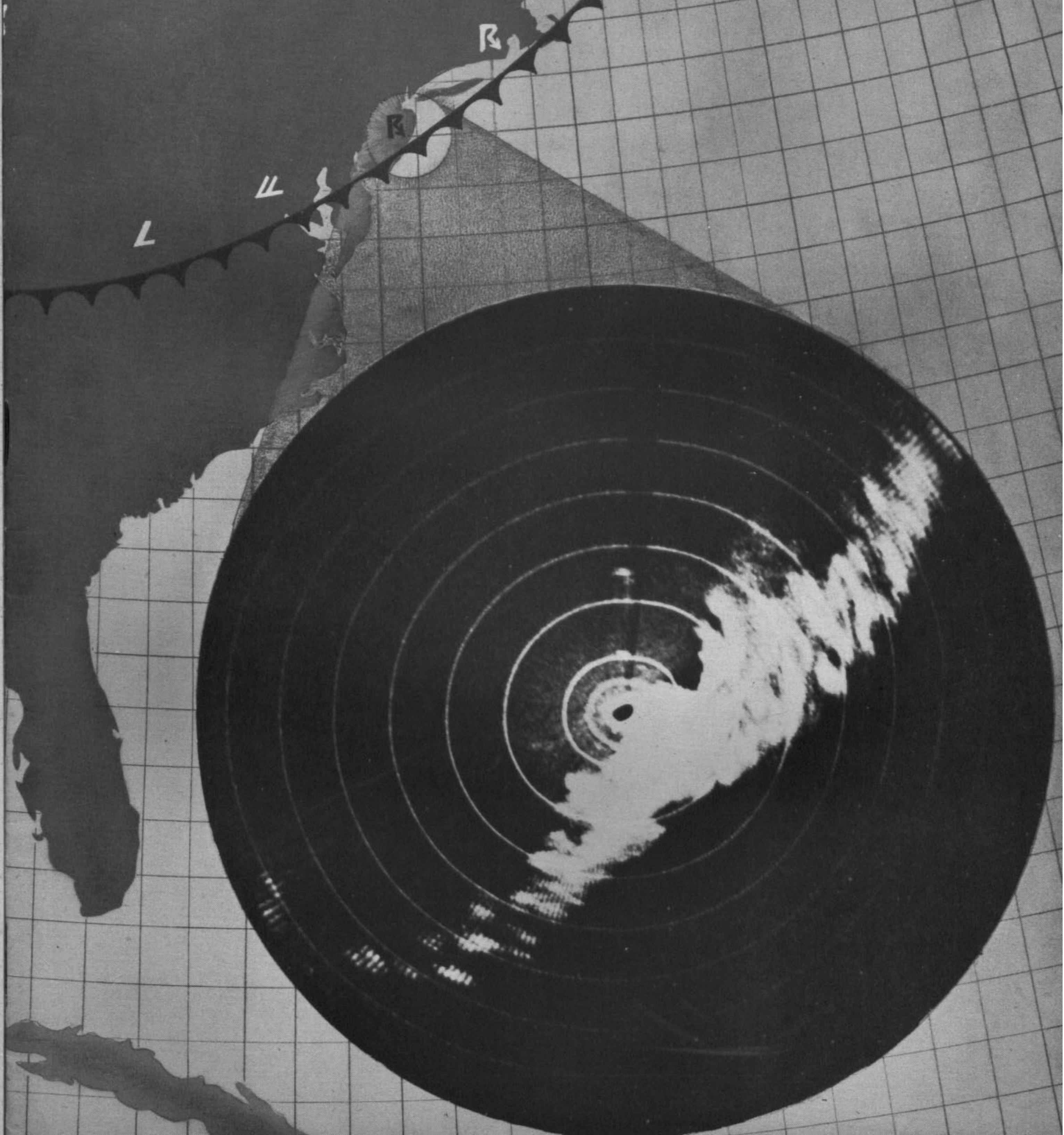
RESTRICTED

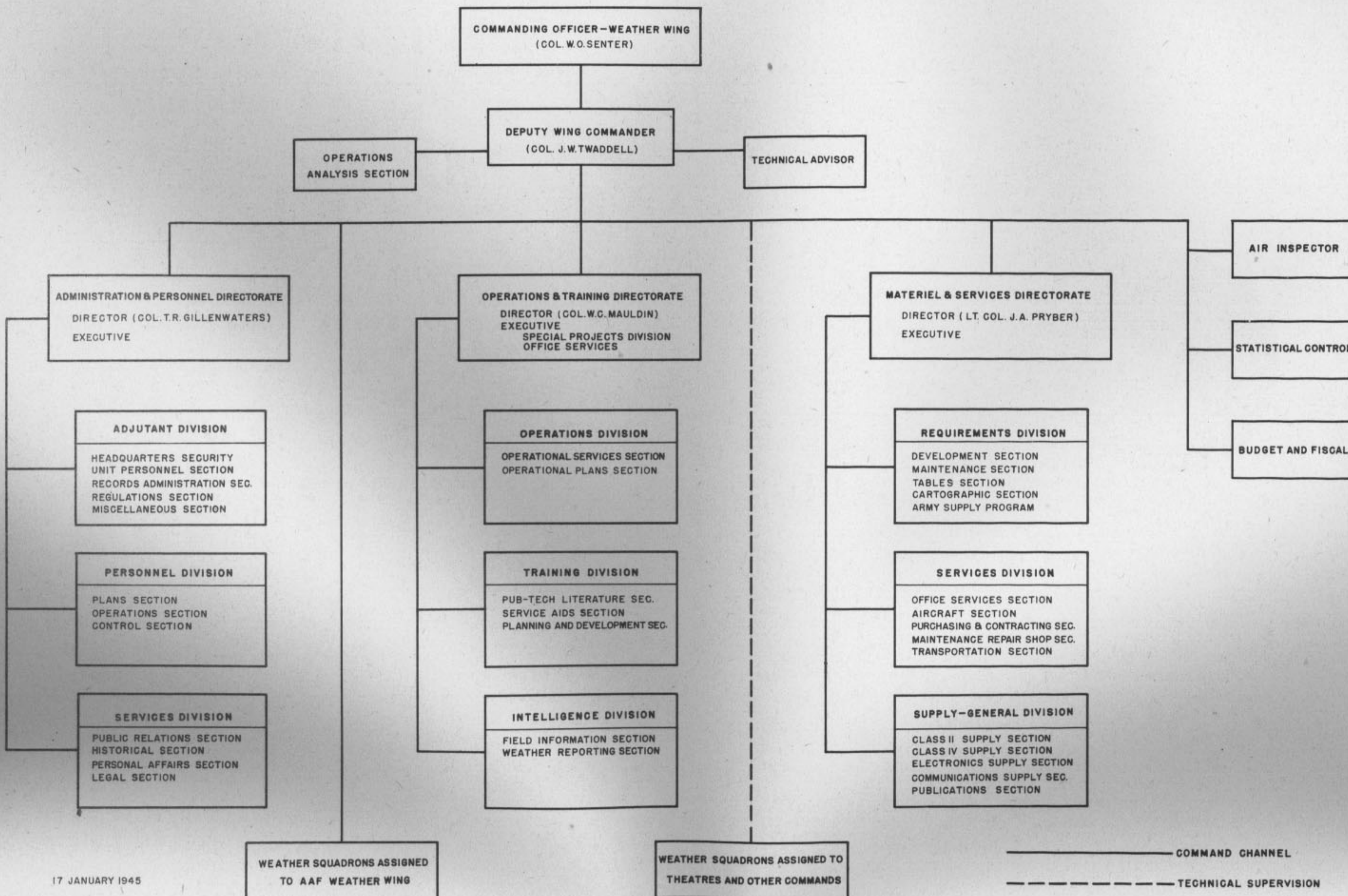
WEATHER SERVICE

Bulletin

ARMY AIR FORCES HEADQUARTERS WEATHER WING
FEBRUARY 1945 ASHEVILLE, N.C. VOL. 3 NO. 2



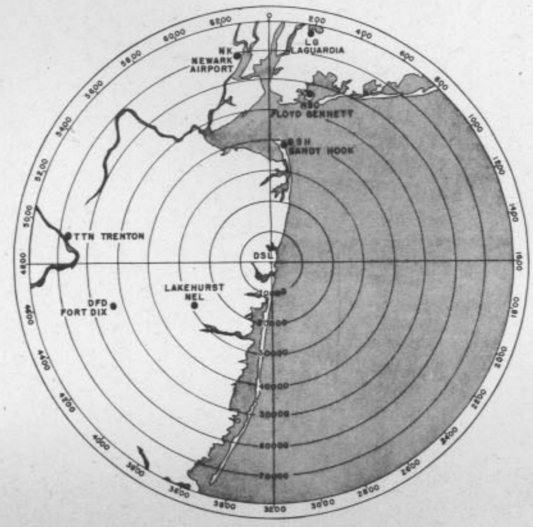
WEATHER WING ORGANIZATION



17 JANUARY 1945

RADAR WEATHER OBS

Weathermen who sharply deny the meteorological value of crystal-ball gazing are ignorant of the latest techniques. Seated before a microwave Radar indicator, an observer can see at a glance the areas of moderate to heavy precipitation within a radius of up to 100 miles and flying aircraft within a radius of 50 miles. He can determine quantitatively the distance, azimuth, area, and, frequently, the height of storms. The direction and speed of storm movements, their development, and their dissipation are clearly indicated on the Radar 'scope as well.



This map shows the area included in the PPI 'scope photos in this article, taken from a set at Spring Lake, N.J. Each circle indicates 10,000 yards of range. North is to the top.

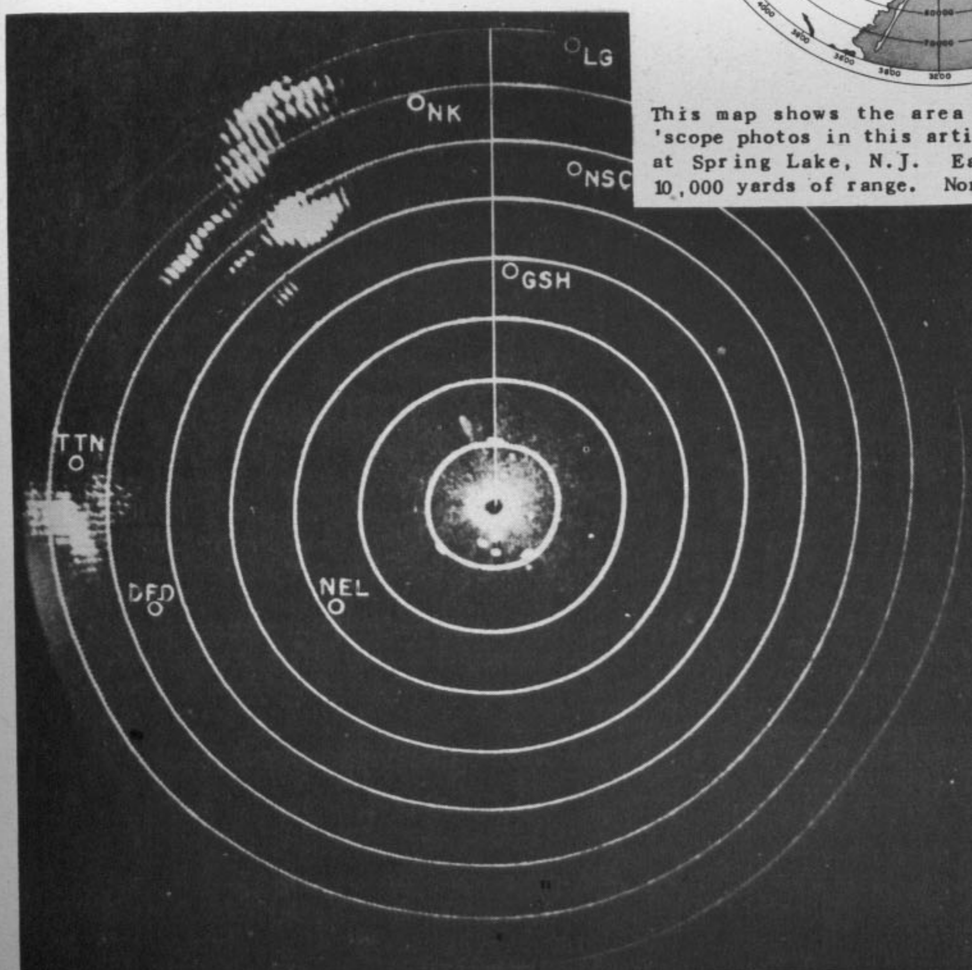


Figure 1 — 1910 EWT — 20 July 1944

TTN SPL 1908E *Thunderstorm, light rain shower, at station. Thunderstorms to NE.*
TTN SPL 1920E *Thunderstorm overhead moving NE, moderate rain shower at station.*
The weak echo over TTN may be identified with the light shower reported at 1908, and the more extensive system 20 miles NE with the activity reported in that direction. The strong echo two miles S presumably moved over TTN 12 minutes later. Reports given in the captions were made without the aid of Radar sets.

