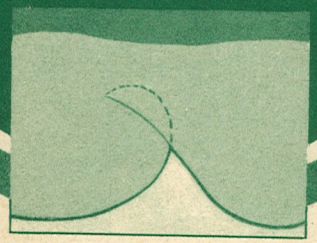
THE OCCLUDED FRONTS



AEROLOGY SERIES ☆ NUMBER SEVEN

KEEP THIS BOOKLET

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THIS is the seventh of a series of booklets on aerological subjects prepared for Naval Aviation by the Aviation Training Division, Office of the Chief of Naval Operations. More of these booklets, each covering an important phase of aerology, will be placed in your hands periodically.

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AEROLOGY SERIES
No. 7

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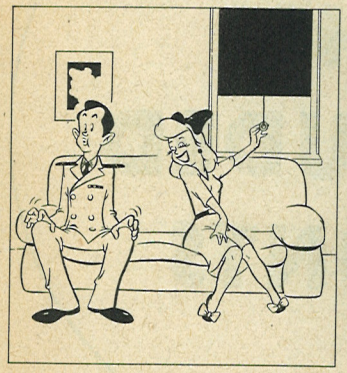
THE OCCLUDED FRONTS

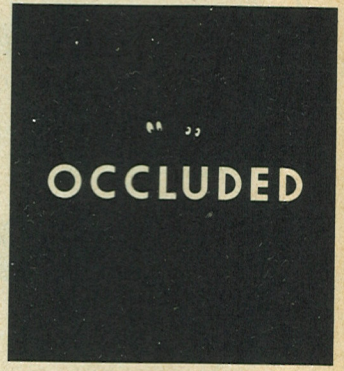
PREPARED BY AVIATION TRAINING DIVISION,
OFFICE OF THE CHIEF OF NAVAL OPERATIONS,
U. S. NAVY

NAVAER-00-80U-8
OPNAV 33-47

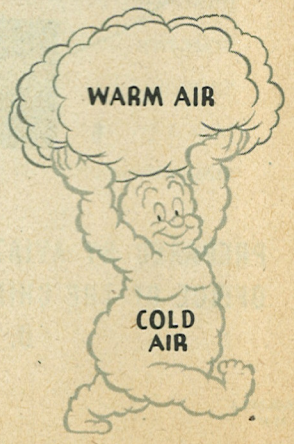
WHAT AN OCCLUSION IS

To start out, let's have a definition of "occlusion." It means to shut something in or out, as you shut light out by lowering a window blind, or as you close off a passageway by closing its doors.





An "occluded" front occurs in the atmosphere when a cold front overtakes a warm front and one or the other is lifted aloft so that the warm air between the two fronts is shut off from the surface of the earth, hence "occluded."



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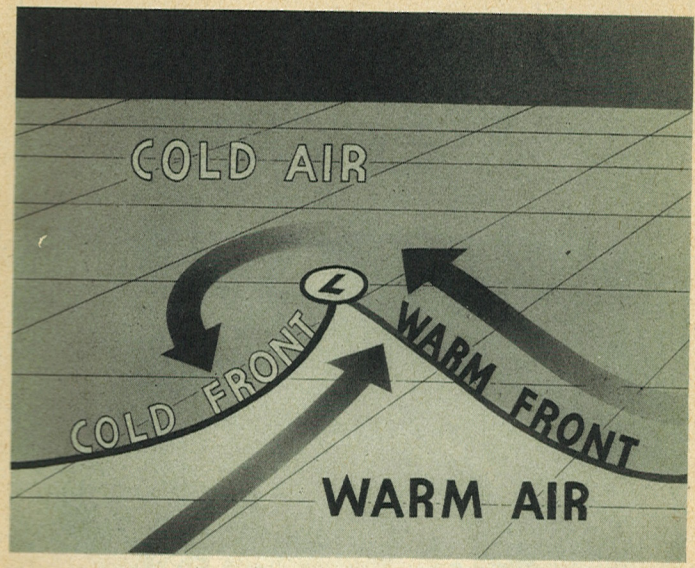

