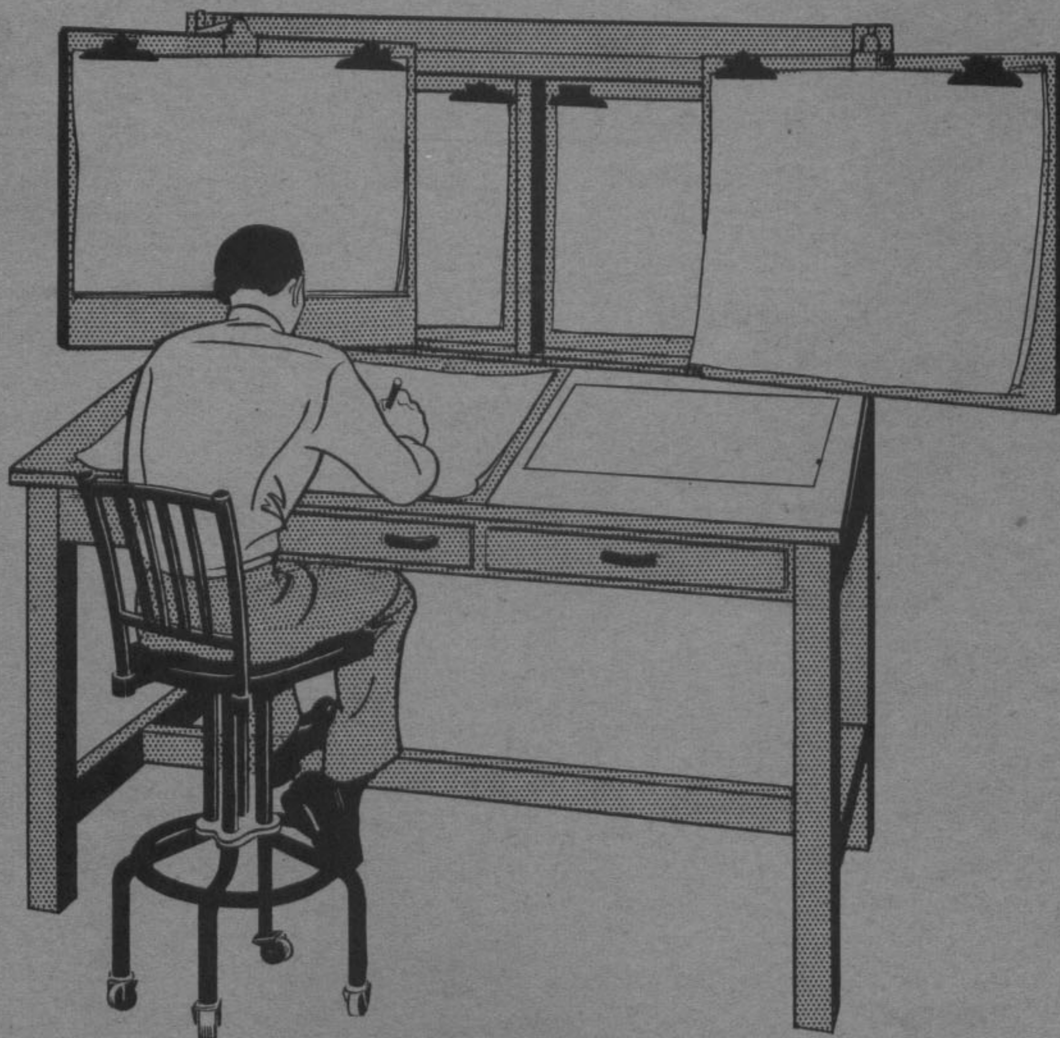
WEATHER SERVICE BULLETIN

ARMY AIR FORCES HEADQUARTERS WEATHER WING
MARCH 1944 ASHEVILLE, N.C. VOL. I NO. 4



EVALUATING THE FORECASTER

Study, Competence, and Effort

Meteorology has taken a lengthy and inexorable stride forward every day for forty years: forecasters must keep step with a corresponding, regular improvement in their technical knowledge. This difficult pace can be maintained only through sincere application and continuous study; often without regard for the extent of an 'official tour of duty.'

The wartime schools cannot produce finished forecasters in the few months allotted them. The schools point the way; only experience plus constant study can accomplish the larger aim. Forecasters who measure their effort by the time clock threaten their own efficiency. Their dim memories of weather school training may be the only basis for forecasts on which planes and men are risked.

Weather Wing and regional supervisory personnel are eliminating such unfit holders of technical positions: every man who cannot or who does not discharge his duties acceptably will be relieved after a fair warning. This action will be avoided when an exception appears justified, but the mission of the Army Air Forces through its reliance on the AAF Weather Service, will not be jeopardized for the sake of an incompetent.

Weather forecasters will not only be held responsible for having maintained that competence with which they were graduated from a weather school---they must have enhanced that competence in the preparation and interpretation of surface maps and auxiliary charts. An understanding of recent meteorological developments will be essential to this program.

The daily example of very many forecasters affords ample evidence that the scientific basis for modern meteorology permits an excellent forecasting record. The nation asks not only the best service you know how to give, but to know how to give the the best service possible.

W O Senter

W. O. SENTER
Colonel, Air Corps
Commanding

MISSION TO *PARAMUSHIRO*

by Capt. VIRGIL SANDIFER

At the time when the first bombing assault on Paramushiro from the Aleutians was being prepared (only a few months ago as clocks count time but thrust into dim memory by the hysteric tempo of warfare), the grave responsibilities which are the normal lot of the Army Weather Service were combined with operating difficulties that might with reserve be called extreme. Many of these still harry Aleutian weathermen.

In the Far North at least, no one moves without a weather forecast: the infantry relies on a bioclimatologic interpretation of forecasts on which to base the choice of equipment for short campaigns and the tactics of the assault; the QM arranges large supply movements to coincide with infrequent clemencies in the weather whenever possible; the Corps of Engineers utilizes climatic as well as current-weather data in the planning and construction of roads, bridges, and airfields; ships in our harbor even have to anticipate heavy weather in order to have steam up---and all of this says nothing about the customary requirements of the Air Force.

Added to concern over these responsibilities was the fact that weather reports were invariably late; the hourly sequences from one to two hours and synoptic map reports from four to eight hours late. For one thing, a close network of weather reporting stations connected by teletype circuits was just another "dream of the States". In this whole area, comparable in size to the United States, there were very few weather stations and even these few often had their signals garbled by radio fade-outs.

When planes are waiting to take off, however, forecasts must be made without excuse, so we sometimes struggled with an analysis which had been made on the basis of as few as four or five synoptic reports. Moreover, operational weather predictions frequently had to be given for regions to the west of all available data by hundreds and thousands of miles. There weren't many boats beyond the end of the Aleutian chain and what few there were didn't use their radios to transmit weather reports.

Even under mild climatic conditions a forecaster wouldn't be happy about such a setup, but the extreme and variable weather of the Aleutian Islands multiplied headaches about as fast as Einstein can use a slide rule. Classical forecasting methods could rarely be applied; for example, the low clouds of winter do not often permit a pibal run to exceed a thousand feet or so ---many times the best recourse for a forecaster was to step outside and look at the weather!

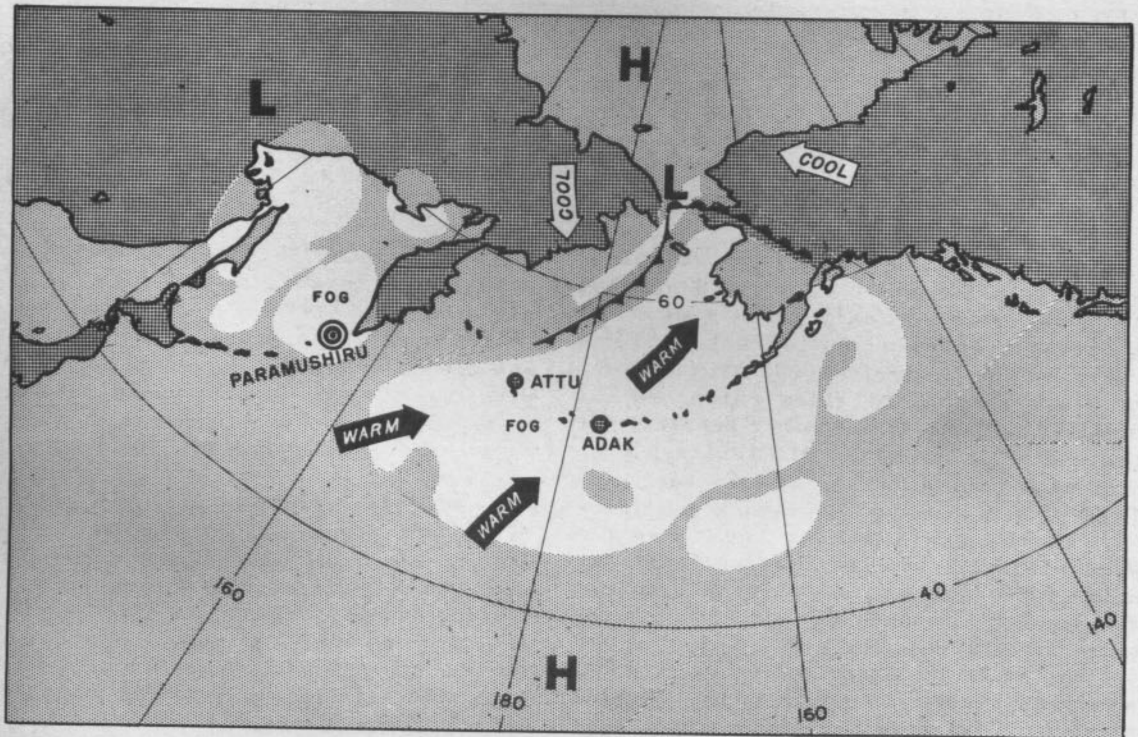
Adequate solutions were managed, however, with location in a general way of storms that might conceivably close terminals or affect routes by means of the sketchy synoptic map. Then a meteorologist in a PBY or patrol plane of similar type took up the track of the storm, and in fifteen minute intervals reported back to the station on the plane's position and the surface observation at that point. If the observer found a large squall, the plane was flown through it, around it, and over it in order to determine carefully its dimensions and intensity. Meanwhile, there were always other planes on flight duty which interrupted their normal duties to transmit meteorological data.

I don't know about other theaters of operations; weather conditions in some may be worse than in the Aleutians, but it can safely be said that there is four times as much bad weather there as in the United States---and that factor of four applies to each individual season.

The best weather in the Aleutians can be expected from the middle of March to the first few days of May. Air-mass weather in this region is largely due to a temperature differential between air and water; when there is little or no difference (as in the Spring), the only concern is caused by cyclonic storms, a relatively easy matter for the forecaster.

As summer sets in, the temperature of the air relative to that of the water surface increases. The familiar advective fog phenomenon then becomes a frequent flying hazard until the end of August. "Good visibility" in this period only occurs when an anticyclone moves down from the Bering Sea toward the south. This cool air from the Arctic, nearer the sea temperature, develops stratus clouds with a 600 foot ceiling.

During the summer the better air bases are those which are in mountain hollows.



The typical summer day in the Aleutians is characerized by light winds and fog. Warm, moist, stable air flows across the colder sea which surrounds the islands, producing fog and stable air in the lowest levels.

There the fog banks up against the mountains and leaves a little clear dome over the field which makes safe landing possible, while the fields that are in flat terrain near the water are fogged up. (In winter, fields on flat terrain escape orographic weather and become preferable in that season).

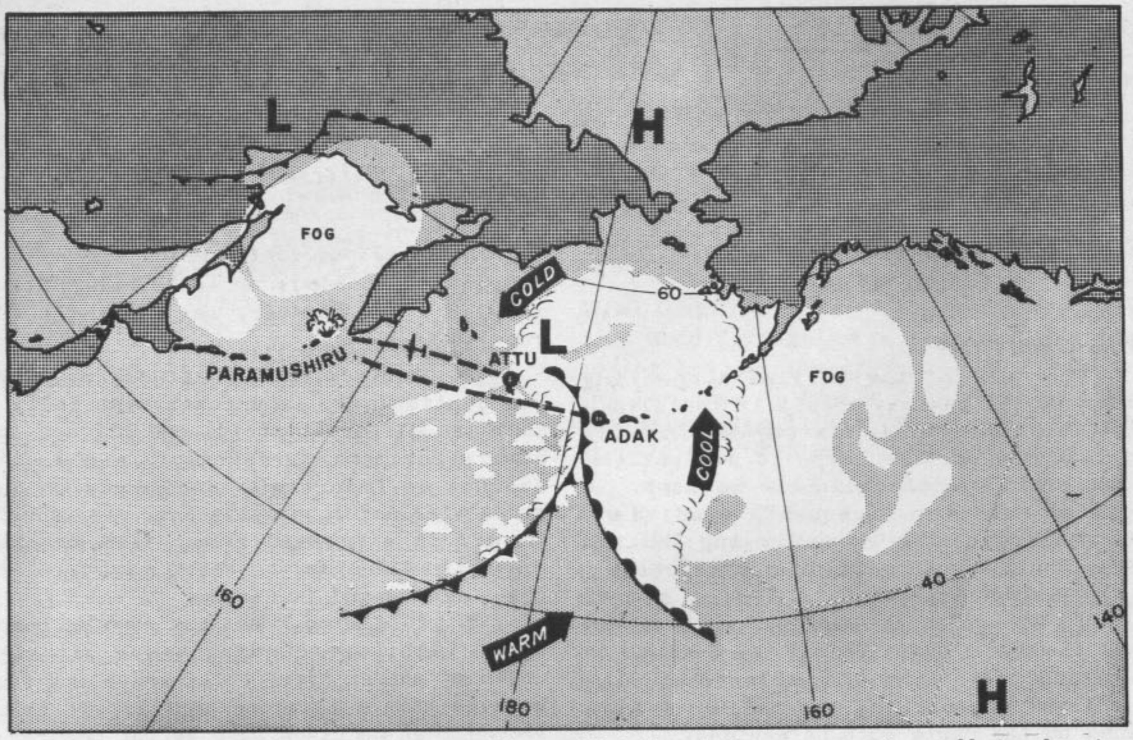
Fall is approximately the same as spring, for again water and air reach the same temperature, but the period is of shorter duration.

Winter weather is characterized by violent cyclones, passing the Aleutians on a normal track of southwest to northeast. The storms, often covering an area as large as the United States, move into the area between Kiska and Dutch Harbor, intensify, and may remain almost stationary for as much as three days. In this time, the central pressure of the low may decrease to 945 millibars.