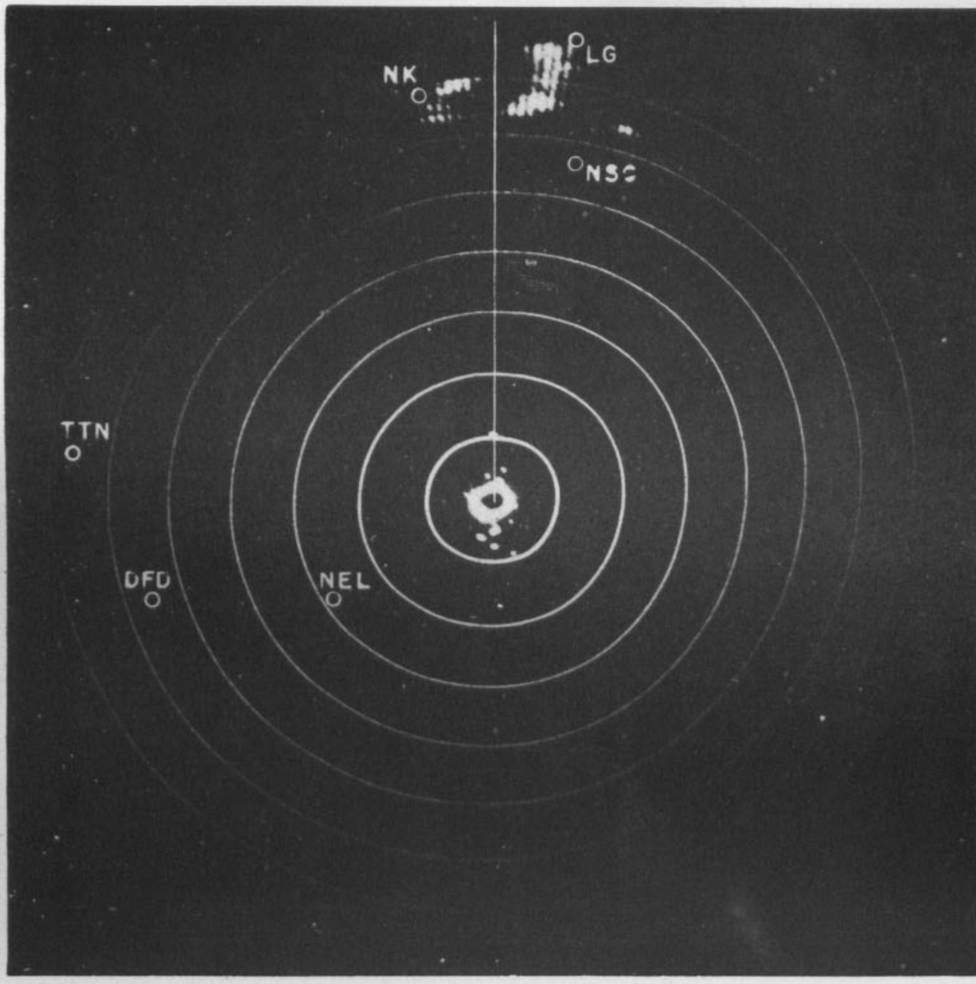


Figure 2 2034 EWT 20 July 1944

SEQUENCE REPORTS FOR 2030 EWT:

NEL - *Light rain shower.* GSH - *Light rain shower.*

NK - *Thunderstorm with light rain shower, moving SE.*

LG - *Thunderstorm with light rain shower. Occasional lightning to W.*

NSC SPL 2035E *Thunderstorm with light rain shower.*

LG SPL 2049E *Thunderstorm, overhead with moderate rain shower, moving E.*

These direct obs reveal three light rain showers which have not been detected by the Radar set. An almost imperceptible echo lies over GSH and no trace of an echo can be found near NEL in this photograph, taken four minutes after both stations reported light rain showers. (GSH has not been plotted in order not to obscure the weak echo nearby). The light rain shower at NSC was probably reported as a thunderstorm because of the intense thunderstorm activity to North.

The 2030 and 2049 reports from LG are in precise agreement with the photograph which shows LG at the NE corner of a strong echo which subsequently moved ENE. NK did report a thunderstorm at 2030, but incorrectly described its movement.

One minute, gentlemen; we said *precipitation* and *storms*. Microwave Radar detects only concentrated masses of large hydrometeors, which usually take the form of cumulonimbi, thunderstorms, and showers. Dense nimbo-stratus from which rain is falling can be detected up to moderate ranges. Fog, stratus, strato-cumulus, alto-stratus, alto-cumulus, cirrus, and clouds of the convective type from cumulus humulis to moderate cumulus congestus have not been observed to return echoes.

But since strong precip and storms are the prime hazards to aircraft, electronic storm detection has a profound operational significance. Consider the heretofore grave situation of a pilot flying toward a terminal which is hidden by tremendous Cb's imbedded in stratus. The microwave Radar screen will be acti-

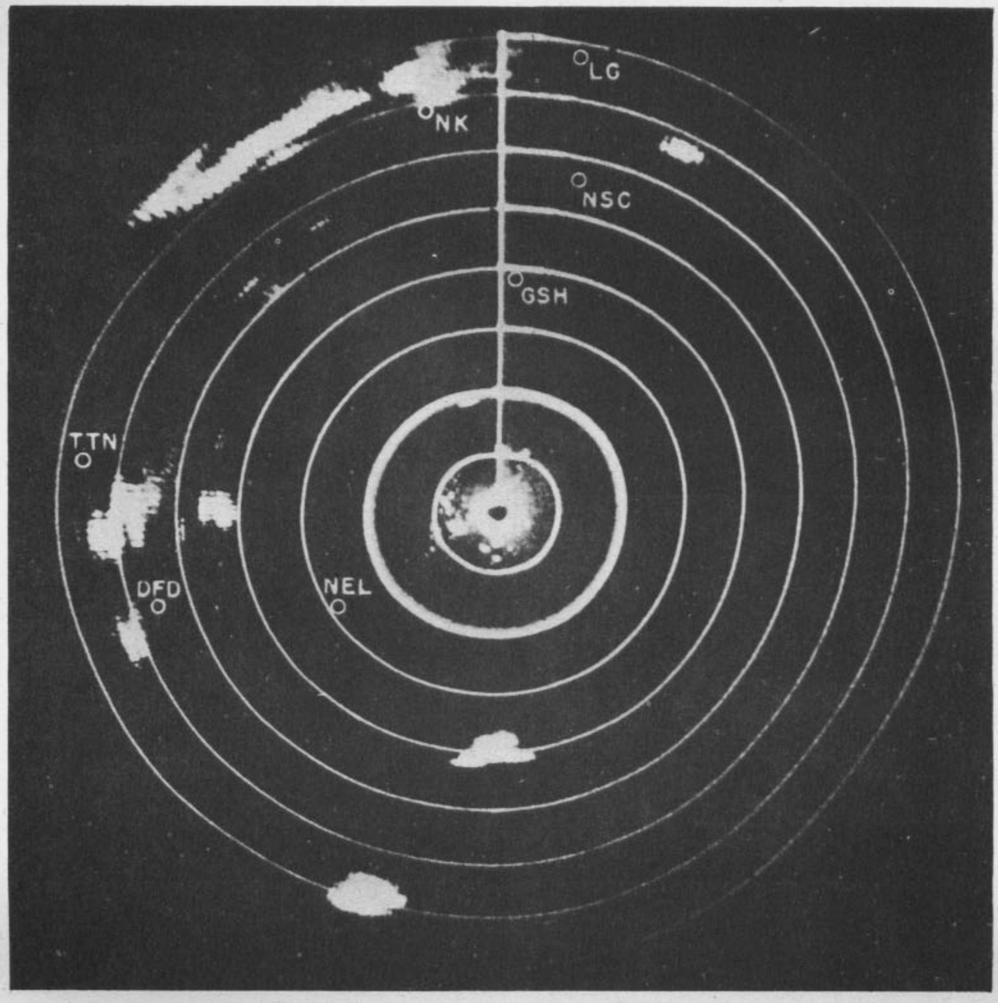


Figure 3 1532 EWT 27 July 1944
SEQUENCE REPORTS FOR 1530 EWT:
TTN - *Thunderstorm to SE, moving E, no rain at station.*
NK - *Thunderstorm, no rain at station, occasional thunder to N, moderate rain shower to NW.*
LG - *Thunderstorm, with light rain shower and occasional thunder, moving E.*
GSH - *Towering cumulus clouds in all quadrants.*

vated by the plane and the storms, but not by the stratus. It's possible, then, to vector the blind-flying plane safely around the unseen dangers and toward the airport.

The accompanying photographs show the view of weather phenomena given by microwave Radar. The concentric circles are markers of 10,000-yard range units; the center of the circles is at the instrument itself; and the top of each picture bears True North from the set. Weather stations within range are shown in figure 1, with their visual obs coincident with each Radar view given in the photo captions.

The principles of Radar apply without modification to the detection of storms, which are merely a particular type of target. Pulses of energy from a microwave set are reflected back to the instrument. The returning energy, an "echo," activates the Radar 'scope at a point which corresponds to the distance and direction of the target.

Meteorological echoes have certain characteristics which distinguish them from other targets, such as aircraft and terrain.

Motion: Cloud echoes usually show a slow movement. *Elevation:* Storms have a considerable vertical extent that enables them to be detected when the Radar beam is tilted upward enough to eliminate echoes from ground targets. *Distance:* Weather targets can be observed at distances far beyond the normal range for fixed ground targets. *Size:* The area covered by a storm echo is variable, but

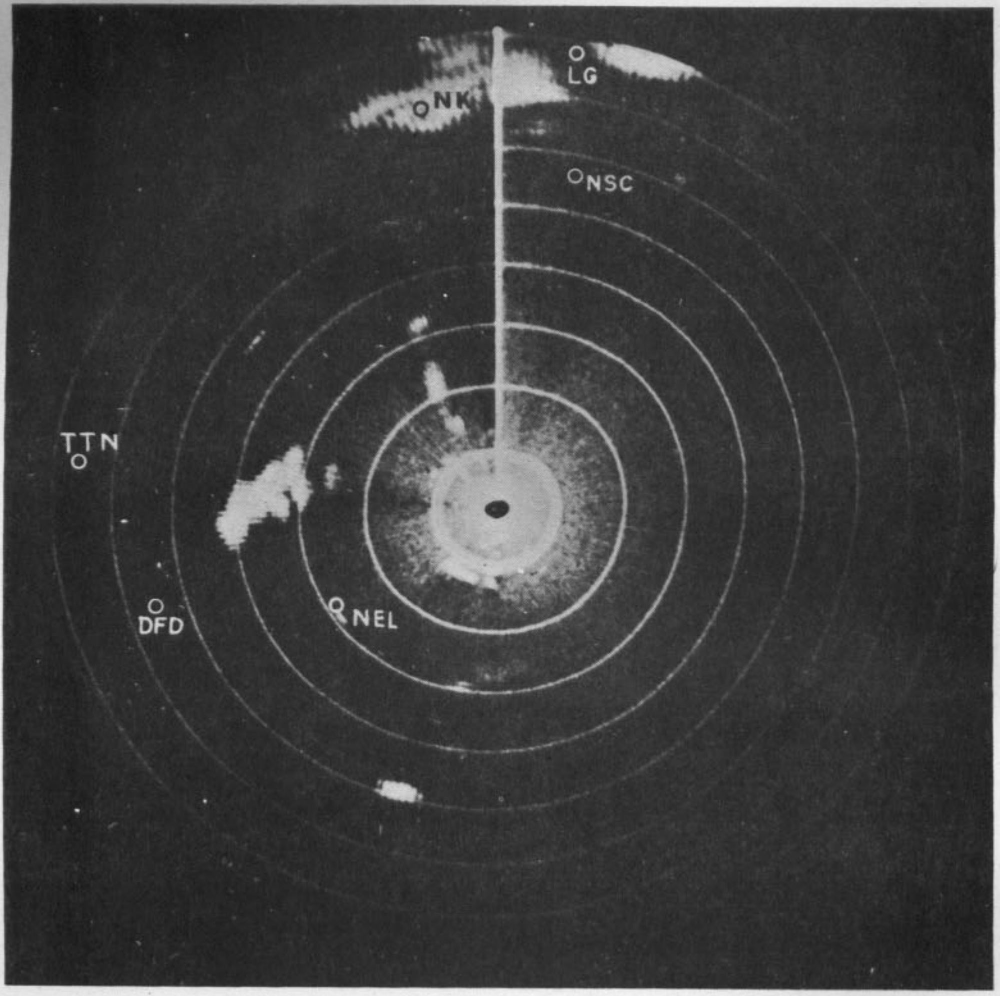


Figure 4 1630 EWT 27 July 1944 (Surface winds are plotted.)
SEQUENCE REPORTS FOR 1630 EWT:
NK - *Thunderstorm overhead, heavy rain shower*
LG - *Thunderstorm centered to E, heavy rain shower, visibility 10 mi. to NW.*
GSH - *Towering cumulus clouds in all quadrants.*

The small echoes which stretch in a line from the center of the scope to 32,000 yards toward the NNW are "second sweep echoes." The sources of these echoes actually lie at the indicated ranges *plus 96,000 yards*. These targets subtend the same angle from the set at the actual range as they do at the indicated range, so the disturbances are much larger then they appear to be.

it is usually greater than that indicated by a ground target. *Shape:* Meteorological echoes are irregular in shape, having boundaries that usually are indistinct. Continuous changes in outline are common. *Intensity:* There are wide variations in the intensities of storm echoes; occasionally, strong land signals are masked by them. Weather echoes may sometimes be intense enough to cause the screen to show a dark area or "shadow" for a short distance behind them. (Figure 4). The shadow is an area where the slight markings from interference or "noise" have been eliminated by reaction of the receiver to a very strong signal. The darkness does not indicate a blocking of transmitted energy, because signals above the noise level will appear in the shadow. *Unsteadiness:* Storm echoes are characterized uniquely by rapid fluctuations of intensity, a quality which can be detected only by an indicator of a type different from the one shown in the accompanying photos.