The occluded front is formed during the life cycle of a cyclone, which is a traveling system of winds that, in the northern hemisphere, rotates counterclockwise around a center of low atmospheric pressure. The reverse is true in the southern hemisphere, but *in the interest of simplicity, this text deals solely with the northern hemisphere.*

You already have studied in "Air Masses and Fronts" how air masses move, and you have learned about cold fronts and warm fronts. In order to understand how occluded fronts are formed it is necessary that you know something about the cyclone—not the technical knowledge of the aerologist but enough to grasp its significance to an aviator.

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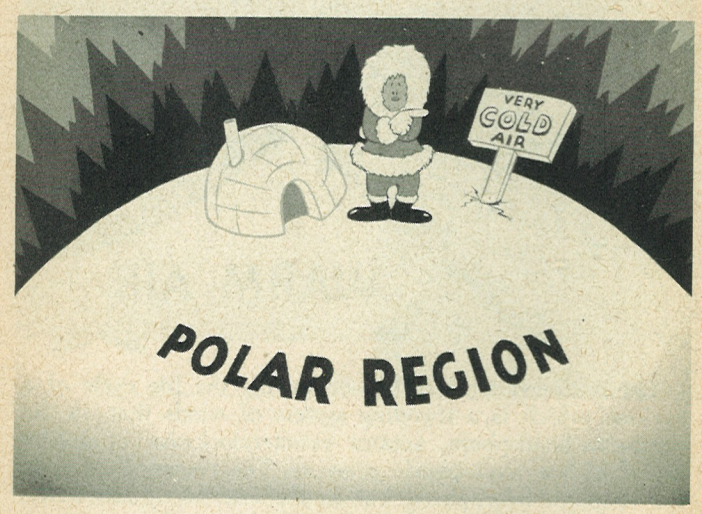
LIFE OF THE CYCLONE

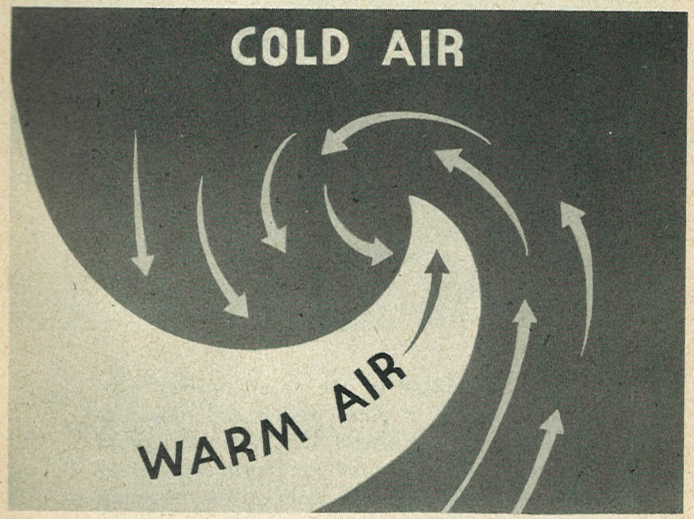
Cyclones are like people in that they are born, they grow to maturity and they die. Here is a simplified explanation of how they are born:



The polar region is occupied by cold, heavy air which produces pressure. The *polar front* acts as a barrier separating this polar air from the warmer tropical air of the middle latitudes. North of this front the winds are easterlies while those in the middle latitudes are westerlies.

LIFE OF THE CYCLONE

As tropical air from the equator is heated it rises and moves toward the north pole at high levels and piles up behind the polar front. Air cannot blow through the polar front, so consequently when the pressure behind it becomes sufficiently great, it is forced to move. A small section of it bulges out into the westerly wind stream of the middle latitudes. When this happens, the westerlies are deflected and become southwesterlies, causing an adjacent sector of the polar front to retreat toward the north.