The most important thing for a terminal forecaster to know is that storms where the center moves north of the Aleutian chain are followed immediately by clearing weather, with the southwest sector characterized by scattered cloud conditions. However, when the center of a storm passes to the south of the Aleutian chain, bad weather for two to three days following may be expected. The advent of a southeast wind is a good indication that a storm is moving into the area. Generally speaking, intense winds occur when the cyclonic center is within 50 miles of the station; extreme gustiness is the rule, with speeds fluctuating from 30 to 80 mph in a few seconds.

In the winter when cold, conditionally unstable air pours from Siberia across the relatively warm Bering Sea, continuous squalls are set off. Turbulent clouds extend from the very surface of the sea up to 6 or 7 thousand feet and are often as much as 20 miles in diameter. Snow pellets are the characteristic precipitation form. Severe turbulence and extreme icing conditions create a definite flying hazard. In the emergency when these clouds cannot be avoided, procedure usually followed was to fly for ten minutes into them at a low altitude on instruments. If the plane had not broken out of the clouds by then, the course was retracked.

The periodicity of frontal passages is marked: while at least one front every 24 hours may be expected, there are sometimes as many as three in this period. Storm centers pass any given station at intervals of about three days. Once a forecaster gets into phase, he may go as long as two months without a miss in predicting frontal



Favorable weather for the Paramushiru raid followed the passage of a well-developed cyclone into Bering Sea north of Adak Island. This storm brought down cool air from the north which momentarily cleared the summer fog from the Adak terminal and the air route between Attu and Paramushiru.

weather, basing his forecasts largely on this rhythm.

Base weather stations were located at outlying points to provide as much coverage as possible. Some of these places were so inaccessible that supplies could be brought in by ship only during a very few months of the year. As a result, materials had to be hoarded carefully; even so, a forecaster was apt on occasion to find himself without such an item as a blank map! The personnel of these bases (which in some places can be as few as four men; two AACS radio men and two meteorologists) worked in twelve hour shifts for seven days in the week. The lack of other activities than duty made such long hours welcome.

The ingenuity of men in these isolated places was superb. A great deal of their equipment; desks, chairs, and a good many of the things ordinarily taken for granted, were handmade. And when something did happen, they somehow managed--with spit and glue, if they had glue and their spit didn't freeze--to patch it up.

These are the things we were up against when it was decided to raid Paramushiro for the first time. Favorable conditions were not hard to define: we had to have two terminals, Attu and Adak, open for the planes upon their return; in addition Attu had to be open in the morning for the take-off. There could be no frontal weather enroute, but stratus clouds over the Kurile Islands to protect the unescorted bombers was desirable; however, there had to be a certainty that Paramushiro was not "socked in" either.

That was the problem. We also knew the solution: when a storm center passes to the north of the Aleutian chain, good weather follows in its wake. A rare possibility having the same effect but which can only be anticipated about twice during a summer was entry of a high pressure dome from the north, providing both good weather and stratus clouds. We didn't count on the high from the north, nor were we surprised. During the ten-day wait for the right conditions, crews and planes were ready to go on our word.

On the fateful day we began work at 1700 as the last report came in. Near midnight the charts and diagrams were finally completed which would serve as the basis for forecasts during the next 36 hours. The situation looked workable to us, so shortly after midnight we woke up the commanding general, Major General William O. Butler. He didn't mind---in fact most of the time he wasn't asleep but was waiting for us to arrive with the maps.

Nothing more than spreading the maps out on his table was needed, for the gener-

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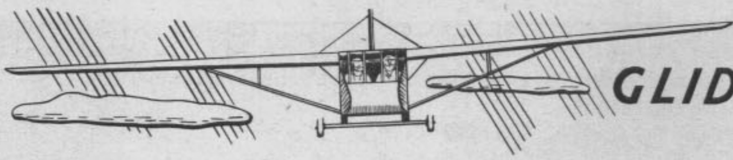

GLIDER WEATHER

Prepared by Meteorological Office, British Air Ministry, Synoptic Divisions Technical Memorandum A53.

THE METEOROLOGICAL FACTORS AFFECTING TOWED GLIDER OPERATIONS

TOWING CONDITIONS

Fracture of the towline connecting glider to its tug may result if the glider pilot is unable to see his tug *continuously* and take appropriate steps to prevent the accumulation of slack in the towrope. A tactical maneuver or squally conditions with different effects on the tug and its glider could fracture the towline by taking up slack suddenly.

a. *Cloud Cover:* A glider must not be towed through cloud. Therefore, a sheet of low clouds or a line of cumulonimbus with base level approaching the height of high ground on the route must be avoided.
Flight must be planned for contact conditions unless the cloud is well broken. Large, isolated cumulonimbus clouds can be avoided if there is sufficient light; that is, they can be avoided readily by day, less easily on moonlit nights, and only with difficulty on moonless nights. Cloud systems of active cold fronts should be avoided, because they are usually accompanied by vertical currents, lightning, and heavy precipitation (see below).

It is obviously much more difficult for a tug and glider combination to avoid clouds than for a single, powered aircraft to do so.

b. *Heavy Precipitation:* Heavy rain, sleet, and snow are dangerous in towed glider operations principally because of the reduced visibility; almost every maneuver is slower and more dangerous in this type of craft when visibility is seriously diminished. In addition, the requirement for continuous visual contact between tug and glider must be stressed.

c. *Ice Accretion:* The general considerations mentioned in the "Icing on Aircraft" series concluded in this issue apply seriously, because the surfaces where icing creates the greatest loss of power and increase of drag are of course larger in a glider-tug combination. Windshield obstruction by rime icing or mist is a major visibility hazard.

d. *Strong Squally Winds:* High-speed winds, although not considered operationally desirable, are not in themselves a deterrent to glider towing which has been accomplished in winds up to 50 mph. Strong *squally* winds however, may cause the towrope to snap.

e. *Violent Vertical Currents:* These are particularly important, especially if they are different at tug and glider: ordinary vertical currents of fair weather are not so important. Dangerous up-currents will occur normally only near cumulus cloud, in a frontal zone, or over sharp discontinuities in the earth's surface when the surface wind is strong.

f. *Lightning:* The tow rope is usually of hemp, surrounding a communication cable of copper wire; the towrope therefore behaves like a trailing aerial. It is believed that no cases have as yet occured of a combination having been struck by lightning, but flight in the heavy rain associated with thundery conditions is normally avoided.

g. *Visibility:* Visibility must be good enough for reliable map reading, more so than in bombing operations, because inaccurate target identification makes very serious the factors of low maneuverability and a single, complete commitment to action characteristic of glider operations.

LANDING CONDITIONS

A glider may make *only one attempt* at landing and, in addition, uses a steeper angle of approach; more restricted landing conditions are therefore required than for a powered aircraft. In cases of remote release, accurate upper winds near the target from release height to the ground must be forecast. As the pilot would probably use a smoke candle if landing in enemy occupied territory, even at night, an essential condition for landing would most certainly be enough light to be able to see smoke on the ground.

a. *Visibility:* A minimum of one mile by day and three miles by night is required; it is desirable that visibility be moderate (2 miles) by day and good (5 miles) by night.

b. *Low Cloud:* Very low cloud is hazardous even if well broken. The base of the cloud should be above 1,000 feet over the target area.

c. *Strong Winds:* High wind velocities, though unpleasant, cause no more danger to a glider than to a light aeroplane, but may cause excessive drift if the glider gets out of line of the wind.

d. *Turbulence:* These may affect landing and approach techniques in as much as they affect aircraft control.

e. *Rime or Mist on the Windshield:* Quantitative advice in general cannot be given on this matter and it is not common, but the possibility of the windshield becoming obscured by condensation during a quick descent from colder levels must be borne in mind, having regard to the probable air temperature and dewpoint below the release level of the glider.

Windshield mist may be observed on a powered aircraft even in conditions of moderate visibility if the humidity is high. In the case of the glider, the steeper gliding angle tends to increase the incidence of this trouble, but the slower speed will offset this disadvantage by decreasing the lag in attaining temperature equilibrium with the environment.

TAKEOFF CONDITIONS

Much of the preceding paragraph dealing with landing conditions, particularly the remarks about gusty surface winds and very low cloud applies to takeoff conditions.

NIGHT OPERATIONS

Good visibility is required, both for towing and map reading while in flight and for landing. A nearly full moon at a high elevation with little obscuration by cloud or haze are the best conditions.

In order that the occupants of gliders may be ready for immediate action on landing, sickness due to bumpiness which is particularly prevalent in glider flights must be minimized. Selection of stable air conditions, in late evening, night, or early morning, is advisable where practicable.

Continued from Page 3

al had learned a lot about meteorology through practical experience. As soon as he had thoroughly satisfied himself that the weather would be suitable, messages went out to the bombers and by the light of dawn the last one had taken off on the flight to the Japanese stronghold.

I never wanted a crystal ball as much as I did that day---but I didn't have one. So I did the only thing a weatherman can do when he sends a mission out: I went to the hilltop where the weather shack stands to "sweat it out". We had a fine view of the Bering Sea, the Pacific, and all the runways there, but that day all I watched was the weather.

My vigil was accompanied by the chattering of teletypes in the radio station next to the weather shack as they signaled the various dispersal points on the island. The worst moment came when a couple of secondary fronts settled at the Adak terminal, closing it in solidly.

About an hour before the bombers were due to return the weather at Adak broke into a very welcome CAVU for the homecoming "missionaries". I was off the hill and away from the weather shack not long after, and for the first time in months I didn't give a thought that night to the weather!

DO YOU THINK YOUR ANEROID BAROMETER IS UNRELIABLE?

The aneroid barometer, ML-102-( ) is designed so that readings taken while the instrument is lying horizontally on its back will be most reliable: at least within .02 inch. However, if the barometer should be read while at some vertical attitude, such as hanging on a wall, the error may be considerably greater.

Icing on Aircraft: IV

by David L. Arenberg

Mechanical de-icers for the wings control moderate ice deposits. They consist of inflatable rubber boots that fit over the leading edge and extend backward to the point where suction begins. The center section first expands and cracks the ice coating; then it contracts and the outer sections expand, lifting the ice clear into the windstream. The entire boot then deflates and the cycle begins again in about 9 seconds.

Procedure recommended by most pilots is *not* to operate the de-icers continuously in light icing but to wait until a layer about one-eighth inch thick has been deposited. Continuous operation will craze *thin* sheets of ice into small sections which will adhere to the rubber. The surface roughness will thereby be increased and more ice will be deposited than if the boots were not used.

Figure 2 illustrates the condition developed in one instance when de-icer operation was continuous in a region where glaze was accumulated. The icing rate was low---such that between each successive tube inflation only a thin coating was added to the leading edge. This coating was not blown entirely clear and served as anchorage for further building of ice. The leading edge became very rough, but the smoothness of the coating over the landing light indicates the eveness of the ice on portions of the wings not equipped with deicer boots.

Under severe icing conditions, continuous operation will be necessary. A constant check on the apparatus must be maintained while in use to see that ice is not accumulating. At present no instrument for measuring icing *rates* is available although several are being developed. Such an instrument would be of great help in determining proper procecure.

Because the boots markedly change airfoil shape and characteristics, they should never be operated during takeoff or landing. A stall or spin might occur at normal flying speed without sufficient altitude for recovery. This effect on the flight characteristics is also important in maneuvering and control. While de-icers are going, a greater radius of turn is required for banking and climbing ability is diminished.

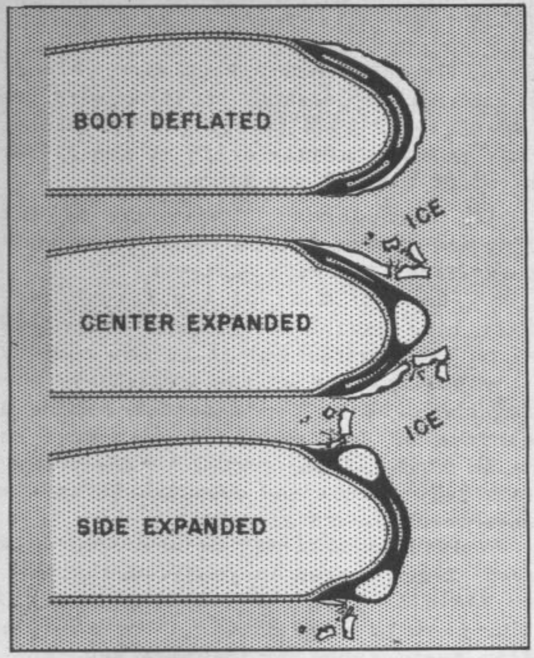

Figure 1 Three stages in de-icer boot cycle.

In landing with ice on the wing, it is important to keep airspeed safely above the stalling speed. It is considered best to "fly" the plane onto the ground rather than run the risk of stalling either the wing or tail surfaces in attempting to land in a tail-down attitude. If an approach necessitates extending the glide, power should be applied and the nose kept low to hold airspeed. If this is not done, the iced-up propeller blades may stall when load is put on them. Safe landing speed with a load of ice will be higher than normal and may in extreme cases be twice as much as normal, requiring a longer landing run and a larger airfield than would be needed under normal circumstances: doubling the landing speed means quadrupling the distance required to come to a stop. The landing run may be further lengthened if the ground is covered by snow or ice. Therefore, landing should not be attempted at a small field if a larger field can be safely reached.

A ridge of rime on the edges of the ailerons, elevators, or rudders may unbalance them and lead to serious vibrations, if not to loss of control.

Propeller icing develops on the leading edges of the blades in the same manner as on the wings but can only be detected indirectly by:

1. Loss of thrust (airspeed) at constant r.p.m. and manifold pressure.

2. Vibration (due to imbalance from unequal loss of ice).

3. The sound of ice fragments striking the plane.

Figure 2 Notice the ragged ice layer remaining on the leading edge after continuous de-icer boot operation in light icing.

The speed and size of the propeller blade render it more subject to icing than the wing, but centrifugal force tends to clear it of rime and loose ice. Adequate protection is secured by the use of de-icing fluid. This is usually an oil or glycerin compound released from vents near the propeller hub which flows over the surface so that not even clear ice will adhere. Fluid de-icers should be applied before the plane enters the cloud or any icing situation and kept on until out of the icing area.

Should this method fail, momentarily increasing the speed of the propeller may furnish enough additional centrifugal force to clean the blades. Increasing the thrust demanded of an iced blade may cause it to stall; dangerous at a time when thrust is badly needed, as in extending a landing approach.

Icing will start first near the propeller hub, and may be directly observed at this point on some planes. Seriously unbalanced propellers cannot be speeded because of excessive vibrations that will develop.