Considering the nature of Radar weather targets, it's apparent that micro-wave sets in middle latitudes will be useful for storm detection most often in summer. In the tropics, however, cumulonimbi and rain occur frequently all year

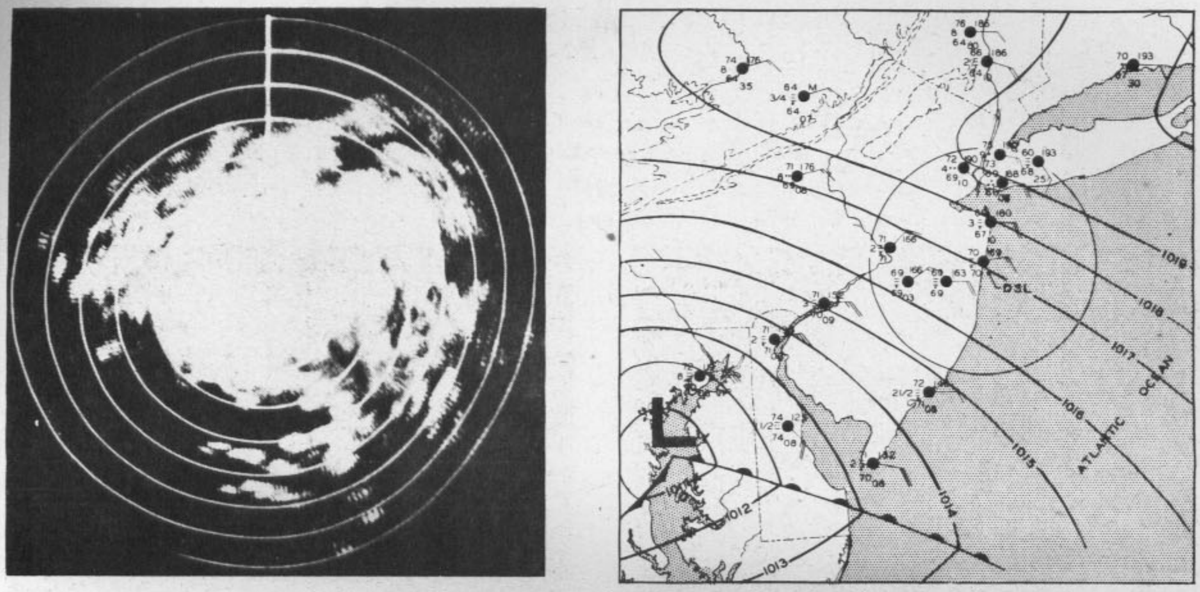


Figure 5: Pre-frontal nimbo-stratus and rain are shown by the synoptic map to cover the entire area encompassed by the range of the Radar set. The oscilloscope screen, however, shows activity only at the center. This occurs because nimbo-stratus cannot be detected at the outer limits of the range of the set.

around, and Radars can be put to daily weather use there.

Since the Radar beam diverges, power density decreases and echo strength dies away rapidly with increasing range to the target. A *bright* echo at the set's range limit is probably a thunderstorm, therefore. No direct comparison of intensity between two echoes at different ranges should be undertaken.

A storm reflects some of the Radar energy incident upon it, but at microwave frequencies few disturbances attenuate the beam appreciably, and it is possible to "see through" clouds. A target usually isn't obscured by meteorological disturbances which lie between it and the Radar set.

"RAREP" is a code word which has been authorized by the CAA to identify RAdar REPorts of weather conditions. About a dozen stations in the U.S. have the necessary microwave Radar to place RAREPS on the hourly sequences, and a few reconnaissance squadrons have been equipped for Radar storm detection.

THUNDERSTORM TRACKING

A typical example of Radar storm detection is given in the sequence of photos on the next pages, taken of the 'scope located at Spring Lake during the evening of 16 August 1944. Intense echoes at first appear between the fifth and seventh 10,000 yard markers to the north and to the west-northwest. Then, in the subsequent hour and forty minutes, they can be seen to converge upon the station---dissipating all the while. Reference to contemporaneous teletype reports identified the targets as thunderstorms, but their velocity and decay were unknown to weather stations, even those in the path. Newark's report at 2130, "TSTM APRTLY MVD SE," shows a lack of assurance that was justified.

On the evening under discussion no fronts existed in the region, and mT air prevailed. A surface trough which extended up to 10,000 feet was slowly approaching the coast from its early morning position along the Appalachian Mountains. Surface heating near the coast was enough to produce swelling cumulus in the afternoon. When the trough arrived that evening, attendant convergence pushed the cumulus beyond the freezing level, forming cumulonimbi and showers. Nocturnal cooling finally caused the Cb's to dissipate.

Air mass cumulonimbi, as exemplified by those in this series, are scattered and hard to vector by forecast. In such a situation, the bird's-eye view of storms in a large area given by microwave Radar is particularly valuable. Even when the range of detection is too small and the trajectory too erratic for much application to storm warning (except for aircraft in flight), such investigation and documentation of air mass storm behavior is a scientific necessity.

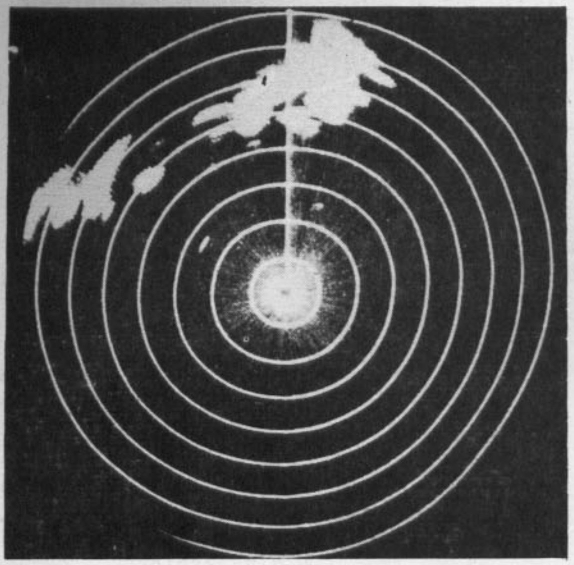


Figure 6 **1938 EWT**

NK SPL 1940E Thunderstorm. Light rain shower. Visibility unrestricted to the NW.

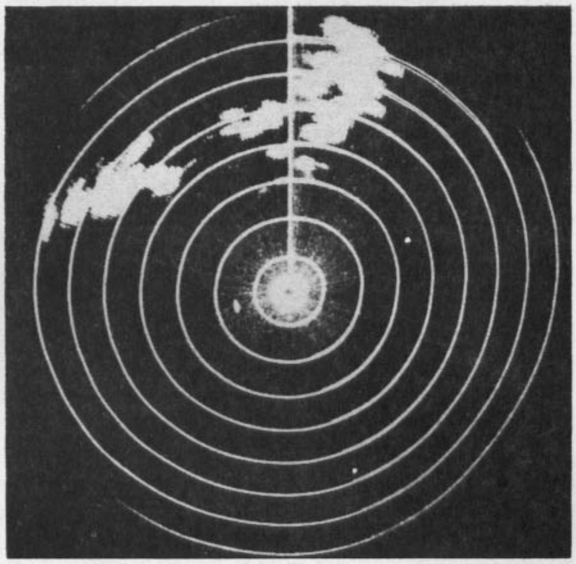


Figure 7 **1948 EWT**

LG SPL 1945E Thunderstorm overhead. Heavy rain shower.
TTN SPL 1951E Thunder and lightning overhead.

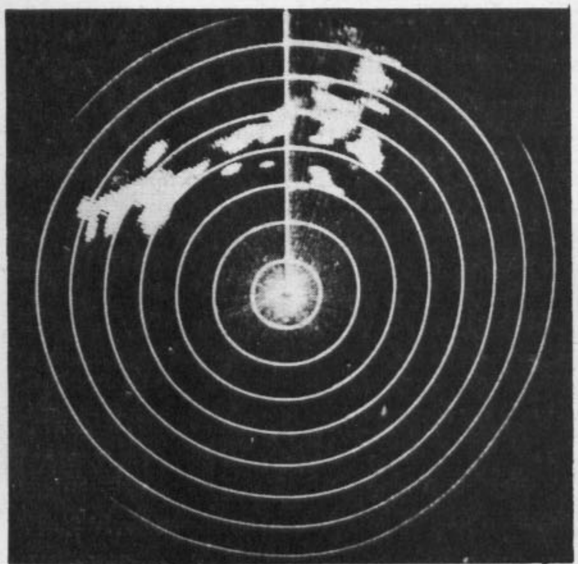


Figure 8 **1958 EWT**

Normally, the echo intensity and area may be expected to increase as the storm moves nearer to the set. Here the dissipation of the storm has more than compensated for its change in distance: the echoes break up into smaller, weaker centers as they approach the center of the 'scope.

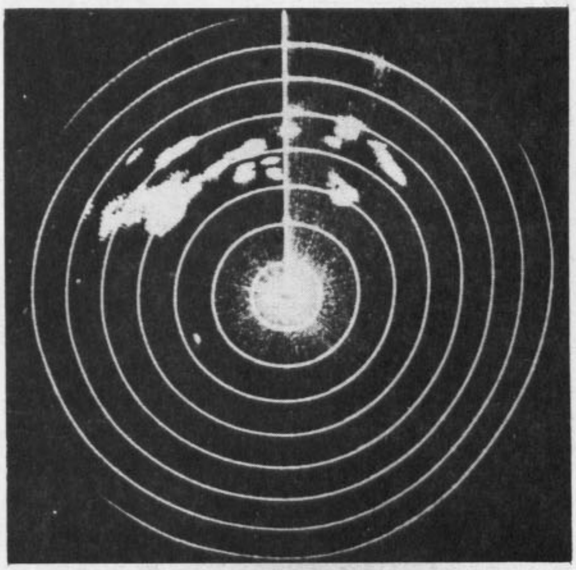


Figure 9 **2008 EWT**

NSC SPL 2010 Thunderstorm. Light rain shower. Vivid lightning N and E.

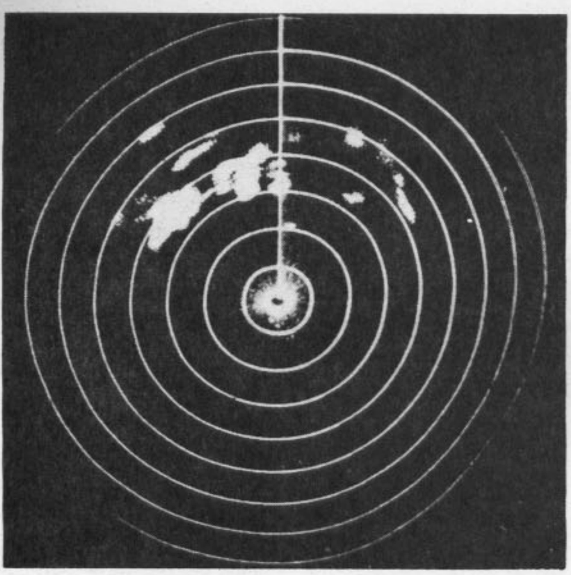


Figure 10 2018 EWT

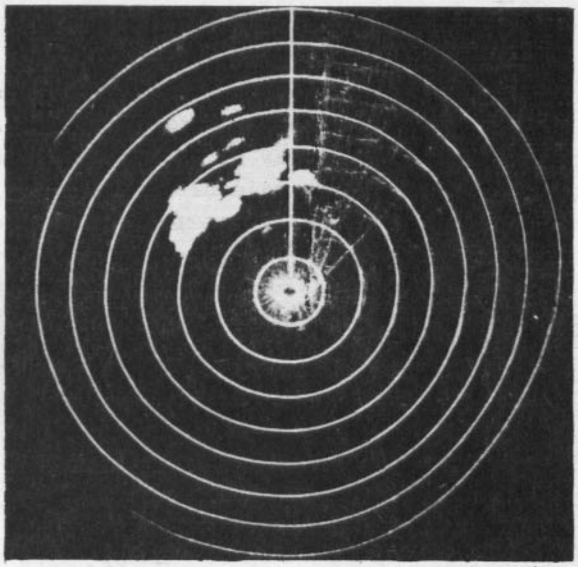


Figure 11 2028 EWT

HOURLY SEQUENCE REPORTS FOR 2030 EWT

NK - Thunderstorm. Ligh rain shower. Lightning from cloud to cloud in the SE quadrant.

LG - Thunderstorm. Light rain shower. Occasional thunder and lightning to the E.

NSC- Light rain shower. Lightning all cuadrants.

TTN- Thunder and lightning overhead.

NEL - Thunderstorm North of station.

GSH - Thunderstorm moving Northwest. Frequent vivid lightning cloud to cloud to ground.

DSL - Thunder and lightning to the Northwest.

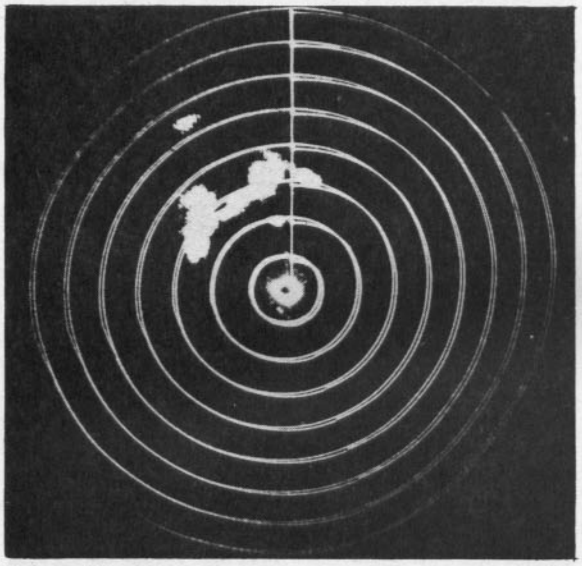


Figure 12 2038 EWT

HOURLY SEQUENCE REPORTS 2130 EWT

NK - Light rain shower. Thunderstorm apparently moved SE.

GSH- Light rain shower. Thunderstorm moved SE.