The result is that there is a southward surge of cold air and a northward surge of warm air, causing an apparent counterclockwise rotation, something like an eddy in a pool of water.

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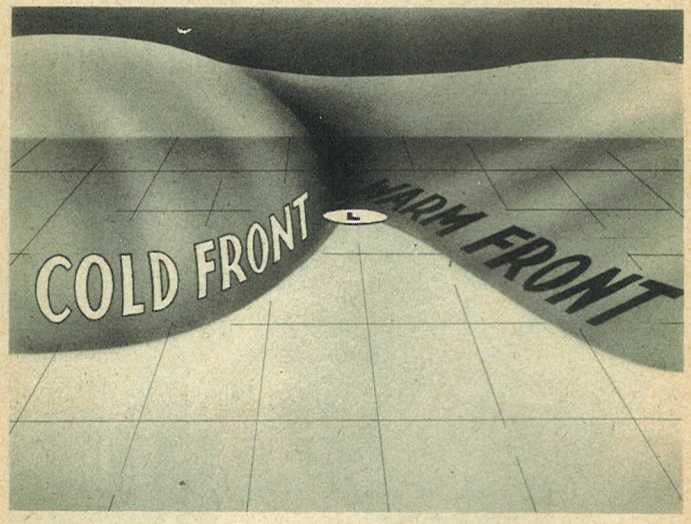
LIFE OF THE CYCLONE

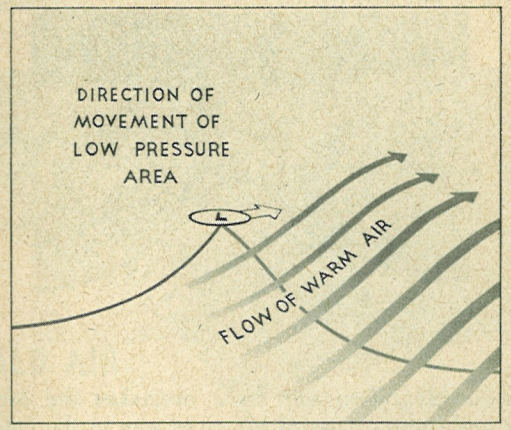
Thus a cyclone is born.



As the bulge in the polar barrier continues south, it rides under and displaces the warmer air ahead of it, forming a cold front. As the warm air from the south moves northward, it replaces the receding cold air. This forms a warm front and the warm air is lifted, which causes a center of low atmospheric pressure to form at the intersection of the cold and the warm front.

LIFE OF THE CYCLONE

As more and more of the warm air flows up over the warm front, the center of lowest pressure moves in the direction of the warm air current. Thus, southwesterly winds of the northern hemisphere cyclone impel the cyclone to move eastward.



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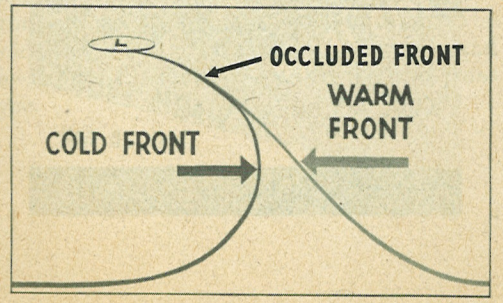
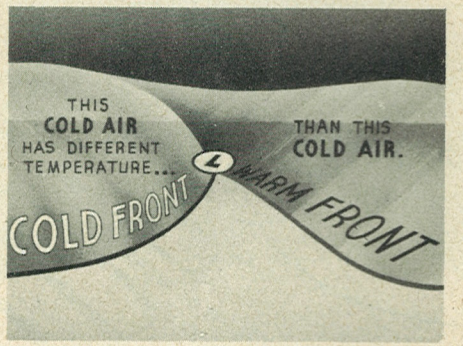
Now, it is characteristic of a cold front that it moves more rapidly than a warm front and thus, as the cyclone continues on its way, the cold front gradually overtakes the warm front.