SUBSIDIARY ICING PROBLEMS

Windshield icing occurs less frequently and with less density than on propeller and wings because of the large cross section of the fuselage. Obstruction of forward vision, most critical when a landing is being attempted, is its greatest hazard. Under these conditions (if the type of plane permits), loosening of the windshield clamps in preparation for opening or breaking out the windshield before final descent is advisable. Means for eliminating windshield icing with de-icing fluid, high speed mechanical cleaners, or local applications of heat are available and should be applied before the condition becomes so serious that they are ineffective. An ordinary paint scraper or putty knife may be used on a glass windshield in an emergency.

Particularly at night, glaze can form on the windshield in freezing rain or drizzle before the pilot is aware of the process. It usually will be rough and hard to dislodge. By this time aerodynamic surfaces may also be iced and landing will be difficult.

Pitot tube icing is very common because of the small dimensions of the exposed head. The airflow in the tube is changed even if it is not completely blocked and readings will be erroneous. A check with engine operation or ground speed may be made if this is suspected. A completely sealed pitot tube will act as an altimeter by showing excess speed on rising and loss of speed on descending. A simple and effective precaution is to turn on the pitot tube heater before entering icing zones.

Antenna icing will be rapid because the antenna is small in cross section and may be severe enough to break the wire. If trailing antenna is used, it should be reeled in.

Icing of controls may cause the jamming of exposed parts. The controls should be kept moving slightly to prevent them from freezing tight.

Ground ice may gather on a cold airplane if it is taxied through puddles or slush. In freezing weather, taxiing should be kept at a minimum and puddles crossed only when unavoidable, and then slowly. Engines should be run where the propellers cannot suck up water from a puddle. These precautions are even necessary when the temperature on the ground is above freezing if the plane will shortly be climbing into freezing air, because water may be accumulated in some pocket and later become frozen.

Carburetor icing cannot be foreseen with the same assurance as other icing. While supercooled water and snow can plug up the induction system of the plane, the most serious difficulties are caused by direct condensation of water vapor. The evaporation of gasoline absorbs a large amount of heat, and further cooling takes place in the venturi throat where expansion occurs. Normally, the temperature in the adapter may be from 12°C. to 20°C. less than the free air temperature. If the air is moist, the dew point is reached. In consequence, the carburetor may ice and the motor fail with clear skies and summer temperature, if the humidity is high. This condition should be foreseen and pre-heat applied before the carburetor temperatures reaches + 3°C. (the instrumental errors may be high). Carburetor temperatures should be kept below + 8°C. to prevent unnecessary power loss.

Carburetor icing obstructs the intake of the air or fuel, or both, and the distribution of fuel to the cylinders, depending on the location of the formation. The net result is a loss of power and a loss of air speed, indicated by failing manifold pressure. In general, the performance will be the same as if the throttle were slowly closed. The butterfly value may freeze when kept in a fixed position; move it occasionally to break it loose.

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SUMMARY OF SERIES, 'ICING ON AIRCRAFT'

The effect of ice on aircraft is cumulative. The drag of the whole plane is increased at the same time that maximum power available from the engine is diminished. The stalling speed is simultaneously increased and this increase is accentuated by increased wing loading caused by the weight of accumulated ice. A point can easily be reached where the engine operating at full power cannot maintain level flight. If this point is reached, airspeed must be maintained by a power glide.

Maneuverability is diminished and all turns must be made as gradually and gently as possible and additional power must be used to maintain level flight. Occasionally it will be necessary to operate the propellers in full low pitch to avoid stalling the blades. Airspeed must be maintained above stalling speed even when altitude has to be sacrificed to do this.

The increased stalling speed means that the landing speed of the plane also is greatly increased, and in an extreme case the distance required to come to a stop may be quadrupled. Snow or ice on the ground may offer further complications. Fields suitable for normal operations may be unable to meet these demands.

In any circumstances where the stalling speed of the airplane has been markedly increased, it is considered good practice in approaching for a landing to start levelling out gradually some distance above the ground and to land on the wheels with the tail high.

A stall caused by the presence of ice does not "feel" the same as a normal stall. In the first place, because it occurs at a higher speed, it is not preceded by any marked sloppiness of the controls, although response to the controls becomes somewhat more sluggish than normal. In the second place, the stall does not break as cleanly as normal; there is a more gradual transition from normal flight through heavy mushy flight to the full stall.

When icing *cannot be avoided*, in most cases it can be combatted effectively if the airplane is fully equipped with anti-icing and de-icing apparatus.

1. Before entering a region where icing is to be expected, turn on the pitot heater, propeller de-icer, windshield de-icer, and carburetor pre-heat. Do not turn on wing de-icers unless severe icing is expected, as in crossing a vigorous cold front at a high altitude.

2. Upon encountering icing, slow down to minimum safe airspeed. This will reduce the icing rate per mile of flight and also make the formation less dense, probably in the form of rime. Remember, though, that the stalling speed will be higher with ice on the plane.

3. If glaze forms and spreads over the wing back of the de-icer boot, do not operate the boot, since a ridge of ice would be left at the rear of the boot which would have a worse effect than the smooth sheath of ice on the leading edge.

4. Do not operate the de-icer boots until they have accumulated one eighth to one quarter inch of ice. Then break this ice loose and allow another layer to build up. Operate the boot intermittently.

5. If the propeller de-icers are not wholly effective, rev up the engines momentarily to several hundred r.p.m. above cruising.

6. Move the flight and throttle controls often to prevent them from freezing up.

7. Do not land or take off with de-icer boots operating.

Summary of Recommended Flight Procedures

It is always wisest to avoid ice whenever possible. At best, de-icing equipment is an aid and not a cure for icing. Additional precautions are necessary by way of careful handling of the airplane. The following is a summary of some rules of flight agreed upon by experienced pilots:

AT ALL TIMES:

1. Slow down, but keep a safe margin of airspeed above stalling speed.

2. Do not operate wing de-icers during maneuvers except under extreme conditions.

3. Make all turns and other maneuvers very gently.

4. If unable to maintain airspeed in level flight, make a power glide.

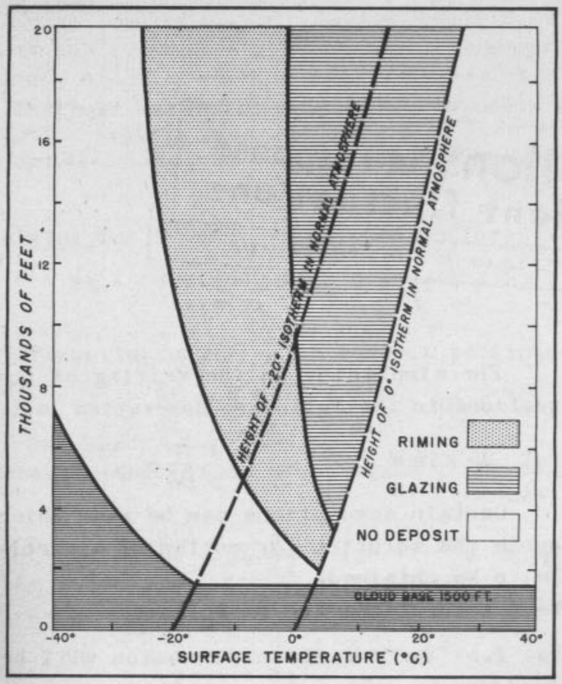


Figure 3 The distribution of icing types in a purely convective cloud. (Schematic)

5. Pass through icing zones, when you must, as quickly as possible. Let down or climb up quickly through icing layers; fly the shortest path through fronts.

6. Know the characteristics of the plane you are flying. Not all planes behave the same way in icing; some will be more gently affected than others.

7. Watch for the first signs that icing is to be expected or ice is forming. Be able to recognize them and take corrective action quickly.

WHEN PLANNING A FLIGHT:

1. Icing of the airplane's surfaces may be expected whenever the temperature is below 0°C and there are water clouds present.

2. Avoid cloud levels whenever possible.

3. Never fly without preliminary information from the weather forecaster regarding icing possibilities for your level and course. Know where the freezing level is for each leg of your route.

4. Know the properties of the air masses in your region and their icing characteristics at each level.

5. Know the characteristics of your plane.

6. Glaze will form in stable stratus clouds mostly above-8°C but even at -20°C in unstable cumuliform clouds.

7. The stronger the vertical currents, the more dense the cloud and the more water the cloud will contain.

8. The maximum rate of icing depends on the distance the air in the cloud has been lifted above the cloud base and its temperature at the cloud base.

9. Precipitation reduces the icing hazard, and clouds with continuous precipitation are safest.

10. The lower the temperature the more likely that rime will be the icing form.

11. The lower the airspeed the more likely that rime will form.

12. The smaller the droplets the more likely that rime will form.

13. Maritime air masses usually form glaze.

14. Continental air masses usually form rime.

15. Mountains increase vertical currents and intensify icing conditions. Know the terrain beneath you.

16. Open water increases moisture and heat in winter, intensifying icing conditions in cold air masses.

17. Supercooled rain may occur below a warm front in clouds or clear air.

WHILE IN FLIGHT:

1. Watch the cloud forms.

2. Watch your thermometer.

3. Stay out of clouds unless it is necessary to enter them.

4. Watch for the first sign that icing is occurring.

5. Use carburetor heat at above-freezing temperatures.

6. Turn on pitot heat when in clouds or rain.

7. Turn on propeller de-icing fluid when in clouds or rain.

8. Turn on wing de-icer boots when they are covered with one eighth to one quarter inch of ice. Operate intermittently.

9. Turn on windshield de-icer when in cloud or rain.

10. Keep airspeed in excess of stalling speed.

11. Move controls to see that they do not freeze or jam.

12. Speed up propeller if de-icer fluid cannot keep it clean.

IN LANDING:

1. Make slow gradual turns.

2. Keep flying speed.

3. Turn off de-icer boots.

4. Turn off carburetor heat and stand by to use alcohol if needed.

5. Shut off pitot heat and propeller de-icers if not needed.

6. Make sure windshield vision is clear.

7. Come in tail-high.

8. Be prepared for a stall.

9. Know the operating characteristics of your plane.

Atmospheric motions in response to pressure gradient fluctuations

by CAPT. P. L. HILL & CAPT. G. M. LEIES

This paper represents an attempt to determine qualitatively and, to some extent quantitatively the type of motion resulting when a pressure gradient is imposed upon an atmosphere initially at rest. Variations of the motion due to friction are considered.

The ordinary hydrodynamic equations of motion are integrated using several simplifying assumptions. These assumptions are made such that the equations of motion deal with a fluid particle in a simple manner.

Two assumptions are made involving the pressure gradient and the external forces. The pressure gradient is assumed to be initially zero and to increase exponentially to a final steady state, approximating conditions actually encountered. The rate of growth of the pressure gradient is governed by the value of the exponential constant a, a numerical constant with no dimensions.

The external force is considered to be a resistance proportional to the linear velocity component. The relative magnitude of the resistance term is determined by the value of the constant k, where k is a constant having the dimensions t^{-1}, that is, the reciprocal of time.

The equations of motion are initially resolved into equations involving only two variables in each case, u and t in one case and v and t in the other case. This results in linear differential equations which are solved for the components of velocity. These equations are then integrated to obtain the components of the path of the particle considered.

The hydrodynamic equations for the motion of an atmospheric particle are:

1A). $$\frac{du}{dt} - 2\omega[v \sin\phi - w\cos\phi] = -\frac{1}{\rho}\frac{\partial p}{\partial x} + F_x$$

1B). $$\frac{dv}{dt} + 2\omega u \sin\phi = -\frac{1}{\rho}\frac{\partial p}{\partial y} + F_y$$

1C). $$\frac{dw}{dt} - 2\omega u \cos\phi = -\frac{1}{\rho}\frac{\partial p}{\partial z} + F_z$$

For simplicity in the writing of the equations in the following derivation let:

$$2\omega \sin\phi = f \qquad \frac{1}{\rho}\frac{\partial p}{\partial n} = P$$

Certain assumptions can be made which enable the solution for motion of a particle to be obtained.
These assumptions are as follows:

1. Only horizontal motion will be considered: $w=0$

2. The coordinates will be chosen such that the positive value of x coincides with the pressure ascendant. The y axis will lie parallel to the isobars.

then: $P_y=0$

3. The pressure field will consist of straight parallel isobars with a uniform gradient of pressure at any instant.

$$\frac{\partial P_x}{\partial x} = 0 \qquad \frac{\partial}{\partial x}\left[\frac{\partial P_x}{\partial t}\right] = 0$$

4. The pressure gradient will be initially zero and will increase exponentially:

$$P_x = P_\infty (1 - e^{-aft})$$

5. The sole external force acting on the particle will be that of resistance. The resistance is considered to be proportional to the first power of the horizontal velocity. This relationship was chosen as being the simplest to calculate and sufficient to interpret the qualitative effects of resistance.

The exponential increase in the pressure gradient is chosen so as to yield an increasing pressure gradient which would approach a final steady value. This condition is approximated in nature and in order to make a comparison with the value for the geostrophic wind as normally determined, it is desirable to study a condition which approaches a steady final state.