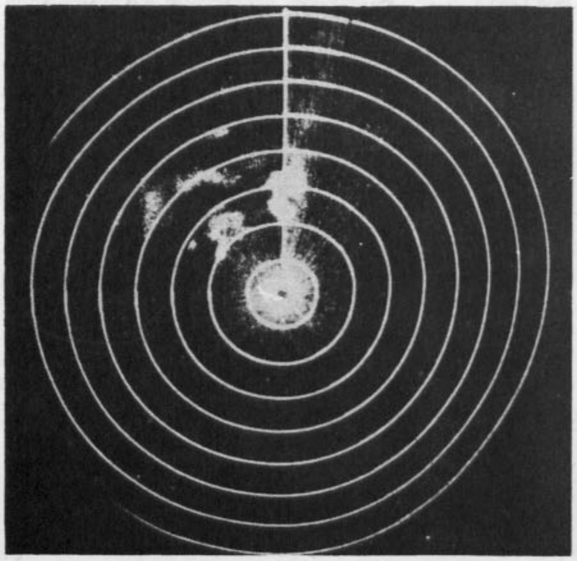


Figure 13 2058 EWT

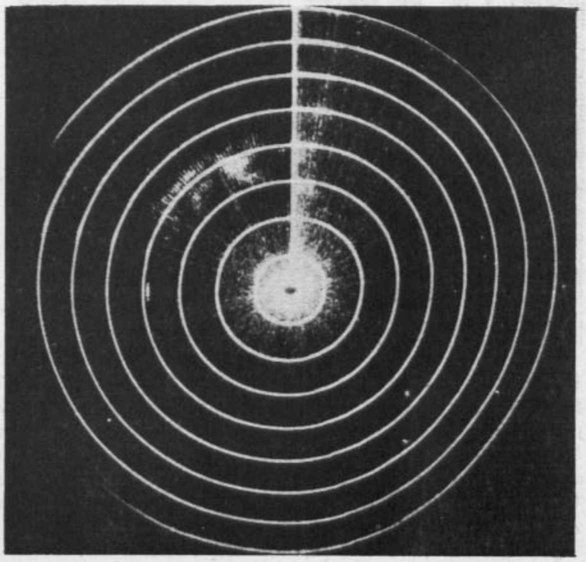


Figure 14 2118 EWT

PACIFIC INVASIONS, WX

Anything is fair play on a Pacific beach head; and not only against the Japs, either. G.I. ingenuity doesn't balk at "moonlight requisition" of any likely object---an anemometer mast may end up as a tent pole or an artillery aiming stake. Some earnest dog face even swiped a thermograph off Weather's pile on the Guadalcanal beach! What he did with it no one knows, but the metro unit had to work without an important instrument nonetheless.

The obvious moral is to leave no equipment unguarded during an amphibious operation. Sergeant Speer gives full measure from his Squadron's experience in this and other combat problems.

by S/Sgt. Robert Speer

"Weather observations on the beach head will be made available to supporting air bases from D-day onward, and the first fighters which take off from newly-won air strips will have been given forecasts." This statement makes no mention of the complex equipment, personnel, and communications needs of a weather service: it merely demands action. In response, Seventeenth Weather has organized "advance units" on eight occasions to establish stations under the smoke of battle since early in 1943, when the first metro group rolled ashore on Guadalcanal and set up on Henderson Field.

This action was repeated in sequence at Munda, Vella LaVella, the Treasury Islands, Empress Augusta Bay, Green Island, and Emirau, as the long march up the Solomons progressed to completion with the isolation of Japanese strongholds at Rabaul and Kavieng. By the end of this campaign, trial-and-error under fire had finally worked out a practical procedure for subsequent weather units which are to "go in early" during the drive on Tokyo. Much of the terrain and climate in the Philippines, Malaya, East Indies, the Bonins, and Japan corresponds to that of the Solomons.

The "old hands" at weather on a beach head agree in their advice to future landing teams. Such unanimity is certainly fortunate, because their ideas cover great areas of free decision not mentioned in AR's or tech manuals: those unpredictable combat conditions which demand solution by experience, ready sense, and ingenuity.
These are their propositions:

I. Forward groups should be selected on a volunteer basis, with rigid screening for certain special abilities and personality traits. If men are selected at random, say by MOS numbers alone, the team may be dismembered by the strain of combat.

II. Each beach head unit should have a sizeable nucleus of men who have "done it before." Those who have accumulated experience, learned short cuts, and solved problems must go along with green men; otherwise, a monotonous pattern of avoidable mistakes will be perpetuated.

III. It's wise to bring along enough supplies for two months and to suppose that no food will be available on the beach head during that period. Especially, the weather unit must be self-sufficient for tools, construction materials, and any luxuries. Certain articles may possibly be requisitioned soon after arrival, but it has been found foolhardy to count on that.

IV. Forward weather units should be organized as "combat *teams*," integrated from specialists as strictly as a bomber crew. At least half should be selected as "weather engineers" to work exclusively on construction of the station and camp area. The others may handle weather duties solely, but if their practical attainments are meagre, they won't be able to help meet an emergency in the construction of a forward-area station.

I. SELECTION OF PERSONNEL

The volunteer system was adopted by 17th Weather in composing the Henderson Field unit, and was continued with other forward-area groups. On the few occasions when other than volunteers were included, some of them couldn't stand the pressure of combat conditions and had to be replaced.

There was never any trouble finding volunteers. The merest whisper that the RCO contemplated dispatch of such a unit was enough to start a flood of applications.

But even the volunteers must be picked over. Occasionally an individual who pleads hardest to be included is the last man in the world who should go when the primary factors of health, temperament, and skill are considered.

First considerations are general health and mechanical "know-how." Men must be able to toil for 14 hours a day, knowing that five of the remaining 10 hours may be spent under air attack, soaking in a foxhole. This stint may continue for two months without letup, complicated by the inevitable dysentery (the main curse of forward areas), malaria, jungle ulcers, a horrid assortment of skin rashes, ear fungus, heat prostration, and other ailments.

Yankee ingenuity, familiarity with tools and primitive engineering, as well as abilities to improvise, adapt, build, scrounge (and if necessary, steal) are all major virtues. Captain Jones may draw the prettiest map in the region and still not necessarily be qualified for forward duty. Sergeant Smith may be a walking Circular N and be utterly useless in combat. A Big Time Operator from Brooklyn may be no budding Petterssen, but if he can do wonders with a beer can, raid a ration dump, or swap a broken-down carbine for a load of lumber when the Regular Channels bog down, he is a "forward" man.

Personal courage is indispensable, even if that is hard to define and harder still to predict. Combat neuroses are nasty to handle, and in a group as short-handed as the average advance unit, loss of any man is a very serious matter from an operational standpoint, entirely apart from its effect on the team morale. A man out of action is a triple nuisance. He cannot handle his share of a tremendous load of work, someone else must perform his duties in addition to their own, and others are distracted from their duties to look after him.

Mistakes in judgment of courage are inevitable because the only real test is battle itself. Phlegmatic men have broken down pitiably after several days of shell-fire. Yet one forecaster who was nervous and excitable---almost feminine in his normal reactions---steadied under fire and gave an exhibition of cold, controlled courage that was an inspiration to his advance detachment.

At least, the obviously-maladjusted can be eliminated beforehand. The selecting officer can obtain invaluable assistance about doubtful cases by consulting with the men already picked to go. They generally know by instinct how an acquaintance will react to enemy action. This estimate will be honest (the team's well-being depends on every one), and they at least can deftly pick the men with whom they prefer to work.

There are heels in every outfit, men whose personalities are distasteful to their fellows in any circumstance. But a peculiarity which ordinarily is only annoying can be stimulus to mayhem when aggravated by weeks of combat, bad food, illness, fear, and the normal irritability of men who are forced to rub elbows with one another for weeks on end.

The writer went into the Bougainville beach head with a warrant officer and another enlisted man, his best friends. That they are still his friends is a triumph of tact and forbearance. After a few weeks alone in a jungle outpost, our sense of humor had to be worked overtime. We had a tacit agreement to stay out of each other's way when irritability mounted to the murder point. Trivial differences can get out of hand and destroy operating efficiency in no time.

There is a strong temptation among detachment commanders, when asked to recommend personnel for new stations, to get rid of their misfits. Nothing could be more ill-advised. Chronic gold bricks, malingerers, rumor mongers, brooders, men with hair-trigger tempers, eccentrics, and men without humor above all, are more dangerous than enemy snipers in a forward area.

II. THE EXPERIENCE FACTOR

Previous combat experience is the best qualification for any man selected to set up a forward station. Beginning with Munda, every 17th Weather Squadron advance unit consisted largely of men who had "cut their eye teeth" at Guadalcanal. Next in importance is experience *within the region*. Even if they have never seen enemy action, men should have served for some time at stations near the combat zone before being permitted to go into a beach head. They should have the "feel" of the climate and geography of the section, as well as a general knowledge of the tactical and technical problems affecting their work as weathermen.

Officers and enlisted men fresh from the States, or whose experience was confined to outlying portions of the region quite different from the Solomons, eventually worked in and became valued members of forward detachments; but they usually were almost "dead weight" during their period of adjustment, and that period usually coincided with the most difficult days. Their well-meaning inexperience resulted in blunders which never would have occurred had they been seasoned in the general area for a time.

III. EQUIPMENT

Solomons weathermen think that the most desirable item of equipment on a tropical beach head is a rugged, fairly large vehicle, preferably a weapons or personnel carrier (a recon will do). All miscellaneous and personal gear, plus the rudimentary complement of observing instruments, should be packed in this carrier with the bulk of heavy equipment to follow as freight.

To my knowledge, no weatherman in the Solomons has ever fired a gun at the enemy, but there were times when weapons were carried in earnest with very real snipers nearby, and some forward weather posts were within 500 yards of the front. Carbines or pistols were favored for their lightness, with a couple of submachine guns to back them up. An '03 or M-1 Rifle is too heavy for "non-combatant" troops.

A half-dozen axes, shovels, crowbars, hatchets and machetes should be included, along with a complete set of carpenter's tools (including extra hammers and saws). Nails and spikes will be unobtainable on the beach head. Tents, cloth or wire netting, several small tarpaulins (to be used as rain covers for foxholes), and extra ponchos or shelter halves have numerous uses. A couple of buckets and a Lister Bag should not be forgotten.

Check mosquito nets for rips before packing. Headnets and an ample supply of mosquito bombs will come in handy for foxhole use. Cots are rare on any beach head. Khaki uniforms, single-piece coveralls, or camouflage suits were found to be almost unbearably hot, and the usual daytine costume was fatigue pants or shorts, T-shirt or none at all, socks, and shoes. A jacket or full shirt must be worn after sundown as malaria protection. An extra pair of shoes and plenty of socks will be appreciated.

Soap, cigarettes, candy and tooth powder can be obtained free from the nearest chaplain, but don't expect your favorite brands. If possible, obtain a new raincoat before leaving, inasmuch as an old one will go to pieces in a few weeks. Every spare inch of space should be packed with extra food, especially the popular "J" rations, canned fruit, and meat. "K" rations make good snacks but they are pretty tiresome.

If a Quonset hut can be secured, bring it along, but pack the sections at the bottom of other station equipment lest it be seen and appropriated by wanderers. The same precautions must be taken with a typewriter, the most valuable single piece of office equipment.

IV. ORGANIZATION

The ideal "advance unit" consists of an initial group of six: a weather officer of sufficient rank (preferably a Major) to obtain the "co-operation" of other units, a junior officer with considerable experience in the region, and four enlisted men, including a forecaster and three observers.

Landing the moment a toe-hold had been won on the beach, or perhaps a day or two after the first wave had gone ashore, this group would become "weather engineers." They would select sites for station and camp areas; complete arrangements for communications, rationing, and medical care; and begin construction work. Their job would also require the taking and transmitting of observations for the use of supporting air bases.

When Allied air strips go into operation on the beach some days or weeks later, forecasting would be added to the group's functions. An additional six men should land then, so that twelve men could be split into two equal units; one to handle weather duties exclusively and the other to concentrate on construction. This plan eliminates the necessity for men to work 12-hour shifts in a makeshift station, only to spend an additional six hours a day at the hard physical labor of hacking out a camp.

When construction has been completed, a full station complement could move in and take over, relieving all but a few of the original twelve to leave gradually for rear areas and a rest. Specially-skilled and selected, these men would be invaluable to an expanding weather squadron, with their cumulative experience making each new job easier.

A thousand islands still lie between the Allies and Tokyo. And every so often, Major McSnowshoe will say to Corporal Hammerschlag, "Why not?"

And the Corporal will reach for his "A" bag and reply, "Count me in!"

Precip Static

From a report by the Operational Analysis Section, Second Air Force

The impact and consequent shattering of precipitation particles against a metal airfoil charges aircraft to a potential difference with the nearby atmosphere. A discharge is inevitable. When minor, it may excite a static disturbance which masks radio reception. In an extreme case, where strong convection has polarized the general atmospheric surroundings opposite to the charge on the aircraft, a major discharge can occur: the pilot may be blinded, radio equipment destroyed, and the plane lost.

Very small charges may leak off by conduction, establishing a current flow which is so weak as to be undetectible. When the rate of charge-accumulation is somewhat greater than the charge-loss by leakage, nocturnally-visible corona discharges (St. Elmo's Fire) appear at the sharp tips or edges of the aircraft structure. St. Elmo's Fire is harmless in itself, but it is a bad omen. When the current flow in any corona discharge exceeds a certain limiting value dependent on local structural characteristics, audible interference develops in the airborne radio facilities. This is *precipitation static*---a crackling, hissing, or frying noise---which grows to a steady roar as the corona discharge increases in intensity. Later, sparks may jump across short gaps within the plane.

In one circumstance, a B-29 was flying through updrafts, heavy rain, and hail. Discharges of static electricity were noted frequently, always when the plane was being bombarded by water or ice. Two-inch sparks flew among metal parts of the radio equipment, and even longer arcs were observed in the plastic nose of the ship. Although the radio operator manipulated the *antenna transfer switch* so as to discharge the skin of the ship and then the trailing antenna, the latter aerial had already been destroyed. If this occasion had been a combat mission, the plane would have been rendered inoperational by such a mishap.

The charge which develops on the outer skin of a plane is proportional to the product of the effective skin area and the True Airspeed cubed: larger, faster aircraft are exponentially more open to precip static and lightning strikes. Unusually intense electrostatic charging has been observed on B-29 Superfortresses.

Excessive charges occasionally accumulate on the skin of a plane that is flying through precipitation, and then a discharge habitually described as "lightning" may occur. This phenomenon is apparently local, and no case is known for certain where a plane has been struck by a full scale thunderbolt. "Junior lightning" may be disconcerting enough, however: temporary blinding, the melting of antennae and prop edges, and damage to radios have been its effects.

Forty-five cases of "lightning strikes" on commercial aircraft have been investigated. Each occurred in some cloud of vertical development (cumulus, stratocumulus, cumulonimbus), at near-freezing temperatures, and when precipitation was falling at flight level (hail, sleet, snow, rain). Sometimes, no purely meteorological lightning was observed in the offending clouds. No cases happened at temperatures above 40°F or below 18°F.

Naturally, only conjecture evidences that lightning might be a cause of major accidents, but this factor is suspected in the famous case of Senator Lundeen's death in a transport crash. Experiments show that lightning can enter through the plastic nose of an aircraft, and in so doing may knock the pilot unconscious.

Commercial airlines, familiar with the dangers of precip static and lightning strikes, have adopted several procedures to minimize them:

Avoid flight in precipitation, thunderstorms especially. (The AAF can often use airborne Radar to avoid the most dangerous areas). Change altitude, preferably to temperature above 40°F, as soon as conditions favorable to lightning are recognized.

Lessen airspeed to a safe minimum above stalling speed, thereby reducing the accumulation of a potential difference (collisions with precip particles).

Use protective goggles or keep one eye (or the copilot's eyes) closed when flying through conditions favorable to discharges.

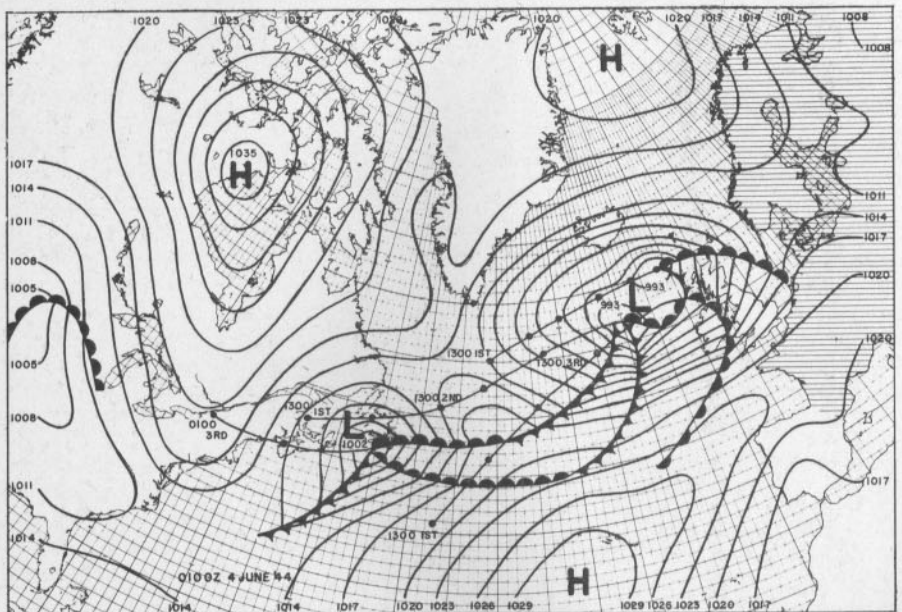
Adjust the automatic pilot so that it follows the flight path: then it can be engaged by a touch if the aviator should be blinded. Few pilots care to use automatic flight continuously in turbulent zones.

Turn up the cockpit lights to their highest intensity when lightning is feared, to aid recovery of vision if blinded by a discharge.

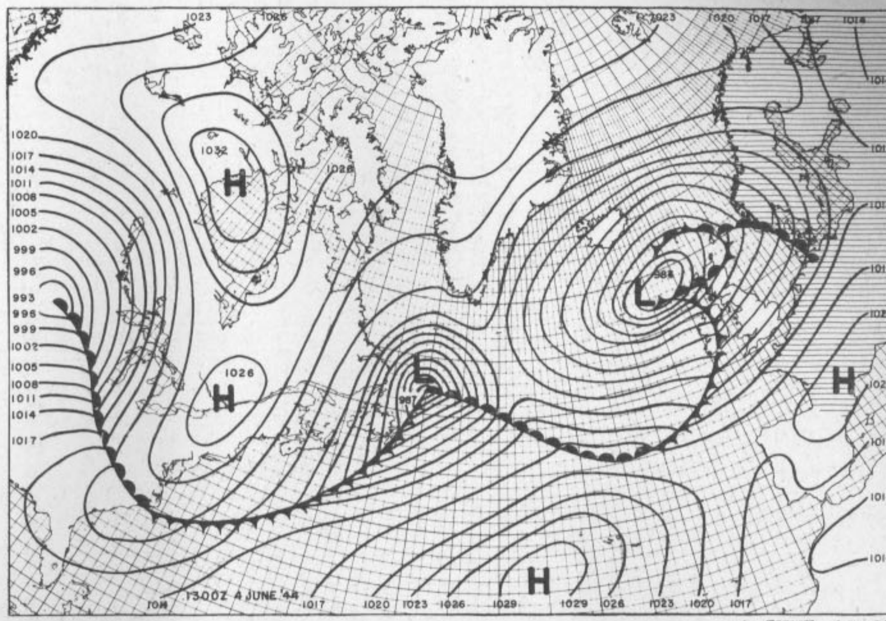
Low clouds and poor visibility restrict air activity but protect naval maneuvers. Swells and surf make landing craft poor targets, but at the price of some swampings. Rain obscures assault but mires vehicular traffic. Obviously, there is no synoptic situation which will satisfy all the component arms in an amphibious landing. A compromise in deciding the 'desirable' or 'minimum' weather conditions must be made ---a more hazardous choice than the actual forecast.

As a working plan for the invasion of Normandy, 5 June at the midnight high tide was the tentative goal of long term preparations. When that date came within the scope of short range forecasts, the amphibious operation was ready to go on schedule. However, a staff of the most prominent names in Allied meteorology could see that a cold front would pre-empt the stage: on 5 June it would be performing its own invasion of the Channel Coast with a fury that man could not match. The Supreme Commander agreed that D-day must yield to nature's priority, but at the same time he made an irrevocable selection of 6 June.

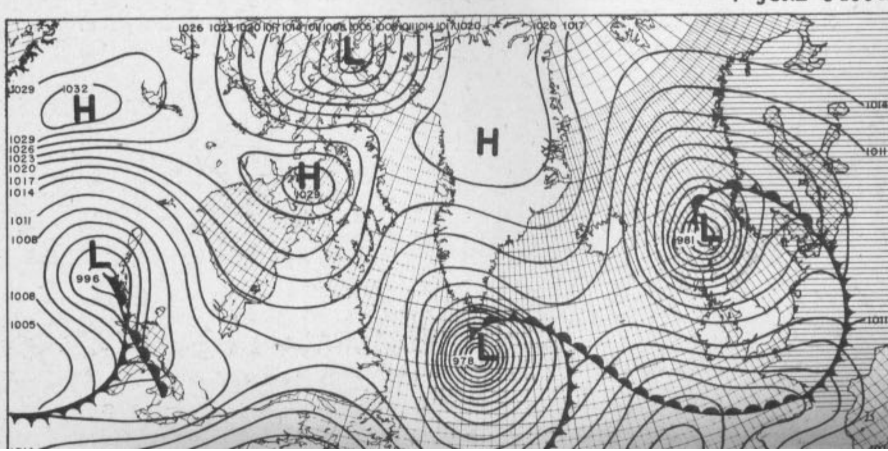
In the 24 hours before H-hour, the Azores High pushed north, thrusting a ridge over France and steering the next Low to the north. Only slight frontal influence was felt over beach head operations. Yet the Commander of Allied Naval Forces was able to say, 'The element of surprise prevailed up to the time of coastal shelling.' Apparently a satisfactory job had been done in '*Choosing the Weather for Action*.'

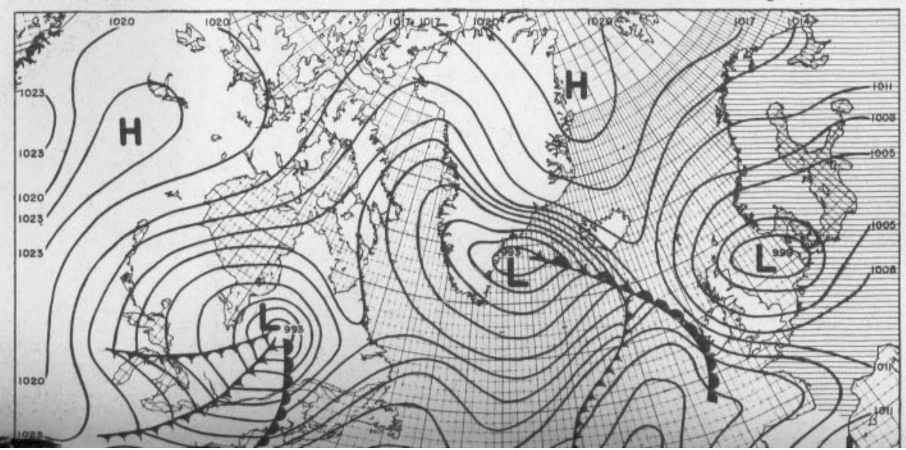


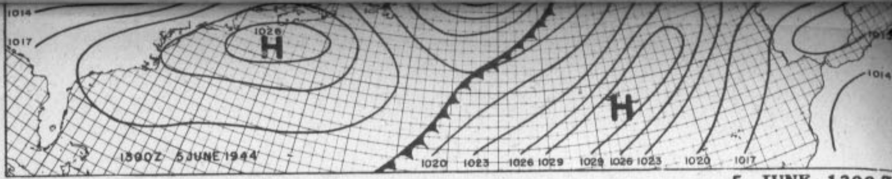
4 JUNE 0100Z



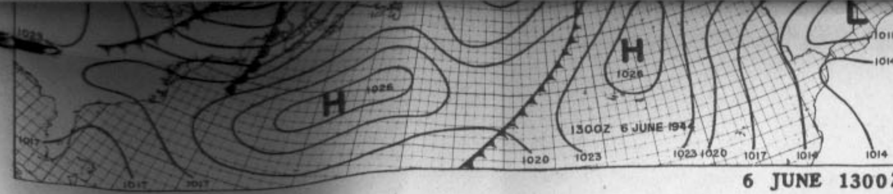
4 JUNE 1300Z



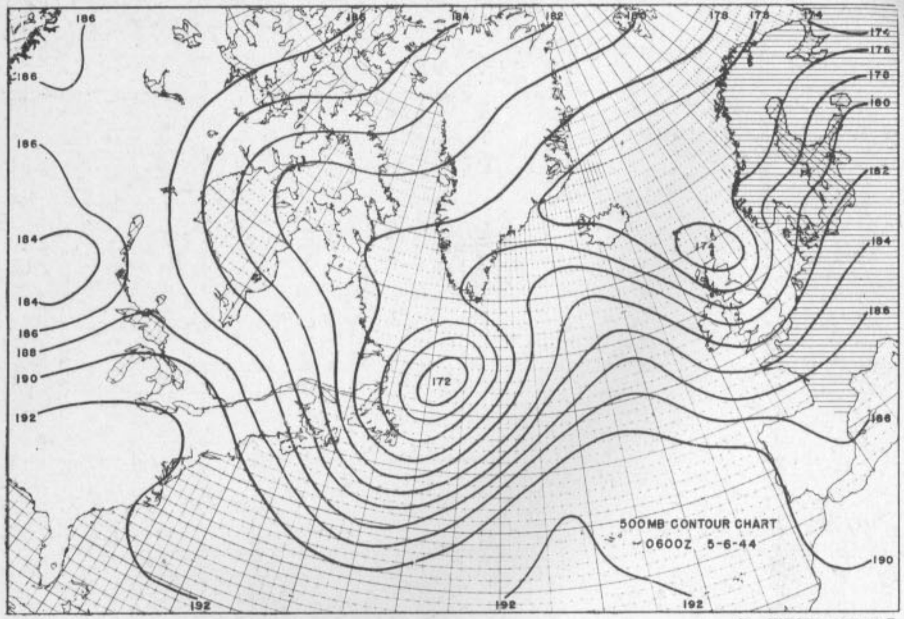




5 JUNE 1300Z



6 JUNE 1300Z



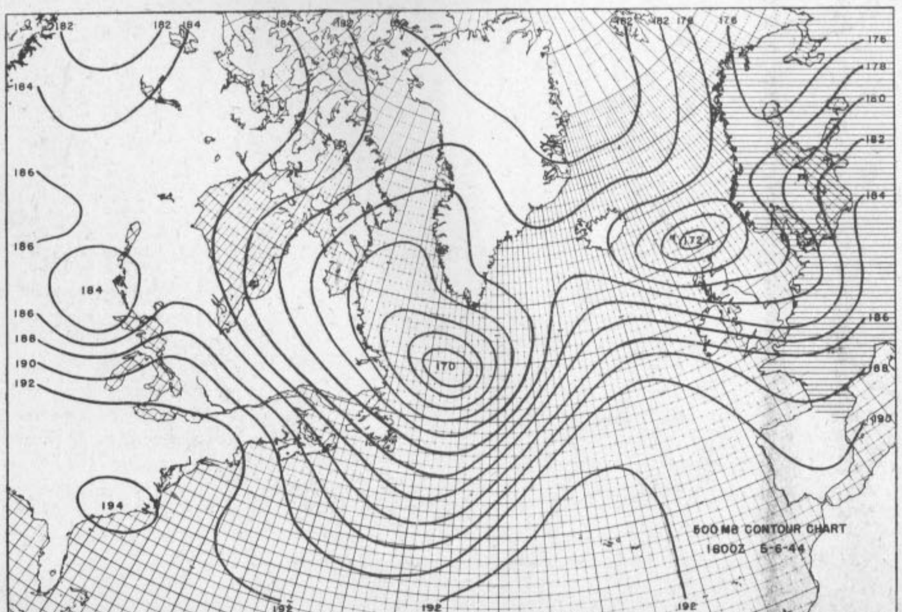
5 JUNE 0600Z

Frontal systems and circulation patterns causing the weather on and before D-day are shown by these surface and 500 millibar maps. (Figures on the upper air maps refer to the height of the surface in hundreds of feet above sea level).