With these assumptions, the hydrodynamic equations may be rewritten:

2A. $\frac{du}{dt} - fv = -P_\infty\left(1 - e^{-aft}\right) - ku$ 2B. $\frac{dv}{dt} + fu = -kv$

Solving for u and v in (2) and differentiating with respect to time:

3A. $v = \frac{1}{f}\left[\frac{du}{dt} + ku + P_\infty\left(1 - e^{-aft}\right)\right]$ 3B. $u = -\frac{1}{f}\left(kv + \frac{dv}{dt}\right)$

Differentiating (3) with respect to time:

4A. $\frac{dv}{dt} = \frac{k}{f}\frac{du}{dt} + \frac{1}{f}\frac{d^2u}{dt^2} + aP_\infty e^{-aft}$ 4B. $\frac{du}{dt} = -\frac{k}{f}\frac{dv}{dt} - \frac{1}{f}\frac{d^2v}{dt2}$

Substituting values of u, v, $\frac{du}{dt}$, and $\frac{dv}{dt}$, in (2) and collecting terms:

5A. $$\frac{d^2v}{dt^2} + 2k\frac{dv}{dt} + \left(k^2 + f^2\right)v = fP_\infty\left(1 - e^{-aft}\right)$$

5B. $$\frac{d^2u}{dt^2} + 2k\frac{du}{dt} + (k^2 + f^2)u = -kP_\infty + (k - af)P_\infty e^{-aft}$$

These equations are linear differential equations of the form:

$\frac{d^2y}{dx^2} + P_1\frac{dy}{dx} + P_2 y = Q$ where P_1 and P_2 are constants and Q is an f(x)

The solution of this differential equation is:

$y = A_1e^{m_1x} + A_2e^{m_2x} + Y(x)$ where Y(x) is a particular integral and where m_1 and m_2 are roots of the equation:

$$m^2 + P_1m + P_2 = 0$$

Thus, substituting from equation 5a:

$$m^2 + 2km + k^2 + f^2 = 0$$

$$(m + k + if)\ (m + k - if) = 0$$

$$m_1 = -k - if \qquad m_2 = -k + if$$

Then: $u = A_1e^{(-k+if)t} + A_2e^{(-k-if)t} + U(t)$

where U(t) is a particular integral.

$$= A_1e^{-kt}(\cos ft + i \sin ft) + A_2e^{-kt}(\cos ft - i \sin ft) + U(t)$$

$$= (A_1 + A_2)\ e^{-kt}\cos ft + (A_1 - A_2)\ ie^{-kt}\sin ft + U(t)$$

Replacing the constant terms by new constants and operating similarly on 5b:

6A. $u = B_1e^{-kt}\cos ft + B_2e^{-kt}\sin ft + U(t)$

6B. $v = C_1e^{-kt}\cos ft + C_2e^{-kt}\sin ft + V(t)$

Solving for the particular integral in 6A. and following the same steps for 5B.:

$$f(D)U(t) = -kP_\infty + (k - af)P_\infty e^{-aft}$$

$$U(t) = \frac{1}{D^2 + 2kD + k^2 + f^2}\left[-kP_\infty + (k - af)P_\infty e^{-aft}\right]$$

$$= -\frac{af - k}{(af - k)^2 + f^2}P_\infty e^{-aft} - \frac{k}{k^2 + f^2}P_\infty$$

$$V(t) = -\frac{f}{(af - k)^2 + f^2}P_\infty e^{-aft} + \frac{f}{k^2 + f^2}P_\infty$$

Therefore, the complete solutions to (5) are:

$$7A. \quad v = C_1e^{-kt}\cos ft + C_2e^{-kt}\sin ft + \frac{-f}{(af-k)^2+f^2}P_\infty e^{-aft} + \frac{f}{k^2+f^2}P_\infty$$

$$7B. \quad u = B_1e^{-kt}\cos ft + B_2e^{-kt}\sin ft - \frac{af-k}{(af-k)^2+f^2}P_\infty e^{-aft} - \frac{k}{k^2+f^2}P_\infty$$

∴The next operation is to solve for the constants B_1, C_1, B_2, C_2.

Substituting in (2B) and collecting terms:

$$(C_2 + B_1)\, fe^{-kt}\cos ft + (B_2 - C_1)\, fe^{-kt}\sin ft \equiv 0$$

In order for the constants to satisfy the above identity:

$$C_2 + B_1 = 0 \qquad \text{and} \qquad B_2 - C_1 = 0$$

Therefore:

$$C_2 = -B_1 \qquad \text{and} \qquad C_1 = B_2$$

In order to factor P_∞ from the equations, let new constants be inserted, such that:

$$B_1 = P_\infty A_1 \qquad \text{and} \qquad B_2 = P_\infty A_2$$

Rewriting equations (7) using the constants A_1 and A_2:

$$8A. \quad v = P_\infty\left[A_2e^{-kt}\cos ft - A_1e^{-kt}\sin ft - \frac{f}{(af-k)^2+f^2}e^{-aft} + \frac{f}{k^2+f^2}\right]$$

$$8B. \quad u = P_\infty\left[A_1e^{-kt}\cos ft + A_2e^{-kt}\sin ft - \frac{af-k}{(af-k)^2+f^2}e^{-aft} - \frac{k}{k^2+f^2}\right]$$

By solving for the initial instant of time, $t = 0$, the constants A_1 and A_2 may be evaluated:

At $t = 0$ let $u = u_0 = 0$ and $v = v_0 = 0$

Then equations (8) become:

$$9A. \quad A_1 = \left[k(af-k) + f^2\right]\frac{af}{(k^2+f^2)\left[(af-k)^2+f^2\right]}$$

$$9B. \quad A_2 = f(2k - af)\frac{af}{(k^2+f^2)\left[(af-k)^2+f^2\right]}$$

Equations (9) may be written in a simpler form for calculations by means of the conversion:

$$a\cos mx \pm b\sin mx = \sqrt{a^2+b^2}\left[\cos\left(mx \mp \tan^{-1}\frac{b}{a}\right)\right]$$

$$b\sin mx \pm a\cos mx = \sqrt{a^2+b^2}\left[\sin\left(mx \pm \tan^{-1}\frac{b}{a}\right)\right]$$

The result being:

$$10A. \quad v = P_\infty\left\{-\sqrt{A_1^2+A_2^2}\left[e^{-kt}\sin\left(ft - \tan^{-1}\frac{A_2}{A_1}\right)\right] - \frac{f}{(af-k)^2+f^2}e^{-aft} + \frac{f}{k^2+f^2}\right\}$$

$$10B. \quad u = P_\infty\left\{\sqrt{A_1^2+A_2^2}\left[e^{-kt}\cos\left(ft - \tan^{-1}\frac{A_2}{A_1}\right)\right] - \frac{af-k}{(af-k)^2+f^2}e^{-aft} - \frac{k}{k^2+f^2}\right\}$$

The y and x components of the path of the particle are obtained by integration of equations (10):

$$\text{11A.}\quad y = P_\infty \left\{ \frac{\sqrt{A_1^2 + A_2^2}}{\sqrt{k^2 + f^2}} \left[e^{-kt} \cos\left(ft - \tan^{-1}\frac{A_2}{A_1} - \tan^{-1}\frac{k}{f} \right)\right] + \frac{1}{af} \frac{f}{(af-k)^2 + f^2} e^{-aft} \right.$$

$$\left. + \frac{ft}{k^2+f^2} - \frac{\sqrt{A_1^2 + A_2^2}}{\sqrt{k^2 + f^2}} \left[\cos\left(\tan^{-1}\frac{A_2}{A_1} + \tan^{-1}\frac{k}{f} \right)\right] - \frac{1}{af} \frac{f}{(af-k)^2 + f^2} \right\}$$

$$\text{11B.}\quad x = P_\infty \left\{ \frac{\sqrt{A_1^2 + A_2^2}}{\sqrt{k^2 + f^2}} \left[e^{-kt} \sin\left(ft - \tan^{-1}\frac{A_2}{A_1} - \tan^{-1}\frac{k}{f} \right)\right] + \frac{1}{af} \frac{af-k}{(af-k)^2 + f^2} e^{-aft} \right.$$

$$\left. - \frac{kt}{k^2+f^2} + \frac{\sqrt{A_1^2 + A_2^2}}{\sqrt{k^2 + f^2}} \left[\sin\left(\tan^{-1}\frac{A_2}{A_1} + \tan^{-1}\frac{k}{f} \right)\right] - \frac{1}{af} \frac{af-k}{(af-k)^2 + f^2} \right\}$$

To give a more readily appreciated meaning to the derived equations certain typical and ideal values are assigned to the constants and the equations then plotted. Values selected as being more representative are:

$a = 1$	$k = 0$
$a = 1$	$k = 5 \times 10^{-5}\ \sec^{-1}$
$a = 5$	$k = 5 \times 10^{-5}\ \sec^{-1}$

and the latitude was 30 degrees.

The value of $k = 0$ is chosen as the ideal case of no frictional or other external forces. The value of $k = 5 \times 10^{-5}$ appears to approximate the conditions for the latitude of 30 degrees.

Two values of a are selected to show the effect of change of the rate of growth of the pressure gradient. For $a = 1$ the pressure gradient reaches 90% of its final value in 9 hours; 99% in 18 hours; and 99.9% in 27 hours. For $a = 5$ the pressure gradient reaches 90% of its final value in 1.8 hours; 99% in 3.6 hours; and 99.9% in 5.4 hours. These periods are for a latitude of 30 degrees. The period will be shorter for high latitudes, and longer for lower latitudes.

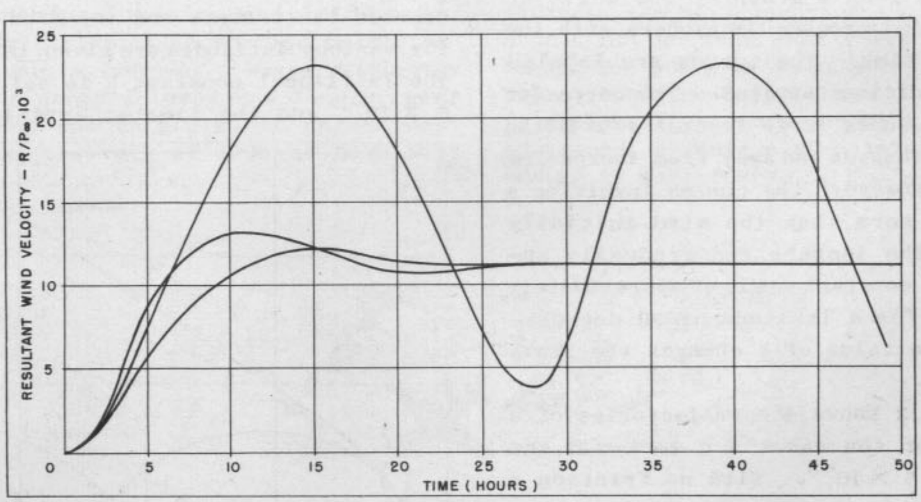


Figure 1

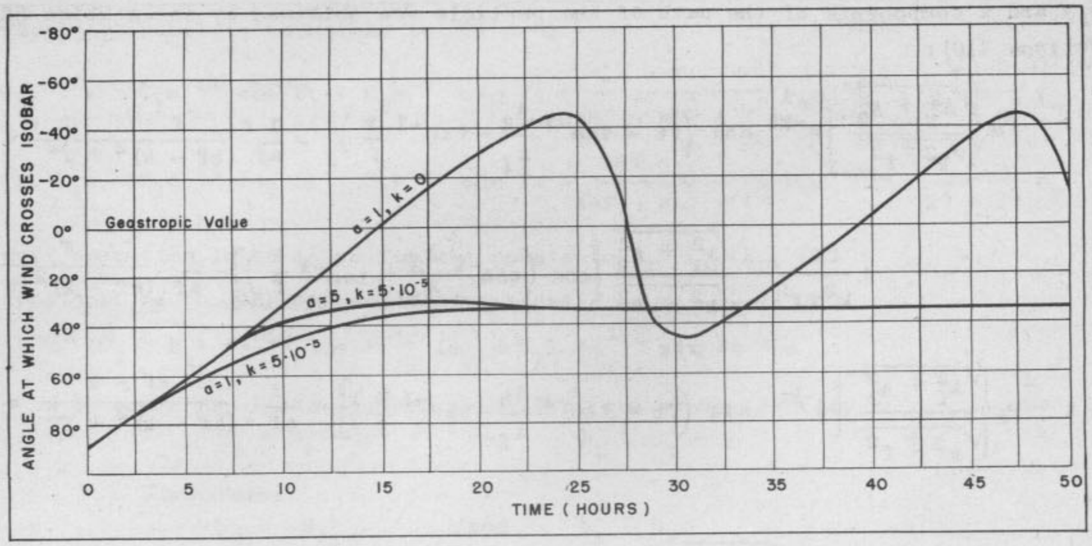


Figure 2

Figure 1 shows the relation between the wind velocity and time. Here is displayed clearly the sinusoidal fluctuations in wind velocity which result when there is no friction. The other two curves give a picture more in conformity with reality; the wind velocity builds up to a maximum in 11 to 16 hours, depending upon the value of <u>a</u>, and then tapers off to a steady value after 21 to 27 hours. The value of the geostrophic wind velocity for the final steady pressure gradient is indicated on the graph. It should be noted that, whereas without friction the velocity varies sinusoidally about the geostrophic value, with friction the velocity never attains the geostrophic value.

Figure 2 is a graph of the angle at which the wind crosses the isobars with the passage of time. The curves are labeled for the conditions applied. The curve for no friction shows large fluctuations in the angle both towards and away from increasing pressure. However, the curves involving a frictional term show the wind initially normal to the isobars and gradually approaching a constant angle of approximately 54 degrees for a latitude of 30 degrees. Changing the value of <u>a</u> changes the curve very little.

Figure 3 shows the trajectories of a particle for the cases $a = 1$, $k = 0$ and $a = 1$, $k = 5 \times 10^{-5}$. With no friction a slightly modified cycloid results; modified because the pressure gradient does not attain its full value immediately. If <u>a</u> were set at infinity the curve would be a perfect cycloid whose period would be 24 hours at 30 degrees latitude.

The curve for $a = 1$, $k = 5 \times 10^{-5}$ is closer to the expected conditions. At the start, when the pressure gradient has its greatest rate of increase, the motion is mainly cross-isobar. As the pressure gradient approaches its final magnitude, the air particle's path cuts the isobars at a smaller angle. Finally, when the pressure gradient has reached its final value, the particle moves in a straight line cutting the isobar at a definite angle.

To complete the picture further and demonstrate the effect of latitude and resistance, several more calculations might be mentioned. The angle at which the wind crosses the isobars and the wind velocity for various latitudes are given in table I. The frictional constant <u>k</u> is set equal to 5×10^{-3} and the time at infinity. The

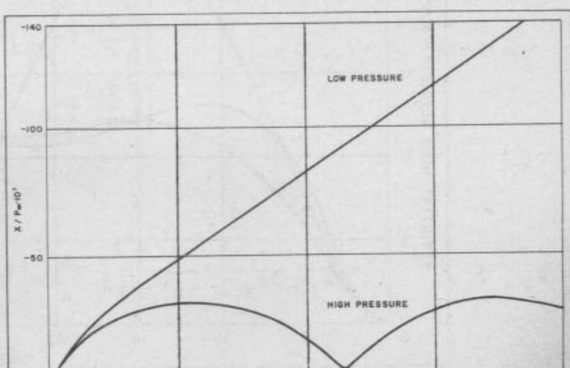


figure 3

TABLE I

Latitude (°)	Angle (°)	Wind speed (%)
5	76	25
15	53	60
30	34	80
45	27	90
60	22	93

TABLE II

Latitude (°)	Angle (°)	Wind speed (%)
5	58	54
10	38	78
15	28	88

wind speed is given in percentage of the geostrophic wind speed. (Table I)

In the lower latitudes the sea is normally smoother than in the higher latitudes, so that the frictional constant for oceans in lower latitudes should be closer to 2×10^{-5}. For this value of the frictional constant the following values are obtained: (Table II)

The effects of varying the different constants are as follows:

The larger the resistance the more the fluctuations in wind velocity are damped out and the greater the angle at which the wind crosses the isobar.

As higher latitudes are considered for a given fluctuation in the pressure gradient: the wind speed is higher, the angle at which the wind crosses the isobar is smaller, the period of any sinusoidal fluctuation in the wind speed is shorter, and the pressure gradient approaches its final steady value more quickly.