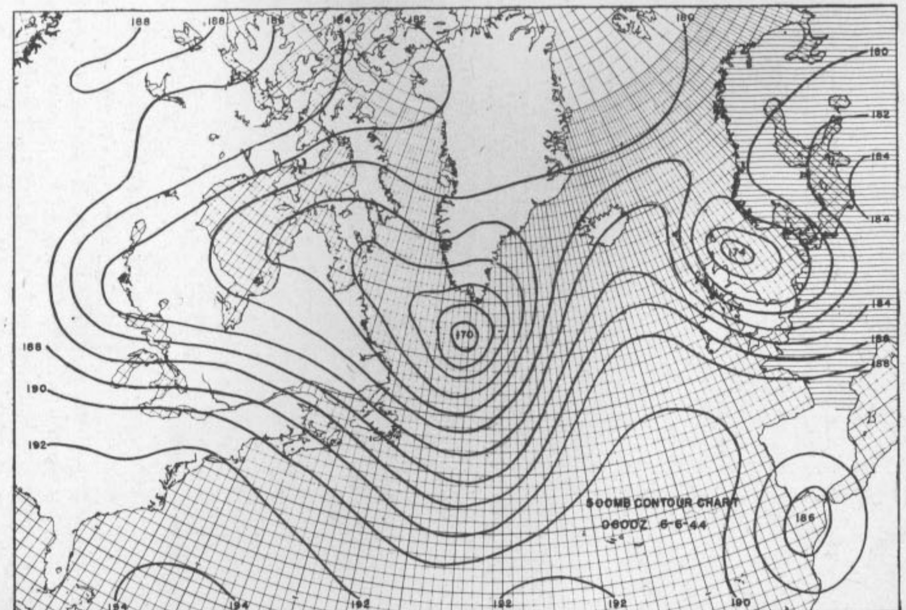
During the first hour of D-day, paratroops and gliders began landing in France, and naval forces were approaching Europe's beaches. A Force 3 wind from the west blew under broken to overcast clouds based at 4,000 feet. Near 0400, the cloud system began dissipating to 4-6 tenths coverage, while the wind veered to WNW. Two hours later, the beach head cleared, although 6-tenths low cloudiness persisted inland. By 0800, the capricious sky became overcast above 11,000 feet, and a low broken layer was established with the base at 3,000 feet and the tops at 7,000 feet.

During the late afternoon, the Channel remained clear, but variable 6-9 tenths low clouds covered the beach head. The wind remained at WNW.

Analysis in the shaded areas of the Continent was based upon both extrapolation and reports from weather reconnaissance flights.



5 JUNE 1800Z



6 JUNE 0600Z

Sferics is short for 'atmospherics', the static from atmospheric electrical discharges.

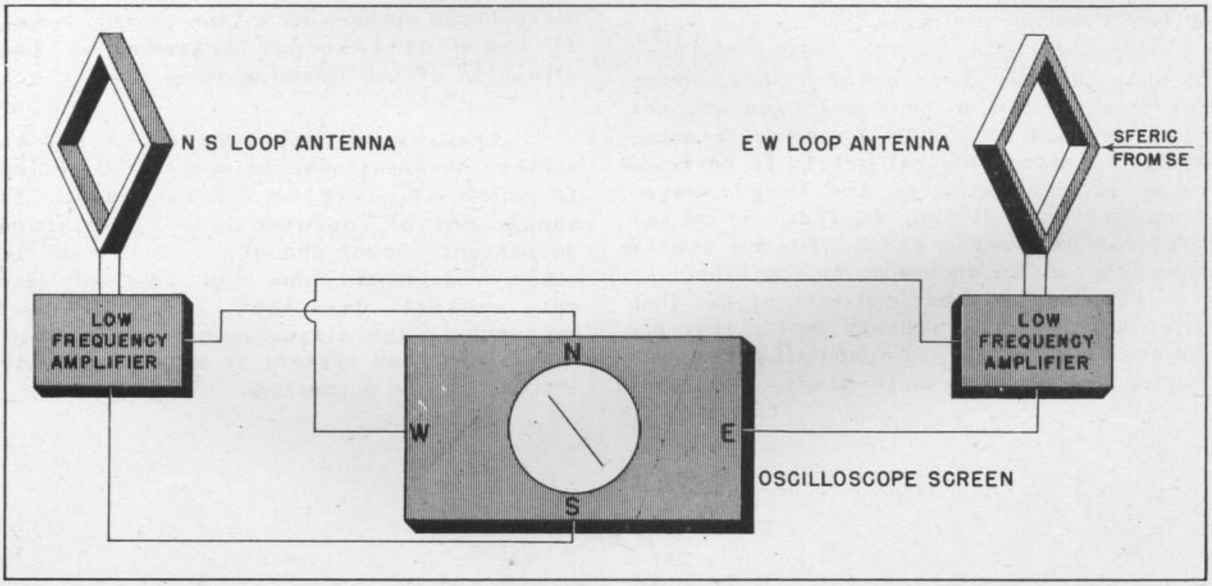
SFERICS

Oceanic areas have given the synoptic meteorologist almost a free hand in drawing a solution around very sparse data. But now that a Sferics network (triangle of special Radio Direction Finding stations) along the North Atlantic Coast is locating discharges of atmospheric electricity far out at sea, another step has been taken toward unique analyses. Atmospheric discharges can be presumed to coexist with strong convection, in the absence of contradictory evidence; a thesis which has been borne out by direct observations of convective phenomena in the vicinity of Sferics fixes.

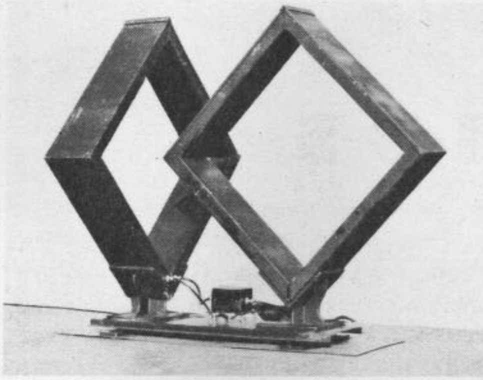
As the static which originates at a discharge of atmospheric electricity is received at each RDF station, a line of light momentarily flashes on a calibrated screen---a line which is oriented in the direction of the disturbance. Simultaneous observations from two or more stations in a widespread network can give lines of direction which intersect at the position of the discharge.

The network establishes communication among all stations according to a fixed schedule. Within the 15 minutes preceding each observation, the stations take a five minute preliminary count of Sferics activity in all directions. The number of flashes in every 20° sector is later included in the message to the control station, so that the observer there can assign qualitative intensity values to the fixes obtained later.

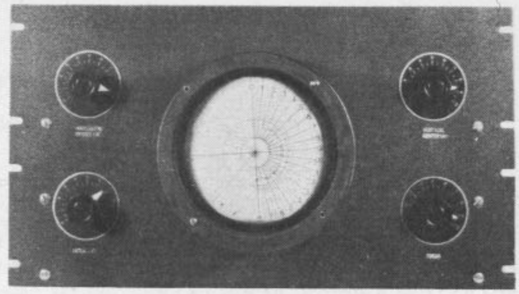
When the scheduled time arrives and inter-station contact has been made, the operator at the control station selects those flashes on his screen which are to be recorded. At the same moment, operators at the other bases are signalled to record the direction of the Sferics flash lines simultaneously observed on their oscilloscopes. Control of the net is rotated during the observation period so that each station designates the recording of about 20 Sferics flashes. Each discharge is classified by the degree of certainty with which each observer reads its bearing.



Basic elements of *Sferics* equipment are shown in this schematic diagram. Static which originates from an atmospheric discharge of electricity is picked up by the directional antennae and amplified. This signal is converted by the oscilliscope into a momentary line of light which points to the direction of the disturbance from the *Sferics* station. The intersection of simultaneous bearings read at widely-separated stations and plotted on a map, "pinpoints" the discharge.



These mutually-perpendicular antennae are called "directional" because the ratio of voltages induced in each by an incoming signal gives information about the direction of the source.



The central dial is the screen on which static from an atmospheric discharge produces a momentary flash of light. The calibrations refer to degrees of azimuth from the station.

The information thus obtained is sent to the control station, which maps the data to determine the location of each discharge by the intersection of bearing lines. A reliable fix is one for which alteration of each bearing by not more than three degrees will produce a pinpoint intersection. Accuracy of the fix is determined from three factors: its position within the Sferics network, the "index of certainty" given at each station for that fix, and the number of fixes obtained in the same position. Coded Sferics reports, giving both location and intensity, are distributed to weather stations in the same manner as other weather data.

High-frequency RDF networks designed to spot aircraft have covered ocean areas for some time. These facilities are not being applied to Sferics, however, because static of meteorological origin is believed to be concentrated in the longer wavelengths. In addition, Sferics use of low frequencies avoids the confusing static from other radio equipment in the area.

Sferics equipment consists of two loop antennae, two low-frequency amplifiers, and an oscilloscope. One antenna loop is mounted in a north-south plane, the other in an east-west plane. The electromagnetic wave originating at the atmospheric electrical discharge passes over the two loops of the direction finder, inducing a voltage in each loop which is proportional to the cosine of the angle between the plane of each loop and the wave's direction of travel. These small voltages are amplified in the same proportion, and each is impressed upon a deflection plate of the cathode-ray tube in the 'scope. These voltages cause a deflection of the cathode ray, resulting in movement of a spot of light on the fluorescent screen of the cathode-ray tube. The resultant of the two deflections appears as a line on the screen of the oscilloscope, oriented in the direction of the incoming wave.

Sferics, an application of RDF to weather observations, is restricted to the location of electrical discharges. It should not be confused with *Radar* storm detection: Radar obs are more limited in range, require only one observing set, give more explicit data about the nature and movement of the disturbance investigated, and record some systems in which no static discharges are occurring.

EARTH SCIENCES *in Liberal Education*

The leaders of military and civil meteorology, with Dr. Rossby as one of the most prominent figures, are performing the spadework necessary to a broadened use of meteorology and the other earth sciences in American life. Many commercial and productive enterprises have already been stimulated to anticipate new efficiencies when the application of geophysics to their specialized problems becomes possible upon the return of military scientists. Beyond this mark there is a further aim---an important place for geophysics in educational programs. Chemistry and physics, the so-called 'basic' sciences, have monopolized the attention of non-professional students of science in the past. Dr. Rossby discussed the narrowness of such curricula before a recent meeting of the Commission on Liberal Education (Association of American Colleges) where the role of physical sciences in liberal education was being discussed. Dr. Rossby's statements there are reproduced below with his permission.

By Dr. C.- G. Rossby

The claim for a place for the sciences in liberal education must be based on the need to clarify, in the minds of educated laymen, the complex character of man's relationship to his physical environment and the role played by the individual physical sciences in exploring this relationship. It is perhaps an oversimplification, but a useful one, to say that we are concerned with both a "microscopic" and a "macroscopic" physical environment. In the basic physical sciences, such as physics and chemistry, "microscopic" nature is brought into the laboratory and studied through controlled experiments, the practical phase of the ultimate objectives of such studies being to teach us how to control nature. Without wishing to question the importance of familiarizing the educated layman with the standard technique of controlled experimentation, it is perhaps fair to state that over-emphasis on this approach may be responsible for the fact that to the man in the street science and technology have become practically synonymous words.

Our physical "macroscopic" environment, on the other hand, can not be brought into the laboratory. In the attempt to study causal relationships in this "macroscopic" world we are generally forced to rely on the ingenious interpretation of such "experiments" as nature itself provides. Hence, the claim that the sciences concerned with the inquiry into this "macroscopic" environment are less suited to illustrate the technique of controlled experimentation may be correct, but it overlooks the fact that this technique, as taught in the laboratory sciences, may fail us in the study of raw nature, and it bypasses completely the character of the processes whereby man slowly has acquired knowledge of his physical environment. Against those who urge for a hierarchy of pure science it may be argued that the real battles for knowledge are staged in those vital fields where our techniques of inquiry are "impure" and uncertain, rather than in areas where techniques have been developed and standardized to the point where they resemble engineering procedures.

Concerning objectives, the practical goal of the study of our "macroscopic" environment must be to provide us, through analysis and description, with a sufficiently-clear understanding of the physical processes in the air, water, and land surrounding us. Only in this way can man effect an intelligent adjustment to his environment, and enhance his ability to enjoy nature through understanding. More specificially, a greater emphasis on the study of our "macroscopic" physical environment, that is, on the earth sciences, would pave the way for an intelligent appreciation of the numerous conservation problems now confronting this nation.

Thus, there is a considerable degree of parallelism between techniques and objectives of the two groups of sciences. The basic group is concerned mainly with controlled experiments and aims towards a control of nature. The second group works with uncontrolled phenomena, set up by nature, and aims at the practical goal of an intelligent adjustment of man to nature.

It is perhaps not entirely out of

place here to emphasize that non-professional, analytical survey courses in the earth sciences would include factual matter which is readily retained by the average student, since he frequently encounters in his daily life the phenomena described and analyzed in such courses.

The proposal that more attention be given to the earth sciences in liberal education does not imply a choice between the basic physical sciences and the earth sciences. Larger and larger areas of the earth sciences are being subjected to rigorous analysis with tools borrowed from mathematics, physics and chemistry; many refer to the earth sciences as the geophysical sciences to emphasize the intimate relationship between the two groups of sciences. Thus, no one claims that the earth sciences should replace the basic physical sciences in liberal education, but it appears to many of us that an introduction to a systematic scientific analysis of the raw nature that surrounds us most intimately, should be of basic value to the student and hence eventually to the country as a whole.

Our backwardness in fostering an understanding of our large-scale physical environment is perhaps best illustrated by the case of oceanography. Eighty percent of the earth's surface is covered by water. We derive an increasingly large amount of sustenance from the sea. We aim to possess the greatest merchant fleet and the greatest Navy in all history. Nevertheless, while there are a few institutions devoted to marine biology, the study of physical oceanography, without which marine biology is a crippled science, has been thoroughly neglected; even now there is in the United States to my knowledge, only one permanent professorship in this field.

From the viewpoint of national preparedness, the proposal to organize a broad, earth-science program at the undergraduate level has considerable merit. During peace time, the number of professional positions in the geophysical sciences is limited and is incapable of supporting an adequate supply of specialists for wartime emergency requirements. The group of broadly educated earth-science specialists required to teach the post-war earth-science program suggested in this memorandum, would represent a pool from which competent specialists could be obtained in emergencies.