It might be pointed out that neither f, the coriolis force, nor k is important by itself. It is the ratio of k to f that determines the type of curve which will result. It should be noted that when there is friction the period necessary for steady motion to be attained is considerably greater than the period necessary for the pressure gradient to reach 99% of its final value. From this it can be seen that the occasions when equilibrium conditions exist are rare and the motions will usually be in the following stage.

The value of the paper can be summed up as follows:

It furnishes a picture of the approximate motions of air when subjected to very simple pressure gradients. This picture can be helpful in understanding such problems as convergence, divergence, and flow patterns. It will also serve to enable forecasters to better evaluate reports and synoptic pressure fields in regions where pressure reports are lacking.

Continued from Page 8

Engine operation is the source of carburetor heat; a dead motor yields none. Carburetor heat must be applied *before* engine failure is imminent. Where carburetor icing is a danger, lower the landing gear rather than reduce r.p.m. to permit descending at the rate of 1000 to 2000 feet per minute.

As pre-heating the intake mixture will decrease the efficiency of the motor, this should not be done when there is a sudden demand for power as in take-off or landing. Injection of de-icing fluid (e.g. alcohol) is preferable at such a moment and has the additional advantage of raising the octane number of most fuels.

Viljhalmur Steffansson, noted arctic explorer, performs his duties as Special Consultant at the Arctic Training Center before weathermen learning to live in the North. Sir Hubert Wilkins, Lawrence Gould, Belmore Browne, and other famed masters of arctic lore regularly appear in a like capacity.

Since the big-game of the arctic regions are not of the pacific zoo variety, this weatherman is careful to set his food supply (obviously the greatest attraction to animals) in this tree platform, well away from his living quarters.

TRAINING WEATHERMEN FOR ARCTIC LIFE

The frigid and severe climate of the Arctic has been invaded by the Army Weather Service, guiding military units into efficient use of the elements from Greenland to the Aleutians. More than courage and good equipment is needed to enable weathermen to perform their tasks in this environment---and the Arctic Training Center in the mountains of Colorado provides the other necessities: "know-how", physical and psychological screening, and self-reliance.

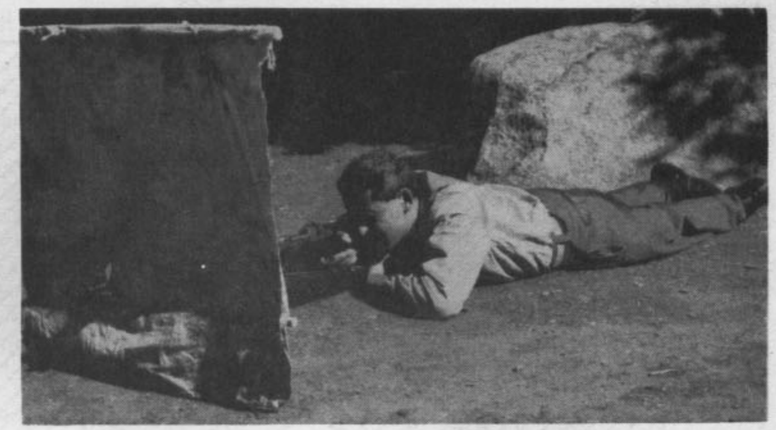
Qualified weather specialists, all volunteers for northern service, arrive at Buckley Field (located at a temperate level in the mountains) where the first two weeks of an intensive five week course are given. This period is used primarily to eliminate carefully those individuals whose temperaments or physiques are unsuited for rigorous, solitary life.

Throughout the training, certain personality traits are

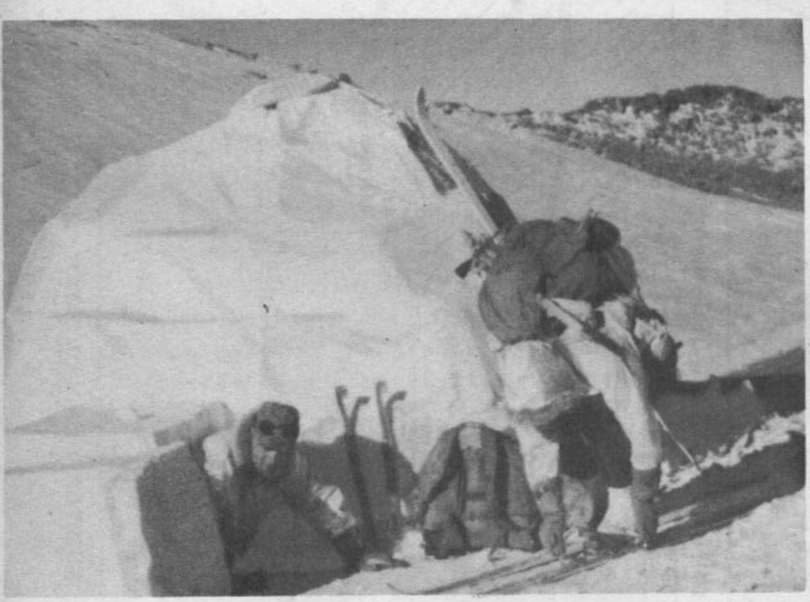
Spruce lean-to's, parachute tepees, log cabins, snow houses, caves, and pre-fabricated shelters are all made familiar to the soldier who will soon have lives wagered on his proficiency in their construction and use. Very different skills are needed in

Any injury is serious in the North, where an active body and an active mind are needed at all times to avoid danger. These men are learning how to manage the rescue of an unforsought: friction with associates, inattention to instructions, ineptness in the given activities, and an unusual lack of self-assurance may serve to eliminate a student at any time.

Echo Lake, snowy the year around and at an elevation of more than 10,000 feet in the Rockies, provides an excellent simulation of arctic conditions and is the environment into which the soldier is placed for the next three weeks. Captain Charles Innes-Taylor, R.A.F. officer in the last war, veteran of the Royal Canadian Mounted Police, and pilot with two Byrd antarctic expeditions, commands the camp. The fourth and fifth weeks are divided between two outposts from Echo Lake---one is set in timber country and the other in a barren waste---where all of the training is put into actual practice in living and working under arctic hazards.



Trainees do their own cooking and even obtain food from the countryside while at Echo Lake. Methods of ice fishing in the winter and bait fishing in the summer are demonstrated, and when dog teams are available, the stalking of elk provides big-game hunting experience. After practice has convinced a man that he can live alone, he is better able to do so.

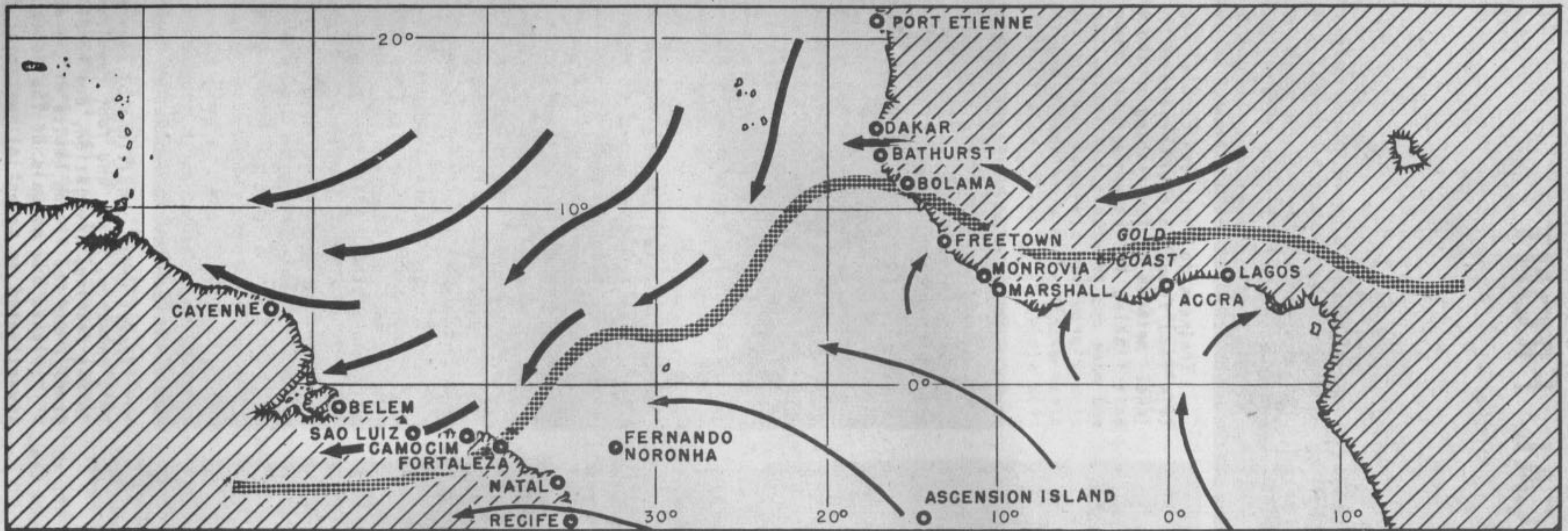


the various seasons, since extremes of temperature are the rule: 70°F. above zero in the summer and 70°F. below zero in the winter may be experienced. The instructors are veterans of a year or more in the Weather Services of cold climates.

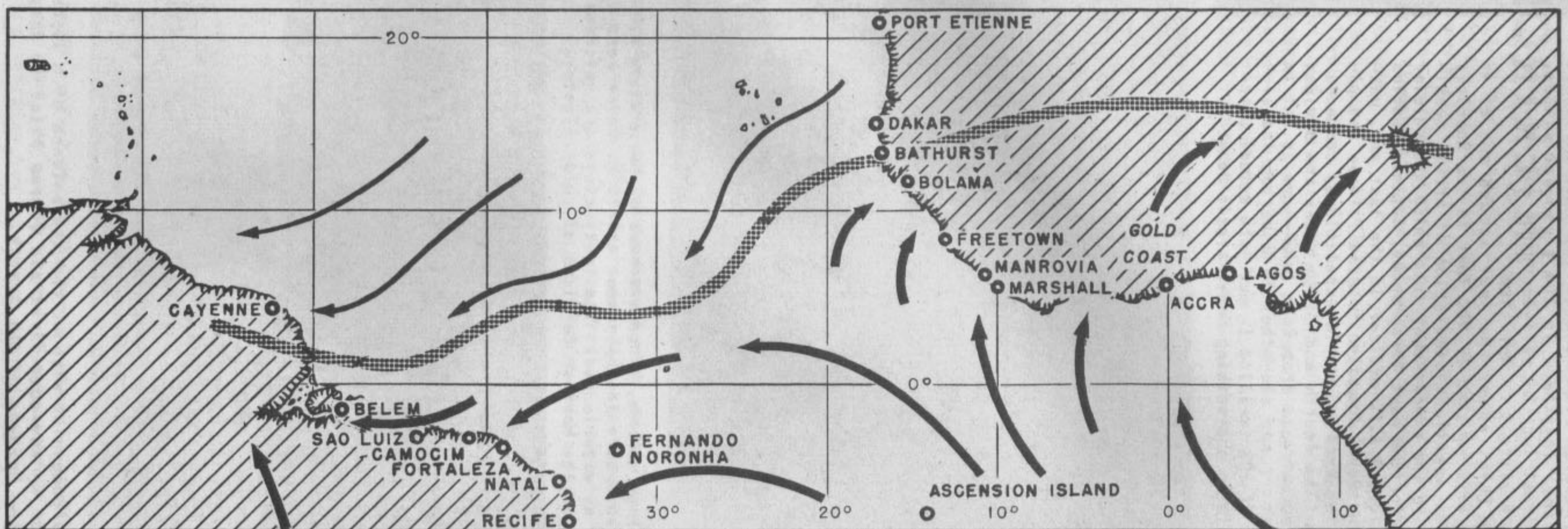
tunate companion without the convenience of a dogteam; all as part of an advanced first aid course which is adapted to the peculiar hazards of the Arctic.

Travel under conditions of severe cold by ski, snowshoe, sled, and foot requires studies in map reading, navigation, dog handling, geography, and the living habits of the aborigines.

Plants and animals of the North are also investigated as potential emergency rations.



MEAN SURFACE WINTER POSITION (DEC.— MAY)



MEAN SURFACE SUMMER POSITION (MAY — DEC.)

INTERTROPICAL FRONT

by P.F.C. C. K. Reynolds

Every textbook recites that a zone of convergence exists between the Northeast and Southeast Trades---in modern nomenclature the Intertropical Front. The silence of the literature about actual weather patterns associated with this "front" is disappointing, particularly because the atlantic equatorial flying routes are affected. It is from my experience at Belem and Camocin that this paper discusses the Front's position, effects, and structure.

When an arm of the Front lies inland from the northeast coast of Brazil (see charts), no band of frontal weather is in evidence; its position on the map merely marks the southern limit of an area of convective weather which extends northward to the coast. Moist, conditionally unstable air is brought inland from the Atlantic by the northeasterly winds to the north of this line of convergence, while dry air composes the southeast winds below the Front because of the lengthy land trajectory.

Transition from the rainy season to the dry season at a particular equatorial station is thus accomplished by the passage of the Intertropical Front over that station in a long-term trend. The contrast between the seasons is not as great as might be expected from an examination of the long overland trajectory of the "dry" Southeast Trades; thick, steaming jungle vegetation transpires large amounts of water vapor into the lower levels of this air.

As distinguished from this semi-annual drifting, the position of the Front is constantly being changed by the influence of adjacent extra-tropical pressure cells and by the passage of waves from east to west along the front. This movement of waves may seem confusing at first, but the definite, steady easterly component of the Trades both north and south of the Front precludes any movement to the east, at least between the coast of Africa and Long. 55^{o} west. Thus an observer located near the mean position for a particular week may experience rapid changes in weather types.

The Intertropical Front, like its extra-tropical analogues, is most active when solar heating is greatest. Particularly in the afternoon, flights have been turned back by the Front both along the coast and inland. Planes have flown more than 50 miles seaward without finding a sufficient break in frontal cloudiness to attempt a break-through. On the other hand, it is often difficult to locate its position on the morning map when the Front is passive.

The rainy season at Belem begins about the middle of December. During the first half of the month, Belem experiences normal dry season weather, with local afternoon thunderstorms. Between 13 and 16 December, 1941, a noticable change in weather conditions was observed, marked by light winds, a minimum of cloudiness, and a slight decrease in barometric pressure. These conditions appear to be representative of the passage of the Intertropical Front to the south of Belem.

Following this period of transition, a marked increase in high cloudiness was noted and very shortly we were subjected to three days of light, steady rain. Typical rainy season conditions prevailed subsequently, with the Front occasionally fluctuating to the north of Belem as waves passed from east to west.