SURVEY COURSE OUTLINE

The approach to a survey course in the earth sciences will necessarily depend on the background of the individual charged with its organization and presentation. As a meteorologist, I would be inclined to stress those perpetual physical processes which at the present time are most in evidence, namely those of the atmosphere and the oceans, including the interaction between these media and their interaction with the land.

Such a course might well start with an analysis of the factors responsible for the general circulation of the atmosphere, leading up to and emphasizing the gaps in our knowledge concerning the extent of correspondence between solar and atmospheric activity. With this background some of the basic facts concerning atmospheric electricity and the earth's magnetic field could be presented, and then, again with the first part of the course as a background, a brief physical analysis of the principal climatic zones of the earth. This might be followed by a discussion of the hydrologic cycle of evaporation, rainfall, and runoff, and by a brief discussion of natural riverflow and erosion phenomena.

With an acquaintance of our terrestrial wind systems and of the nature of the transfer processes at the sea surface available from the earlier parts of the course, it would be possible to present an analytical picture of the circulation patterns of the oceans and of the factors which produce the various distinctive water masses. This could be followed by a brief account of the physical, chemical and biological factors which control the fertility of ocean areas.

SPECIFIC RECOMMENDATIONS

If the proposed earth-science survey program is of interest to our colleges, I propose that the following steps be taken:

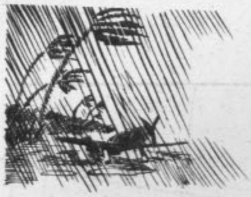
1. Distribute to the colleges a reasonably detailed outline of the survey course, endorsed by the American Geophysical Union and by the American Meteorological Society.

2. Organize pilot programs at one or two selected institutions.

3. Obtain active cooperation from academic geophysical institutions in the formulation and organization of broad earth-science programs at an advanced level, capable of producing both specialists and instructors for the proposed survey courses.

4. Give the weather officers now serving in the Armed Forces detailed information about the proposed earth-science program.

5. Make available to the colleges of America the personnel data on file with the American Meteorological Society, to assist the colleges in securing the best possible instructing staffs.



TYPHOON

By Captain John C. Glasgow

This is the story of a typhoon, but at the same time it is a story of the experiences and tribulations encountered by Weather Task Team #19---the first American forecasting and observing unit to operate in the Philippines since they were lost to us in 1942. The D-plus-2 boys...

The men of this team are old hands. Three out of four have been in the SWPA for over 28 months, with plenty of time in Northern Australia, New Guinea, and the Dutch East Indies. They have moved up with the war, from Melbourne to the Philippines. Their SWO, Lt. Lorin Hamel, took a team into Biak on D-plus-Three with the Nips only a half-mile away, and he knows the score. Cpl. Nelson Gage is a holder of the DFC, won in aerial combat while flying as a weather observer.

Why dwell on the difficulties of unloading equipment from ships, setting up the station, forecasting "on a shoestring"; or of bombings, sleepless nights, and mosquitoes? These hardships are nothing new to weathermen on foreign service, but let us tell you about typhoons!

The first was just a baby, but the synoptic maps showed plain omens for its arrival on 29 October. It didn't look like much to worry about, so when warnings had been issued that night, the boys anticipated with relish a long-delayed slumber. "The Nip can't possibly make it over tonight..."

At 0100 Item time (LST) the Tacloban weather station blew down.

Chagrined, cursing, and red-eyed, Task Force Team 19 sloshed around all night repairing the damage. With sheepish faces they bore the ribbing given them at daylight. Of all things to blow down, it had to be the weather station!

The second Typhoon, however, wasn't a baby by any means...

4 NOVEMBER

Tall and motionless palm trees are silhouetted against the twilight. Several helmeted forms can be vaguely seen, seated on sandbags around slit trenches. A low harmony hums from one group. Three blasts of the red alert still echo in the air...

"Heaney, hand me that bug-juice. I want to make myself repulsive to these mosquitoes"

"Are you kiddin'? It doesn't take repellent, Len, to do that in your case."

Ack-ack sounds. Shapes often can be seen for a moment, then disappear into the ground.

1400I: The Intertropical Convergence Zone is running WNW-ESE through the Carolines, filled with heavy showers and moderate thunderstorms. Guam reports 1003.6 mb with an east wind of Force 4. Palau's pressure is 3 mb higher, and its wind is Force 2 from the north. Equatorial air is still far to the south, but the typhoon is generating there.

5 NOVEMBER

The same quartet which sang the night before is at it again. A motor's roar is dimly heard in the distance, and the bawdy ballad stops...

"That's a Jap ship if I ever heard one, Mac."

"Naw, Murth. That's a guy in a jeep."

"You're both wrong. It's only a lil' old generator."

Suddenly a thunderous rumbling is heard. Flashes are seen. Four shapes dive for a hole.

"Jay, that's ack-ack if I ever heard it." (As he lands on the bottom of the trench).

"Naw Murth. Betcha' five pesos in Jap invasion money, they're bombs." (As he lands on Murtha).

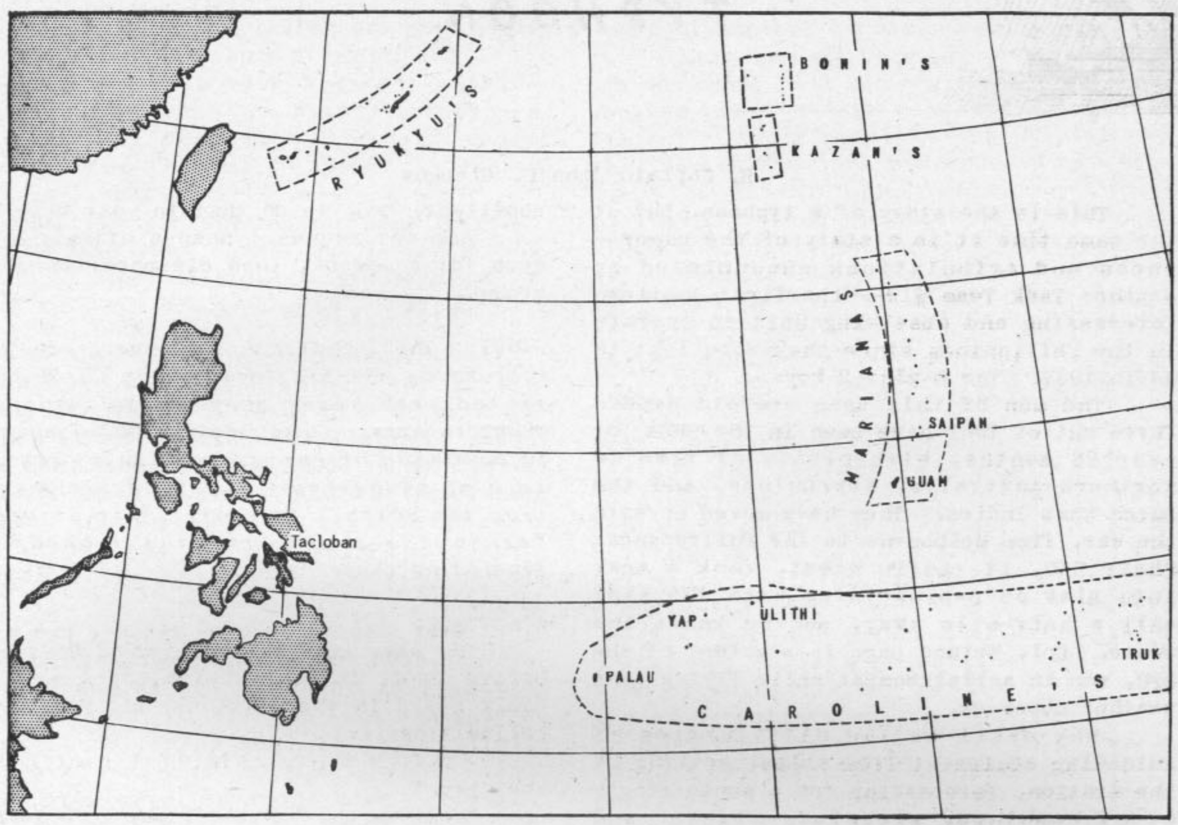
"You're both wrong, that's just our artillery shelling the Nips. We're wasting our time in this hole."

Just then a *swish* is heard, and a nearby explosion crumbles the foxhole walls.

2000I: Palau barometer now reads 1005.1 mb. Its wind is from the west, still Force 2. Thick, broken altostratus covers Palau at 10,000 feet. Charts show Equatorial air from the Dutch Indies pushing into the southern side of the Convergence Zone, "funneling in" at 140°E, 8°N. Tacloban's scattered stratocumulus moves from the north over a calm surface layer. Distant lightning. Northeast winds aloft veer to east at 5,000 feet, freshening to Force 7 at 11,000 feet.

6 NOVEMBER

A thick bamboo grove trembles under the chopping of a weatherman-detail.



"There's a big one, Handy Jim."

"What's the idea of all the bamboo? Are we going fishing or something?"

"Didn't you see that typhoon brewing on the map? The Lieutenant says we got to reinforce the station with this bamboo; he doesn't want another red face after this blow."

1400I: Warning is received that Ulithi Island (NE of Yap) has east winds of Force 7 with a pressure down to 1003 mb. Palau reports west winds, same pressure. Southerly flow (potent for Typhoon formation) is now rapidly pushing from the southwest (Biak winds aloft) with velocities increasing aloft, forcing out the Easterlies south of the Intertropical Convergence Zone. A "triple point" has now definitely formed at Yap, with the typhoon intensifying there. Movement of its center is calculated at 17 mph to the west. Storm warnings are issued from the Tacloban station, forecasting arrival of the typhoon at 1200I, 8 November. (This estimate, given 2 days in advance, proved later to be just 5 hours too soon). Tacloban: High overcast of cirrostratus and altostratus; broken stratocumulus from NE. Pressure is 1006 mb, with a NNW, Force 1 surface wind. Winds aloft are NE at 25 knots, becoming E at 10,000 feet, and reaching Force 8 at 20,000 feet.

7 NOVEMBER

Afternoon. Two observers are lying side by side on "sacks" in their pyramidal tent. One has a battered garrison cap pulled down over his eyes. A pretty little Filipino girl has just departed with their laundry.

"Shorty, seems to me you were making eyes at that cute little Filipino girl just now."

"You Beaut'. You were right in there pitching yourself, Iron Man. Good thing her big brother was along." (He is an admirer of Aussie expressions).

"Yeah. She's so small that typhoon will probably pick her up and carry her away. I hope it drops her right into this blinkin' tent."

2300I at Tacloban: Overcast to broken altostratus and altocumulus from the NE, broken stratocumulus from the north. Pressure falling to 1005 mb, indicating that the typhoon center is about 200 miles away, traveling at 13 mph. Haze aloft during the day. Lightning in the south to east quadrant.

8 NOVEMBER

0800I: Storm center is at 129° East, 10° North. Palau winds are South, Force 5; pressure rapidly rising. Storm definitely tracking to the NW, indicating passage of *the center just north of Tacloban. Warnings come from Palau of 80 knot winds.*

All precautions had been taken the day before, with planes staked, sand-bagged, and headed into expected winds. Tentage also had been staked and sand-bagged. At 0900I, the Tacloban wind picks up to 20 mph from the NNW, becoming gusty. Light to moderate rain begins, reducing the visibility to one mile. Overcast stratocumulus at 500 feet becomes stratus. At 1500I, the wind blows in strong gusts as high as 56 mph. Pressure falls rapidly to its minimum at 1700I: 922 mb.

The typhoon has reached Leyte. Torrents of rain beat against the weather station tent. Westerly gusts above 60 knots belly out its sides. Palm trees bend far over toward the east. Occasionally a soaked and miserable soldier enters the station through a small opening---from a detail which is pounding down tent stakes. Five men are lined up against the tent's west wall, pushing and straining to hold the pole upright as the station rocks and shakes.

"I think she'll hold this time. Who'll volunteer to go out and clock the wind with the hand anemometer?" Sarcastically, from the SWO.

The phone rings. Station Chief, holding the tent pole with one hand and stretching toward the telephone with the other, hears a voice ask for the wind velocity. "About 65 knots!" he shouts.

"The *We Never Sleep* Weather Service. Cheerful information always given under any conditions at any time." Cpl. Gage's irony rouses a cackle of appreciation.

No, the weather tent did not blow down.

The typhoon's center proceeds to pass across the northern horizon, and winds shift to SW with gusts at 80 mph. Pressure rises steadily thereafter, winds abate, gusts stop at 0300I on 9 November, and rain ceases at 0400I. During the 9th, the pressure rises to 1002 mb. by 1000I, indicating that the typhoon center has moved to about 150 miles northwest of Leyte.

This typhoon sprayed weather and winds over an area 400 miles across. Winds blew strongly at Tacloban for 18 hours. But weathermen will be able to forecast these disturbances if they watch the signs at Palau, Guam, Saipan, and the Carolines closely. Both those at Leyte were right out of the book.

METEOROLOGICAL SUBTERFUGE

The Pyramid Bowl football game at Cairo, Egypt, between the base hospital "Rebels" and the "Hurricanes" of 19th Weather had to be postponed from New Year's Day when it rained for 30 hours before game time and flooded the field.

Since rain is a rarity at Cario, the hospital boys now are claiming that the weathermen tried to stave off a defeat by finagling that radical change in the weather.

TSTM *Post Mortem*

Many flights from the Central Plains to the Gulf States this summer took off at night with an ETA for the next afternoon. Perhaps it wasn't realized that this schedule sent planes through the nocturnal maximum of thunderstorms in the Great Plains and the mid-day maximum in the Southeast. This circumstance appeared after a study of thunderstorms at four cities in these areas, of which further highlights follow.

ATLANTA

The primary cause of the vast majority of thunderstorms at Atlanta was surface heating. As would be expected from this fact, the season of maximum occurrence was June through August, and a great majority were daytime storms. More than half were classified as "non frontal."

OKLAHOMA CITY

Despite the large number of days in which the temperature rose to over 100 degrees, very few thunderstorms at Oklahoma City were thought to have been caused primarily by surface heating. Instead, the strongest factors were advection of warmer air, frontal lifting, and convergence. The monthly distribution curve showed a distinct maximum in the late spring, and a secondary maximum in August.