Statistics indicate that the return of the Front to a mean position north of Belem at the end of the rainy season is not as clearly marked as its movement to the south of Belem. This may be explained by the statement thad southward movement is a displacement due to penetration of colder air from the north, while northward movement is a replacement by warmer air from the south.

An interesting wave pattern was observed on 21 February, which by 1200 GMT on 22 February was so located that Belem was in the warm sector, with the front to the north of the station. Our inexperience led us to believe the front would pass southward again over Belem on the early morning of the 23rd. However about 2100 GMT on 22 February, about the arrival time of scheduled coastal flights, a very black squally condition preceded by a high dark altostratus layer moved in from the east northeast, giving the most intense rain observed at Belem up to that time by our staff. The flight from the north landed just prior to the arrival of the front, and had great difficulty finding the ramp. Although we missed forecasting the actual arrival time of the front, we were pleased to see our "wave theory" working. Unexpectedly strong winds aloft, revealed by a re-examination of data, resulted in more rapid movement of the wave than had been forecast.

During the first week of February, a rather large drop in pressure was observed along the northeast coast of Brazil from Natal to Belem. At this time, flights from east to west over the ocean reported flying on instruments for short periods of time in rain and clouds within a radius of about 400 miles of Natal, but with apparently rapid clearing within 200 miles of the coast in the vicinity of Natal. These factors, when co-ordinated with observed intensification of rainy season conditions along the entire coast and a noticeable change in reported weather from Fernando Noronha, indicate a deepening of the pressure system associated with the *semi-permanent wave structure* which is centered at about Lat. 1°North, Long. 32°W.

The decrease in coastal pressures, as well as the pressure drop at Fernando Noronha, probably indicates a deepening of this pressure system; but there is also the possibility that it indicates a southward movement of this depression.

In the extreme lower levels, temperature changes deflect the Trades. This fact is clearly evident along the African coast where the southeast Trades of the southern hemisphere are deflected to light southwest winds north of the geographical equator. These blow onto the Gold Coast, and more northerly portions of the coast as far north as Boloma, where monsoon winds are experienced from March to October. This monsoon is most consistent from June to August. This is quite logical, as in this period the intertropical front is extended north of Boloma by its semi-permanent coastal wave.

The following descriptions and analyses are the results of an attempt to obtain an accurate method of forecasting weather along the northeast coast of Brazil, particularly the Belem-Recife area.

The Meteorological Station at Belem was opened about the beginning of the rainy season which was 15 December 1941. It soon became apparent that the various articles on tropical weather and analysis (2) were all of great assistance, but were not written for the particular area in which we were interested.

During the second week in December 1941, extremely calm conditions and relatively low pressure prevailed. Our synoptic charts led us to believe this condition represented the passage of the intertropical front from the north to the south of Belem. Subsequent maps showed our assumption to be correct, and indicated a still further southward movement of the intertropical front until at the height of the rainy season the discontinuity had reached a mean position inland about 300 miles due south of Belem.

It is not possible to detect waves moving along the intertropical front until they pass on shore, usually near Camocim. The movement of a wave through this area gives the following phenomena: first, an increase in intensity of northeasterly winds, particularly in the lower levels in advance of the wave to the north of the front, and widespread areas of rain and squally weather in advance of the wave. Ceilings are quite good in this area, and it is believed that the front is at this time a warm front sloping to the north.

As a station came within the warm sector of a wave the following changes were noted. The lower clouds no longer moved from the northeast, but from the south. Cloudiness became broken with scattered light showers continuing. Winds in the lower levels (to 5,000 feet) became light southerly or southwesterly.

The passage of the second leg of the open wave was usually less clearly marked than the first. It was attended by a shorter line and a return to northeasterly winds in the lower levels.

The movement of such waves from east to west along the intertropical front is not a regular action, but seems to be affected by the activity of adjacent extratropical highs and lows in causing changes in the intensity and direction of flow on both sides of the front.

A station located in the open sector of a wave has typical cool air mass weather, cumulus humilis building to cumulus congestus and to cumulonimbus by mid-afternoon, with clearing in the evening and clear nights. A station outside of an advancing or receding wave usually has showery conditions all day, with a high overcast and light rain at night. The dissipation of the high overcast after sunrise seems to indicate that radiational cooling is effective under these conditions and is at least partially responsible for the light rain at night.

SUMMARY OF RAINY SEASON CONDITIONS:

The following points will be of value to meteorologists and pilots who are interested in the weather along the northeast coast of Brazil.

1. Wave movements from east to west

result in periods of three or four days of continuous showers and rain.

2. Ceilings below 800 feet are not common although scattered stratus at about 400 feet is common.

3. Low ceilings and visibilities accompany shower activity and therefore are of relatively short duration, seldom remaining unchanged for more than half an hour. Ceilings in rain from stratiform clouds are always good, being between 2,000 and 7,000 feet.

In the past ten years, fog and low stratus have occurred several times each year, but only in the early morning. An observed case of this sort showed stratus at tree-top level extending from the coast well inland, but not over the Belem landing field itself which is about 60 miles inland. This indicates the fog-forming effect of radiation and the transpiration of moisture by vegetation.

4. As in extratropical fronts, weather conditions along the intertropical front are less favorable during the afternoon period when insolation has rendered the moist, conditionally unstable air absolutely unstable. Flights have been turned back by the intertropical front, both along the coast and inland. Along the coast, planes have flown more than 50 miles to seaward without finding a break in frontal conditions. During the morning, the intertropical front is generally passive; it is often difficult to detect its location. Flying south from Belem, we first observe an altostratus layer at about 14,000 feet. Near the tree tops, low, ragged, thin stratus may be observed. Upon passing through the passive front the altostratus is left behind, giving way to cirrus and cumulus formations.

5. Winds both at the surface and aloft along the northeast coast of Brazil as far south as Fortaleza vary with the changing intensity of the gradient caused by the formation and translation of neighboring extratropical high and low pressure areas. The greatest variation is in velocity aloft, which varies between 12 and 45 miles per hour. The direction below 9,000 feet is generally easterly to east southeasterly, tending to easterly and east northeasterly above 9,000 feet. In general, winds decrease above 10,000 feet as they shift to an east northeast or northeasterly direction.

Flying Conditions on the Trans-Equatorial Atlantic Route (Flights departing from Natal)

1. *From Natal to Accra or Lagos* This route is always south of the surface position of the intertropical front, and except near the African coast little or no weather is encountered. Over the first 1500 miles, cumulus clouds are scattered to broken wibh bases averaging 2,000 feet and tops rising to 7,000 or 8,000 feet. Scattered altocumulus or altostratus may be present above. Within 100 miles of the African coast cumulus congestus and cumulonibus become broken to overcast, with showers and turbulence. If the flight is conducted over the seacoast much of this off-shore weather is avoided, and by flying at low altitude the haze condition of this region is made relatively unimportant. Arrivals at Accra or Lagos during the middle morning hours find scattered to broken cumulus and ample visibility. Surface winds are usually light southerly for landing.

3. *From Natal to Marshall (Roberts field) or Monrovia* - In general, weather conditions over the first half of this route are very similar to those of the Natal-Accra sector. Cumulus congestus is scattered to broken, with scattered middle clouds. About 1100 to 1400 miles out of Natal, middle clouds increase, becoming broken to overcast, with a lower deck of stratocumulus. This condition is accompanied by rain and very slight turbulence during the period from October to February, when the intertropical front is moving south. During the remaining months of the year, the above mentioned cloudiness is present in this area but precipitation is uncommon. During the entire year it is possible to fly between layers through this area.

Upon passing through this area and approaching the coast, one notes increasing haze, with often a thin cirrus, broken to overcast, and low broken cumulus. The coast in the early hours and until shortly after daybreak may be shrouded in low stratocumulus or stratus which dissipates soon after sunrise. The presence of such coastal weather definitely shows the monsoon effect, and that the intertropical front is to the north.

3. *Natal to Freetown, Boloma, or Bathurst* - During the period of October to March, the intertropical front crosses the coast well south of these African stations. As the front is north of Natal, it must be crossed on this route, and under certain conditions one of its active portions must be paralleled for some distance. After passing through and away from the frontal area, one will encounter scattered cumulus clouds, bases 2500 feet with tops to 6,000 feet. Cirrus is not uncommon over the remainder of the route as are increasingly hazy conditions.

Winds over Trans-Equatorial Atlantic Routes

In general, the winds below 10,000 feet are east southeasterly over the western third of the route, backing to east northeasterly over the eastern third. Velocity varies from 10 mph to 35 mph, apparently being quite consistent over the entire route at any one time. An average velocity is about 20 mph. It is not possible to make definite statements as to the direction and velocity of winds above 10,000 feet. However, it is probable that they are lighter and much more variable than in lower levels because of the anti-trade effects and passage of upper level pressure centers.

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DRY SEASON CONDITIONS

The dry season along the northeast coast of Brazil begins about the end of May as the intertropical front moves northward. This northward movement is not limited to the portion of the front which affects the coast of Brazil, but is characteristic of the frontal structure as a whole. The change from rainy to dry season occupies about two weeks at any one point, during which time the weather conditions fluctuate between rainy and dry season types. This is caused by the passage from east to west along the intertropical front of migratory waves which change the latitude of the front by as much as 200 miles.

On land the characteristics of dry season weather are more pronounced than at sea. Over land, there is lower dew point and somewhat higher afternoon temperatures. Clouds continue to be predominantly cumuliform, but with bases 1000 to 2000 feet higher than in the rainy season.

A typical dry season day may be described as follows: clear in the early morning, with cumulus clouds scattered to broken by noon, and scattered thunder showers during the afternoon. The intensity and number of thunderstorms is clearly diminished in dry season weather. The visibility is much better during the dry season, because few hygroscopic salt particles, low humidities, and thermal turbulence are the rule.

It should be remembered that the dry season follows behind northward movement of the thermal equator coinciding with summer in the Northern Hemisphere. It follows, then, that the intertropical front should slope upward and to the south if colder air is present to the south. In fact, however, remembering that there is much less land area in the Southern Hemisphere and that all air masses are therefore maritime or transitional maritime, polar air masses moving from the south towards the equator are seldom if ever colder than corresponding air masses from the Northern Hemisphere, even in its summer. As a result, the slope of the intertropical front is always northward, varying in steepness with the temperature and pressure gradients. This fact is also shown by Schnapauff (1) in his analysis of trans-equatorial weather.

In general, we may state that flying conditions are much improved during the dry season along the northeast coast of Brazil. Over the ocean the same is true. As pointed out previously, the flying routes from Natal to Dakar, Boloma, and Bathurst must cross the intertropical front during the rainy season. During the dry season, (northern hemisphere summer) these routes and all routes from Natal to the Gold Coast are south of the intertropical front. Along the Gold Coast and as far north as Port Etienne the dry season is the monsoon period. Naturally, the Gold Coast has a more or less year round monsoon effect; but the area from Monrovia, Liberia, to as far north as Port Etienne, is the region of fluctuation of the intertropical front. In the Gold Coast rainy season the intertropical front is near its northern limit, which means that the monsoon effect then extends as far north as Port Etienne. During the winter months of the northern hemisphere the intertropical front is near its southern limit, Monrovia, and the coast line from Port Etienne to Monrovia is then in a much drier flow from the Sahara high pressure cell.

The effect of this variation in the location of the intertropical front is shown in the humidity values from Freetown and Bathurst.

Freetown Humidities		
Lowest mean	February	73%
Highest mean	July	88%
Bathurst Humidities		
Lowest Mean	January	44%
Highest mean	August	79%

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HINTS FOR RADIOSONDE OPERATORS AND TECHNICIANS

Useful comments on the smoothing of kinks in radiosonde operation are given by enlisted men of the 12th Weather Squadron in a series of letters circularized among "R" sections and Weather Equipment Technicians. Other squadrons might profitably publicize such matters under initiative of the regional Weather Equipment Engineer.

Choosing the Site

Too often a faulty site for the radiosonde ground station causes poor soundings. The Weather Equipment Engineer who is sent to survey the possible sites where a station is contemplated should bear in mind the following points:

1. Keep away from possible sources of A. C. line interference, such as fan motors, drill presses, and lathes.

2. Install the antenna as high as possible, bearing in mind that it should be higher than nearby trees and preferably on a hilltop. Remember, however, that the maximum of a 200ft. transmission line may not be exceeded.

3. Choose a site close to a suitable launching area. It is always a good idea to be able to see the spot where the balloon is launched from a window of the radiosonde station.

Many station weather officers wish to have the radiosonde ground set installed in or close to the weather station. This is naturally a desirable feature, but often one or more of the above points will have to be sacrificed in consequence. After all, the station weather officer primarily wants the highest sounding possible and he should therefore adhere to the better judgment of the Weather Equipment Engineer.

Instrument Difficulties

Radiosonde operators have often found that an ascent yields a temperature trace only, with little or no switching. If he is quite sure that the pen arm was down before the release, the trouble usually lies in improper cleaning of the commutator. Don't slight the job of polishing the commutator! It is a very important step and must be done with extreme care. The crocus paper should be rubbed lengthwise across the commutator being careful not to apply any appreciable pressure. When complete, wipe with a clean soft cloth or tissue paper to remove any particles. Never clean the commutator with the fingers, as oil or grease from the skin may cause a poor contact with the pen.

Oftentimes operators will bend the pen arm down on the commutator in the belief that there is not enough tension to depress the pen arm sufficiently to make a contact when on "humidity". This is usually a false assumption, and "corrective" action based on it throws the instrument out of calibration. Never attempt to bend the pen arm!

Radiosonde Release Technique

In a moderate or strong wind the lower antenna of the instrument sometimes whips around and affects the steadiness of the received signal. To overcome this difficulty, attach a piece of masking tape to the very end of the instrument box holding the antenna in place there---then with a long strip of tape completely enclose the rest of the antenna.

Calibration of Ground Station

The radiosonde ground station, although a very large instrument, is none the less delicate. It is very easy for its electrical characteristics to change. When the Weather Equipment Technician completes an installation of a ground set he leaves a calibration curve to be used in making corrections to the received data. The ground station should be recalibrated once a month if possible--at least once in three months. If for any reason the ground set has to be moved, a recalibration is necessary. Be sure to have the set so situated that any part may be reached without actually moving the instrument. Naturally field conditions do not always permit recalibration of the set after each time it is moved. In any case, use extreme care in moving the instrument and take steps to assure recalibration as soon as possible thereafter.

SAFETY MEASURES IN POWER UNIT OPERATION

The recent loss by fire of two power units, PE-75A and PE-75K, focuses attention upon the fact that small power generating units are hazardous unless very carefully operated and maintained. The process of filling the fuel tank has to be done with extreme care to avoid spilling of gasoline over a heated engine. Even if gasoline is spilled over a *cold* motor, it must immediately be wiped dry. All connections should

Continued on Page 30

REPORTS FROM THE REGIONS

15th Weather Region

The 15th Weather Squadron is issuing certain forecasts in an abbreviated form at the request of the Fifth Air Force Advance Echelon, by classifying weather situations into six groups:

"A" - Less than four tenths clouds below 18,000 feet. Visibility six miles or more. Satisfactory for high level bombing and complete fighter protection.

"B" - Four to six tenths cloud between 300 and 18,000 feet. Visibility six miles or more. Conditions are satisfactory for low level bombing, but the success of high level bombing is doubtful as the target is occasionally obscured by clouds -- fighter cover is possible.

"C" - Seven tenths or more clouds above 10,000 feet. Four tenths or less clouds below 10,000 feet. Visibility six miles or more. Satisfactory bombing below 10,000 feet. Close fighter cover only.

"D" - Seven tenths or more clouds between 2500 and 10,000 feet. Visibility six miles or more. Satisfactory low level bombing or strafing only.

"E" - Seven tenths or more cloud between 1000 and 2500 feet. Visibility generally greater than three miles. Intermittent instrument flight conditions. Formation flying difficult; success of strafing doubtful; unsatisfactory for bombing.

"F" - More than seven tenths of cloud at 1000 feet or below, or visibility less than one mile. Prolonged instrument flight conditions. Terminal closed.

When weather conditions are expected to change during the forecast period, change will be shown by second letter indicating new class of weather followed by two numbers indicating time of change in local time. Example:

Class "B" weather deteriorating to Class "E" weather after 1100L would be codified "BE 11".

23rd Weather Region

The Army Air Base at Harvard, Nebraska, in the person of Lt. Morris Dansky provides a method for the estimation of high-level winds:

Geostrophic wind scales are constructed for the 20,000 feet and 10 km. mandatory levels using the following mean densities of air:

At 20,000 ft. 6.53×10^{-4} gm/cu cm.
At 10 km. 4.05×10^{-4} gm/cu cm.

Such a ready-made device as the Bellamy Horizontal Temperature and Pressure Gradient Scale may also be used. Winds at each of these levels are determined using the geostrophic assumption. To find velocities at intermediate levels, follow this example:

GIVEN: Wind at 20,000 feet, 220° 24 mph.
At 33,000 feet (10 km.) 270° 40 mph.

TO FIND: Direction and speed of wind at the 24,000 foot level (for example).

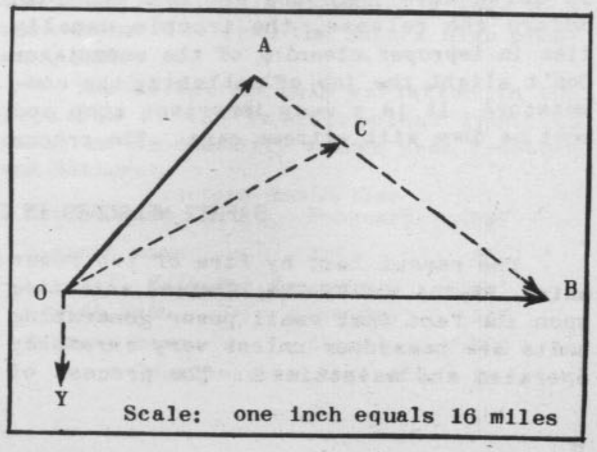
METHOD: Let OA represent direction of wind at 20,000 feet and length OA be proportional to speed. Let OB represent direction of the 10 km. wind and be proportional in its length to the speed at that level.

Draw the line AB.

Since 24,000 is 4/13 the distance from 20,000 to 33,000, find a point C such that distance AC is 4/13 distance AB.

Draw OC. Its direction will thus be proportional to the required wind speed.

In the example above, wind at 24,000 feet should be about 240° at 26 mph.



Of course the assumption of a steady turning of the wind from 20,000 feet to 33,000 feet is made in this example. If data is available on the layers in which advection is taking place (from consideration of discontinuities and temperature changes in RAOB ascent), the thermal wind relation may be used in conjunction with vectorial interpolation for better results.

If say, it is known in the example given that warm air advection is occurring up through 20,000 feet and ceases at 28,000 feet, the given 10 km. wind may be taken as steady down to 28,000 feet and, in the example, point C taken at AC $\doteq$ CB.

9th Weather Region

The Ninth Weather Squadron is now probing the atmosphere from bases on land, sea, and in the air. This familiar trilogy was recently completed when a weather station of the "D" type was established on an ATC Air Sea Rescue Boat to operate in the Caribbean area. Observations are being transmitted for the first time from areas where lack of supplies, housing, and terra firma had previously prevented coverage.

Operation of a weather station on shipboard brings up many new problems, not the least of which is the use of naval-type equipment. Balloon runs must be taken under the handicap of a constantly changing orientation of the theodolite in relation to the balloon, caused by movement of the boat. The marine type equipment simplifies this and other problems, although additional computation is necessitated.

The observers taking the cruise, Staff Sgt. Clyde Wells, Sgt. John Warden, and Cpls. Leon Geisler and James Turner, have received training in crash boat and anti-submarine tactics. Clad in the regular sea-going "uniform" of dungarees and sneakers, these men give the Ninth Squadron the flavor of a "Combined Operations" unit.

ABSTRACT

COMPUTATION OF PRESSURES AT A CONSTANT ISOPOTENTIAL LEVEL

Edward Skolnik

Bull. Am. Met. Soc. Oct. 1943

A slide rule has been developed by the Weather Bureau to permit semi-skilled personnel to compute the pressure at three dynamic kilometers from adiabatic charts.

To begin with it is assumed that the integrated hydrostatic equation,

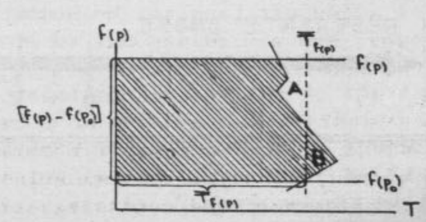
$$\ln \frac{p}{p_o} = -\frac{gz}{R\bar{\bar{T}}_v}$$

where the value g has been treated as constant with height and the acceleration term has been dropped, is correct. The resulting error in g is infinitesimal compared with instrumental errors. The error due to the dropping of the acceleration terms is negligible under ordinary conditions, but may be great when convection is occuring.

The Stuve diagram with abcissae of T and ordinates of $p^{.288}$ is used to solve this equation. As geopotential measures energy levels, a true-energy diagram theoretically should be used (T vs. ln P). To examine the validity of this substitution, consider a mean temperature taken on the adiabatic chart, which will be:

$$T_{p^{.288}} = \frac{-\int_{p_o}^{p} T \, d(p^{.288})}{p^{.288} - p_o^{.288}}$$

This can best be shown graphically:



The shaded area is expressed by:

$$\int_{p_o}^{p} T\, d[f(p)]$$

This integral also represents the rectangular area since $T_{f(p)}$ is chosen so that A=B; then we have that the mean value of T with respect to f(p) for the portion of the curve under consideration will be:

$$\bar{T}_{f(p)} = \frac{\int_{p_o}^{p} T\, d(f[p])}{f(p) - f(p_o)}$$

This can be integrated if T can be shown as a function of P. To manage this, assuming half the adiabatic lapse rate as an average of observations we have:

$$T = \frac{T_o + T_o(p/p_o)^{.288}}{2}$$

from Poisson's equation.

Integrating (1) with this assumption we get:

$$\bar{T}_{\ln p} = \frac{T_o}{2}\frac{[1 + (p/p_o)^{.288} + 1]}{2}$$

With the same assumption is derived:

$$\bar{T}_{\ln p} = \frac{T_o}{2}\frac{[1 + (p/p_o)^{.288} - 1]}{.288 \ln p/p_o}$$

The ratio of $T_{\ln p}$ to $T_{p^{.288}}$ at normal pressures for sea-level and three dyn. km, will be or the order of 1950/1951, and the error involved in finding the mean temperature on the adiabatic chart rather than on an emagram will be in the neighborhood of .15°C.---entirely negligible.

The familiar method of determining the mean temperature by constructing an isotherm by eye which was meant to give equal areas on both sides between the sounding and the line proved difficult and inaccurate because the areas to be equalized were frequently large and irregular in shape.

To overcome this difficulty, celluloid strips were prepared with full and half scales marked on them, as in Figure 1. The reference cross at the top of the figure is set any place along the estimated pressure at 3 dyn. km. and the strip is then swung until the areas between the

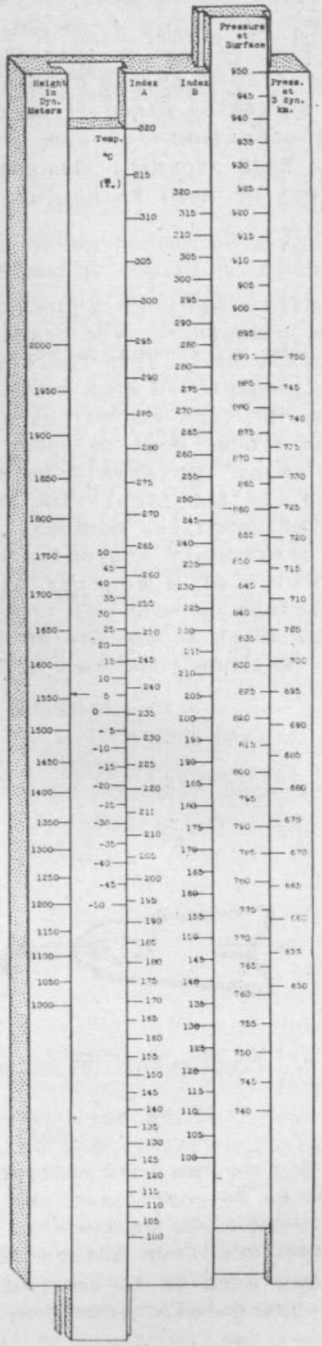


Figure 2

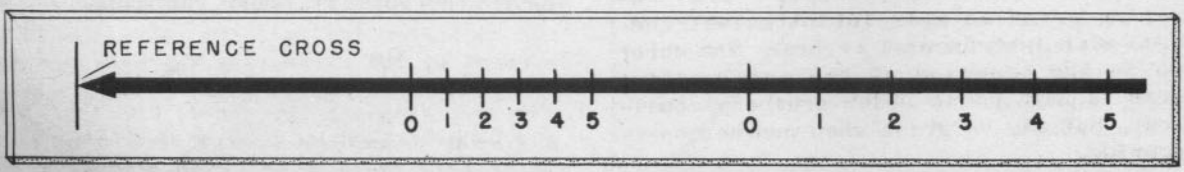


Figure 1

sounding and the center line of the figure are apparently equal on both sides. The full scale is read at the bottom of the sounding, and the mean temperature is read at the corresponding unit on the half scale. Since the device can be so placed so as to give very small areas, accuracy in the determination of mean temperatures is high--so high in fact, that two persons using the same method rarely differ in their estimates by more than .1° C.

Given the mean virtual temperature of the air column, the pressure at its base, and the altitude in dynamic meters above sea-level, the reduction of pressure to three dyn km. is simple in the formula as modified:

$$\ln \frac{p}{p_0} = \frac{K(3000 - h)}{\overline{T}_v}$$

A slide was devised to do the work of the formula, by setting each side of the equation equal to an index. In that form,

$$I = \ln p - \ln p_0$$

$$\ln I = \ln (3000 - h) - \ln \overline{T}_v - \ln K$$

A diagram of the slide appears as Figure 2. The left hand slide solves the second equation, giving an index number. The pointer on the right is then moved to the corresponding index number of that side, and pressure at 3 dyn. km. read directly opposite the surface pressure.

THE STORAGE AND USE OF HYDROGEN CYLINDERS

The following instructions are extracted from Signal Corps Supply Letter A192 and are recommended as a precautionary guide:

In view of the hazards attendant upon the use of inflammable and explosive gases such as hydrogen and acetylene, rigid adherance to safety regulations is needed to avoid the destruction of property, personal injury, and loss of life. Personnel engaged in the use of these gases should be required to use every precaution. Suitable instructions should be conspicuously posted where practicable at or near such places where operations requiring the use of these gases are performed or where cylinders are stored.

The regulations of the Interstate Commerce Commission as to marking, testing, charging, and handling compressed-gas containers are to be complied with.

Compressed-gas cylinders must be tested and marked with the date of test at least at once in five years, in accordance with the regulations of the Interstate Commerce Commission.

A container once filled with one kind of gas must always be used for the same gas, except when other wise directed by the Office of the Chief Signal Officer.

Avoid dropping or jarring gas containers at any time, but especially when they are filled with gas at high pressure.

Store containers of inflammable gas in open, unheated shelters rather than in inclosed rooms. The shelter should be such as to protect the containers from the direct rays of the sun. In case of fire near enough to heat such containers, all unauthorized persons should be kept at a safe distance.

Do not carry lighted cigars, cigarettes, pipes, matches, candles, oil lamps, or lanterns into, or have any open fire, in the room or in the vicinity of containers of inflammable gas.

Do not attempt to repair cylinders or their valves, but instead return defective or even suspected containers to the shipper or turn them over to proper agencies for reconditioning.

Where possible use inflammable gas from the container in an open shelter and at least 15 feet away from other containers. If gas must be drawn from a container within a room, make sure that the room is well ventilated and that the container is well removed from radiators or other sources of heat.