The most favorable synoptic pattern was the presence of a quasi-stationary front or wind shear line within 150 miles of the station. Few thunderstorms were associated with either occlusions or deep cyclones.

Nocturnal thunderstorms, which accounted for nearly half the total, were found to have a longer duration than their day time counterparts.

The convergence acting on air parcels having a south-to-north trajectory often served as the "trigger" to set off thunderstorms at Oklahoma City, which normally would have had insufficient moisture and instability for cumulonimbus formation.

BROWNSVILLE

Surface heating was the primary cause of thunderstorms at Brownsville. The prevailing synoptic pattern was "non-frontal": the typical situation was anti-cyclonically-curved, southeasterly flow in lower levels.

An even distribution of storms was shown from April through October, except for a pronounced maximum in September. Only a few more occurred during the day than at night.

Saturation of lower layers by falling precipitation was the cause of several thunderstorms. This situation implies the existence of a colloidally-unstable cloud layer in the upper levels. Confirmation was found in the fact that increasing moisture at high levels almost always preceded the outbreak of thunderstorms by 12 hours or more, even though dry conditions prevailed a short distance above the surface until shortly before storm development. In marked contrast to soundings at other stations, strong moisture stratification was invariably present at Brownsville preceding an outbreak of thunderstorms. Two or three moisture inversions were usually present 12 to 24 hours before the storms, with relative humidities dropping as low as 20 to 30% *beneath* the inversions.

ST. LOUIS

The primary causes of thunderstorms at St. Louis were warm air advection in lower layers, frontal lifting, and surface heating (less important). The predominant synoptic situation was warm frontal, with warm sector, pre-frontal, and non-frontal patterns accompanying most other storms.

During the summer months (when most of the thunderstorms occurred), daytime storms were more frequent than nocturnal.

The frequent occurrence of thunderstorms in the Gulf States in ridges of high pressure was noted during the study. Investigation of one storm (at Lake Charles) suggested a *possible* means for the release of instability in this situation:

Warm maritime air is brought inland at night, and is cooled from below. Microturbulence transports some of this cooled air upward. Further cooling of the air aloft is effected by radiation, especially at the top of a fog or cloud layer. Because of the high relative humidity and marked conditional instability of Gulf air, small amounts of cooling bring about saturated conditions. This cooling is small enough so that the lapse rate above the saturated parcels remains conditionally unstable; hence any upward impulse to the saturated air parcel is not damped. Impulse is provided by normal turbulence, slight orographic lifting, or by the lifting of the onshore maritime tropical air up over the cooled surface layer of air.

From "Analyses of Thunderstorms in the South and Central United States", by Lynn L. Means, and A.V. Carlin, D.L. Jorgensen, and R.H. Simpson.

Visual Bombimg thru Clouds

"Ok, assuming that your target forecast of 3/10 cloudiness is right, what are the chances that one stray cloud out of the 3/10 won't obstruct our vision during the bombing run and ruin it?" This is a tough one for the weathermen on duty with Heavy Bombardment. After making an accurate forecast of the amount and height of clouds, he must turn mathematician and look to the laws of probability---that is, he did have to until Major Riley set up the following procedure.

by Major Allen Riley

Cloud cover over a target affects the possibility of visual bombardment in a complex way: the number of elements, their vertical and horizontal extent, their shape, and their distribution with respect to size are all important. In practice, of course, many of these factors must be ignored if an answer is to be obtained.

Assume at first that clouds are circular disks of uniform size, scattered randomly. Then the length of opening between cloud cells (x) necessary for a bombing run of a certain length (L) is

$$(1) \qquad x = L\,h/H,$$

where "H" is the bombing altitude and "h" is the cloud height. To keep the units correct, the average distance between cloud centers (D) must be the unit of length for each variable. Once "x" has been found, Table I gives the probability in per cent that the target will not be obscured at all during the run. For example, given that:

Bombing run is 30 seconds (or enough assure the required accuracy),

Bombing level is 12,000 feet,

Ground speed is 220 mph,

Clouds are 4/10 thin fractocumulus at 2,000 feet, and the average distance between cloud centers is 2 miles,

then

D, the unit of length, is 2.00 miles,

L = 1.83 miles = 0.92 units

H = 2.27 miles = 1.14 units = 12,000 ft.

h = 0.38 miles = 0.19 units = 2,000 ft.

Solving equation (1),

$x = L\,h/H = 0.92\ (2/12) = 0.15$ length units.

Use of this result in Table I with interpolation yields the answer that the chances are 53% that the run will be cloud free.

Table II shows the probability of having at least one unobscured run if circumstances permit more than one attempt. Using the previous example, the chances are 53% for a single run, 78% for two tries, and 90% if three can be attempted.

Many clouds do have substantial thickness, however, In such a case, if "t" expresses the cloud thickness, and "p" represents the horizontal distance from the point of bomb release to the target, the basic equation becomes

$$(2) \quad x = L(h/H) + (p + L/2)\ (t/H).$$

"p" is equal to the product of the bomb's free-fall time and its forward speed (considered to remain that of the aircraft's Ground Speed). The quantity "h" should be taken as the distance between the ground and the middle of the cloud layer. Solution for "x", and use of Tables I and II as before are the final steps.

Using data from the first example again, assume further that the cloud deck is 2,000 feet thick. The average free-fall time of a bomb from 12,000 feet is 27 seconds; and, since the plane is traveling 220 mph, "p" must be 1.65 miles or 0.83 units. Solution of the equation gives "x" as 0.37. Table I then determines that the chances of an unobscured run are 45 out of a hundred.

Table I

Probability of Unobstructed Run

$x = L\ h/H$

		.1	.2	.3	.4	.5	.75	1.0	1.5	2.0
	1/10	87	84	81	78	75	68	62	52	43
	2/10	76	72	68	65	61	54	47	36	28
	3/10	66	61	57	53	50	42	35	25	18
Cloud	4/10	55	51	47	44	40	33	27	18	12
Cover	5/10	46	41	38	34	31	24	20	12	8
	6/10	36	32	29	26	23	18	14	10	5
	7/10	26	23	21	18	16	12	9	5	2
	8/10	17	15	13	11	10	7	5	2	1
	9/10	8	7	6	5	4	3	2	1	0

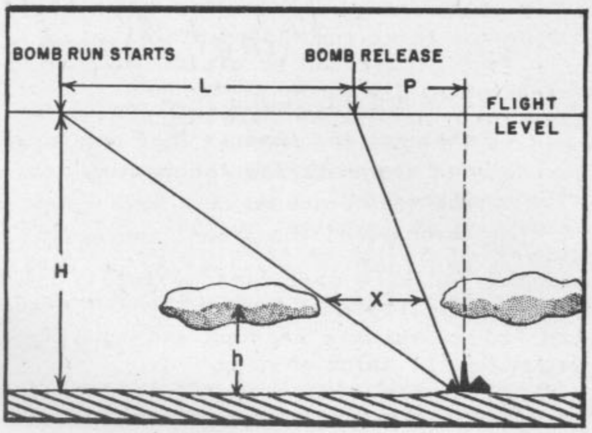
(To nearest whole percentage.)

Table II

Probability of at Least One Success in *n* Independent Trials

Percentage Chance In Any One Trial	2 Trials	3 Trials	4 Trials
10	19	27	34
15	30	39	56
20	36	49	59
25	44	58	68
30	51	66	76
35	58	73	82
40	64	78	87
45	70	83	91
50	75	88	94
55	80	92	96
60	84	94	97
65	87	96	98
70	91	97	*
75	94	98	*
80	96	*	*
85	98	*	*
90	*	*	*

(*Indicates over 99.)



This sketch shows the elements involved in determining the chances for an unobscured bombing run. L is the length of the run, x the opening between clouds, H the bombing altitude, h the height of the clouds and p the horizontal distance from the bomb release to the target.

Summarized from 'Probability of Cloud Obstructing Vision During Bombing Run,' Ninth Air Force Weather Service Technical Paper #3, written by Major Riley.

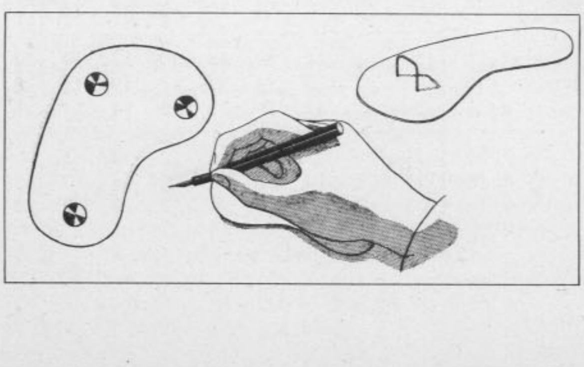
Metro Musings

PLOTTING PERFECTION

Observers who plot maps in sticky climes are well aware that it is advantageous to shield their fingers and palm from the map surface---spots and stains are unavoidable otherwise. A simple, yet efficient device for this purpose is in use at the Ardmore, Oklahoma, weather station.

Stiffish material (drawing board) has been cut out to support just the curved base of a hand in writing position. "Skids" were attached by pressing thumb tacks into the under side and bending over their sharp protrusions. A wire frame to fit between a plotter's unused fingers was made to stand up from the top surface.

This device slides easily along with an observer's hand wherever he chooses to work on a map, without laborious attention to moving a blotter or shield along with him. Many weathermen will find it convenient to spend a few minutes in making their own version of the Ardmore station's gadget.

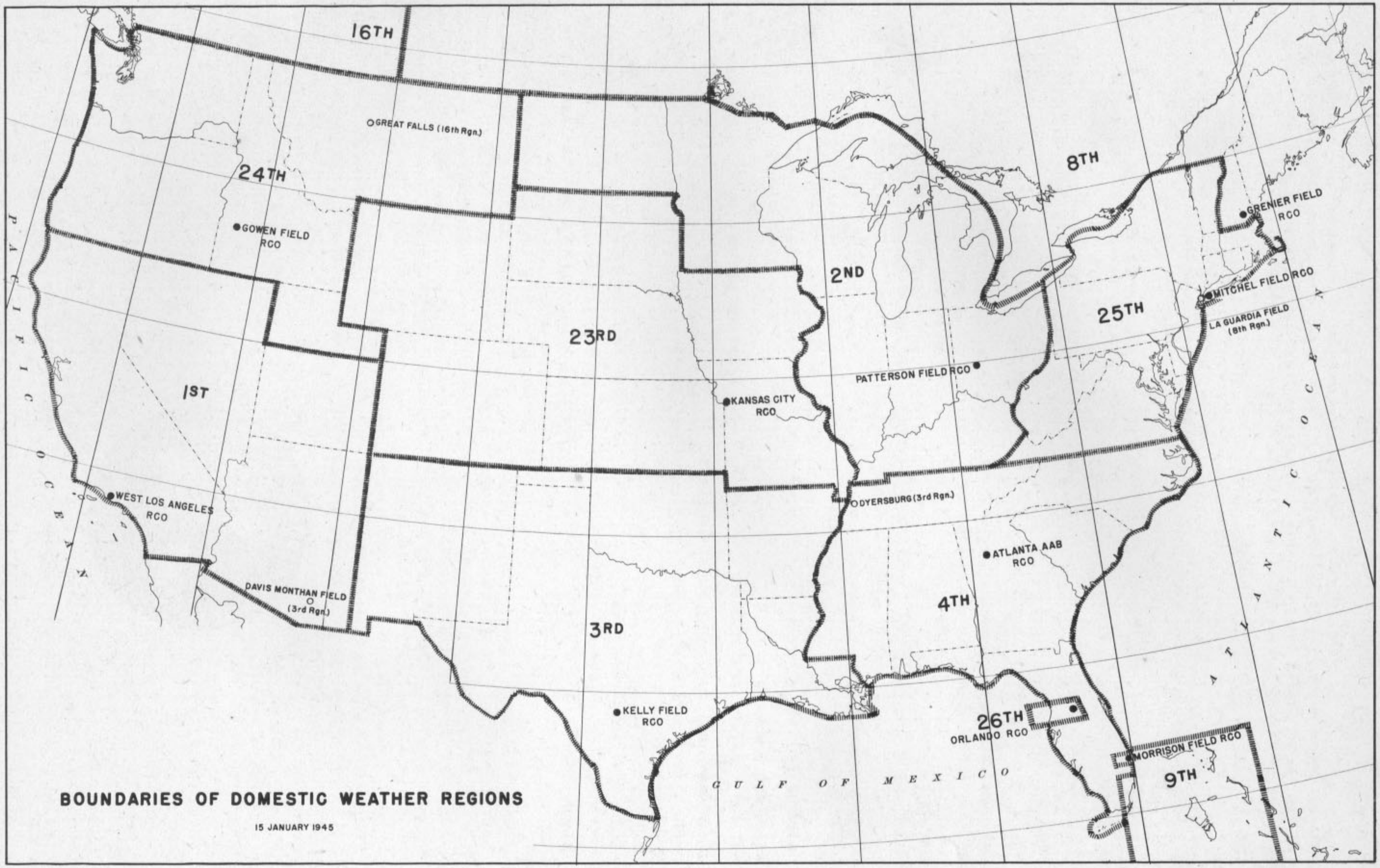


CARBURETOR ICING

Clear skies and flight-level temperatures as high as 50° F are no insurance against carburetor icing in aircraft. Sections of fuel induction systems are normally 12 to 20°C lower in temperature than the free air as a result of gasoline evaporation and subsequent expansion---a situation which often leads to obstruction of fuel flow by ice formation. If a gremlin were to close the throttle secretively, his sabotage would have effects like those of carburetor icing.

The Second Air Force's magazine, "Crash Critiques," says to fighter pilots:

"It has long been a popular belief among pilots that carburetor icing could be prevented by maintaining turbo boost in the carburetor intake system, and by limiting manifold pressure with the throttle. However, exhaustive tests under actual conditions have recently disproved this theory. The following method is now accepted as the



BOUNDARIES OF DOMESTIC WEATHER REGIONS

15 JANUARY 1945