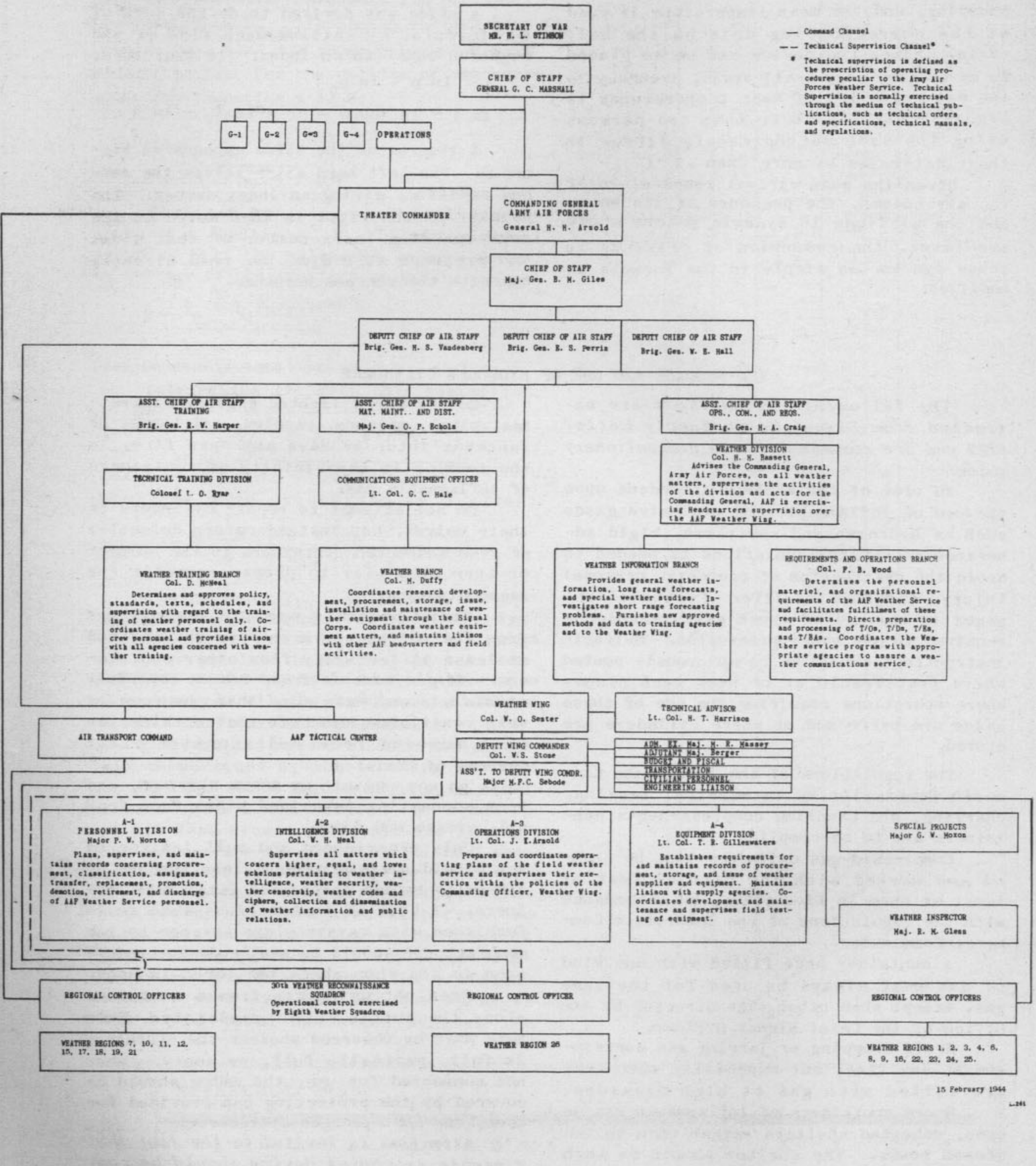
DO NOT USE OIL ON SCREW FITTINGS, and keep connecting tubes and pipes free from oil, grease and dirt.

Only experienced and well instructed men should operate oxyacetylene torches or otherwise handle compressed gases from cylinders. A book of instructions such as is furnished with oxyacetylene torches by the manufacturer should be available for reference in the shop where the torch is used.

When not using gas from a container close the outlet valve completely. This rule must be observed whether the container is full, partially full, or empty. When not connected for use, the valve should be covered by the protecting cap provided for acetylene and hydrogen cylinders.

Attention is invited to the fact that a simple grounding device should be constructed for the purpose of grounding the generator in use, to prevent build up of a static electric charge produced by friction of escaping gas.

ORGANIZATION OF THE ARMY AIR FORCES WEATHER SERVICE



REVIEW

"CONDENSATION TRAILS" TRAINING FILM 1-84

A notable enigma is finally dissolved by a discussion on the "Restricted" level with the release of TF-1-84, entitled "Condensation Trails". The direction and production of the film from a "commercial" standpoint demonstrate that important refinements over the stilted training movies of not so long ago have been made almost directly as the Hollywood technique has been adopted; the handsome protagonist, a Weather Service captain, may very well achieve a matinee-idol status, particularly if it is decided to instruct WAC personnel on this subject.

The original technical research was largely performed by the National Advisory Committee for Aeronautics, and especially R. V. Rhode and H. A. Pearson.

The script is obviously directed at air crew members, but weather men not assigned to advanced operational echelons where the "Confidential" forecasting methods are in frequent use, can profit much from this theoretical and practical exposition. "Contrails" are quite worthy of consideration, principally because they make easy the determination of force, altitude, number, and course of attacking planes both by ground and fighter defences; in the attack-approach to bombers, defending fighters may even use the bomber trail to screen their movements.

An outstanding fact about condensation trails, particularly important for flight crew attention, is that occupants of a plane frequently do not know that the plane is leaving a trail, even when one is expected. It is frequently necessary to make a sharp turn of 180° before such trails become apparent from the aircraft.

Occasionally it may seem to a pilot that only one engine of four is making a trail. Generally this means that the trail behind that engine is starting closer to the plane than trails behind the others. Pilots have reported that opening of cowl flaps caused a trail to form. Actually opening the flaps probably causes the trail to form close enough to the engine to be visible from the cockpit.

Exhaust Trails: From tactical considerations (the only significance of contrail study) the most important type is the exhaust trail, formed by condensation of moisture emitted from the exhaust stacks. This trail may be consistently encountered at some altitudes and latitudes, is very difficult to eliminate once formed, and may persist for a half-hour or more.

In this type, the hydrogen of the fuel used combines with oxygen from the air and forms water in the normal process of providing energy for engine operation. When regular aviation gasoline is burned in an engine, about 1.25 pounds of water is formed as vapor and discharged with the exhaust for each pound of fuel burned.

Behind the fuselage or nacelle, a turbulent wake is formed by the aircraft in flight. Exhaust moisture and some engine heat are discharged into this wake and become diffused, but only in the limited area surrounded by "smooth" air. The vortices in the wake grow and rotate more slowly as they pass downstream from the airplane; thus the wake expands and decays. During this process the energy of the turbulence is converted into heat by friction and dissipated; finally so much energy has been lost that the wake can no longer continue to grow. This point is reached at a mile or more behind the airplane, depending on the speed and power of the plane. The interaction of wing-tip vortices by this time changes the wake form into a flat, ribbon-like solid with curved edges, but this change does not involve any further mixing of the air.

At high temperatures, the rate of change of the function relating saturated mixing ratio to temperature is great and the saturated mixing ratio is great; at low temperatures the rate of change is small and the maximum water content is small. For these reasons the true exhaust type trail will rarely occur at temperatures higher than -25°C. regardless of the initial humidity. Below this temperature level the addition of exhaust water to that already in the atmosphere may cause condensation and exhaust trail formation. It is obvious then that regions of high humidity and low temperatures are favorable for such formations: thus planes must be cautioned agsinst approaching cloud layers at temperatures below -25°C when in the combat zone. It is also true that modern planes with "clean" design and high fuel consumption are more prone to exhaust trail formation because of the greater water weight added to a smaller wake.

These facts provide clues to corrective measures. Opening the cowl flaps increases the size of the wake; throttling back reduces the fuel consumption; and climbing into the stratosphere means entering a zone of low atmospheric moisture content.

Convection Trails: The convection trail is similar to the exhuast trail, but in this case, instability of vertical stratification in the atmosphere permits the airpaane wake, heated to about 1 1/2°C. above the free air temperature and with water-content increased by engine combustion, to rise as an eddy to a lower temperature where a cloud-like trail may appear as much as five minutes after passage of the plane. Convection trails may form in temperatures between 0° and -25°C. and the presence of any broken layer of clouds within this range indicates the possibility of trail formation. Usually a minor change in altitude (perhaps 200 feet) will suffice to eliminate the trail. This type may be combined with the aerodynamic trail (see below), in which case it will form at the plane.

Aerodynamic Trails: When air flows past the wings, propeller, and other parts of the airplane, there are reductions of pressure that cause adiabatic cooling of the air. This cooling may be enough to raise the relative humidity in the affected regions to 100 per cent, and, in some cases, condensation will take place. For the most part, air comes back to atmospheric pressure and to substantially atmospheric temperature after passing the plane. The condensate then evaporates immediately, leaving no trail. There are, however, regions within which the pressure and temperature remain less than atmospheric for a considerable distance downstream, such as the cores of the wing-tip and the propeller-tip vortices. Condensate may persist in such regions until the vortices decay.

When the humidity is very high, evaporation can be so slow that a persistent or a semi-persistent trail will form even in regions where the pressure or temperature have returned to atmospheric values. If conditions are favorable for such trails to form at sub-freezing temperatures, the condensate may freeze and hinder the return to dquilibrium. Aerodynamic trails are rather rare in occurrence and usually form only as a short, dissipating type which is of minimum tactical importance; however, they cannot be predicted with any certainty.

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The writer's experience of an average day along the African Coast from Port Etienne to the Gold Coast is as follows: clear to scattered clouds in the morning with good visibilities and cumulus clouds becoming broken to overcast shortly after noon, and shower type precipitations starting at this time. Precipitation continues during the evening, becoming less intense after dark.

It is interesting to note that while the northward movement of the equatorial front during the summer months brings dry season weather to the northeast coast of Brazil, it brings monsoon rainy season conditions to the west coast of Africa from Port Etienne to Monrovia and the Ivory and Gold Coasts. The dry season over West Africa coincides with the rainy season over eastern Brazil.

General characteristics of trans-equatorial Atlantic operations:

1. *Flying conditions are less favorable during the rainy season.*
2. *In general, daytime weather is of a convective nature, and ceiling and visibilities will vary with the passage of showers. Early morning offers better flying conditions then afternoon.*
3. *Over the ocean, flying conditions are generally good, with the exception of the vicinity of the intertropical front.*
4. *Care should be taken to avoid the migratory waves attending the intertropical front and the semi-permanent low centers associated with it.*

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be frequently inspected to insure that they have not become loosened or cracked from the vibration which is characteristic of the units.

Personnel using such equipment ought to take meticulous pains in seeing that motors are maintained in an immaculate condition and that no fuel or oil is spilled or allowed to leak onto parts of the motor, thus creating a fire hazard. Fuel, oil, rags, or other inflammables must not be stored in the same tent, shack, or leanto with the motor.

MAY WE MAKE YOU FAMOUS?

Nationally prominent military and civilian publications have responded to the current high level of public interest in the Army Weather Service by applying to this headquarters for stories and photographs about our organization. Present policy is to emphasize at every opportunity the accomplishments of individuals and small units of the Weather Service in these releases, so why not take the few easy steps which will bring your station to general notice?

Write an account of some distinctive phenomemon, achievement, or hazard in your immediate surroundings and send it through channels to the Public Relations Office, Headquarters Weather Wing, Asheville, N. C.. Even a photograph by itself, taken with a careful eye to newsworthiness, may be sufficient. However, news value is an elusive quality that may be missed entirely unless one observes certain precautions:

Does the subject represent some unique feature of your station? A shot of your observer shooting a pibal run will wind up in an editorial wastebasket even if you are in Tibet. On the other hand, an enterprising weatherman who filmed the ball of wire which his landing strip had become after the passage of a 'williwaw' achieved attention from 'Naval Aviation News', 'Impact', and 'Life'.

Overclassification of your photographs will certainly prevent any editorial use. The label 'Confidential' means that the author's considered opinion is that the subject matter will be of real value to a foreign nation. Enclosures in a 'Secret' letter may be unclassified: it is merely that the whole must be handled as would the unit of highest intelligence value.

One who is familiar with idiosyncrasies of editors will advise that photographs in particular should be accompanied by full information: full names, dates, places, and home towns with street addresses are all useful. Another hint would be to send negatives or an 8 x 10 enlargement when possible.

FLIGHT TESTS OF A MINNEAPOLIS-HONEYWELL ICING INDICATOR IN NATURAL CONDITIONS.

FLIGHT TESTS OF AN AIR-SAFE INSTRUMENT COMPANY ICE INDICATOR.

Lack of quantitative reports of the intensity and duration of icing conditions has long hampered meteorologists in their attempts to obtain useful data for the understanding and forecasting of icing conditions. The pilot, too, is interested in being able to tell from a glance at an instrument just how severe an icing condition he is in, particularly since it is difficult to observe icing at night. Both these reasons lend impetus to the development of some suitable instrument for detecting and measuring the formation of ice on an airplane.

So far the answer has not been found. Various types of instrument are being tested, some of them promising good results: but none of them have as yet passed the experimental stage.

It is nevertheless reasonable to expect that within a few years accurate icing rate indicators will certainly be more often installed in the larger commercial and military aircraft.

THE DEATH OF A LIBERATOR

Vast flights of the most modern Luftwaffe pursuit aircraft, shrewdly coordinated with excellent ground defences by experienced air marshals, very rarely can prevent the safe return of more than 95% of American heavy bombers from a thousand-mile thrust into Fortress Europe. Yet one of these battle monsters was crushed into a burning wreck which consumed the bodies of five air-crewmen after a routine training flight over the peaceful Colorado countryside one evening in the recent past.

How? The home airport was completely smothered by a low, thick sheet of up-slope stratus which made an attempt at landing a failure. Listen to the official report: "...By this time the B-24 was headed directly for the tower in a steep left bank. The pilot was told again to pull up, at which time subject aircraft dove for the ground with the left wing striking first. Immediately upon impact the airplane burst into flames and broke in half....Probable cause of the accident was temporary night-blindness caused by 'flareback' of light due to turning on of lights in a skiff of fog."

But doesn't the Army Weather Service provide a facility which will enable operating units to know when such hazardous conditions will occur? The forecasters on duty at the time of the accident have this to say:

"Up-slope stratus and fog were forecast for this station beginning at least by 2000 hours with ceilings between 500 and 1000 feet and visibility limited to 3-5 miles. This forecast was completed by 1600, when the combat crews and an operations officer were briefed on the weather to be expected."

"At 1730 the operations officer came into the station to check the local weather. He was advised that the existing closeness between temperature and dew point was a sure indication of stratus and fog conditions and that the fields would close due to weather not later than 2000. The statement was made that the stratus would move in fast when it came, and that in the past under similar conditions operations officers had found it advisable to keep the ships flying in close to the field so that they could land on short notice."

Despite these and other warnings the Liberator was not ready for landing until 2019.

The report of the Aircraft Accident Investigating Committee:

"Major contributing factors to this accident were...supervisory error in allowing night flying under impending weather conditions...lack of cooperation between weather office and flight operations...Recommend that a policy be set up with regard to the relationship and co-responsibility of flight operations, weather offices, and supervisory personnel. In subject accident it is evident that there was no cooperation between the three."

The scientific basis for modern meteorology which makes quite sound the prediction of future weather is not often understood outside of the Weather Service. For this reason, individuals are apt to be hesitant in basing action on a forecast unless forecasters undertake determined yet subtle action to persuade as well as inform other agencies. Otherwise the service rendered is almost valueless. Obviously in the case of this accident neither operations nor the pilot was convinced of the authenticity of what turned out to be a perfect forecast.

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