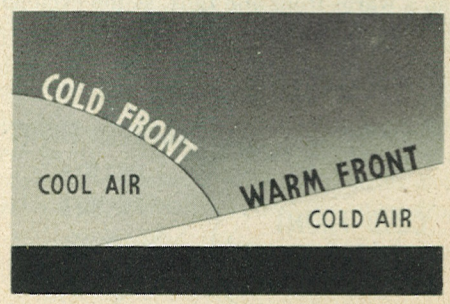


WHAT AN "OCCLUSION" IS

Obviously, the surface of the earth does not have a constant temperature over a widespread area, and therefore since the earth's divergent temperatures act upon both, the cold air behind the cold front rarely has the same temperature as the cold air ahead of the warm front.

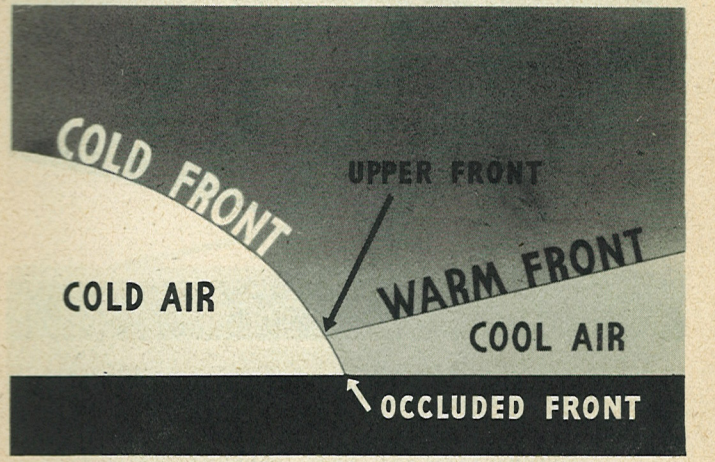


Consequently, when one front overtakes the other, the warmer and lighter mass of air gives way to the colder and heavier mass and is forced aloft. This process, in which the warm air is shut off from the surface of the earth, is called an occlusion.



TYPES OF OCCLUSIONS

There are two types of occlusions and which one of them occurs in any particular cyclone depends upon the temperature distribution in the mass of cold air that lies to the north of the two fronts.



When the air *behind the cold front* is colder than the air *ahead of the warm front*, the cold front pushes in under the warm front. The cold front remains at the earth's surface and the resulting occlusion is called the *cold front type.*

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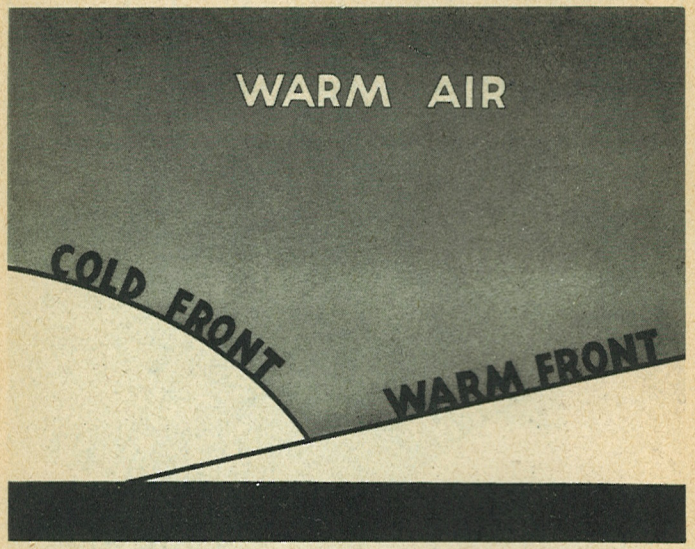
TYPES OF OCCLUSIONS



But sometimes the cold air *ahead of the warm front* is of lower temperature than the air *behind the cold front*. When this happens, the cold front rides up over the warm front, and the occlusion is known as the *warm front type*.

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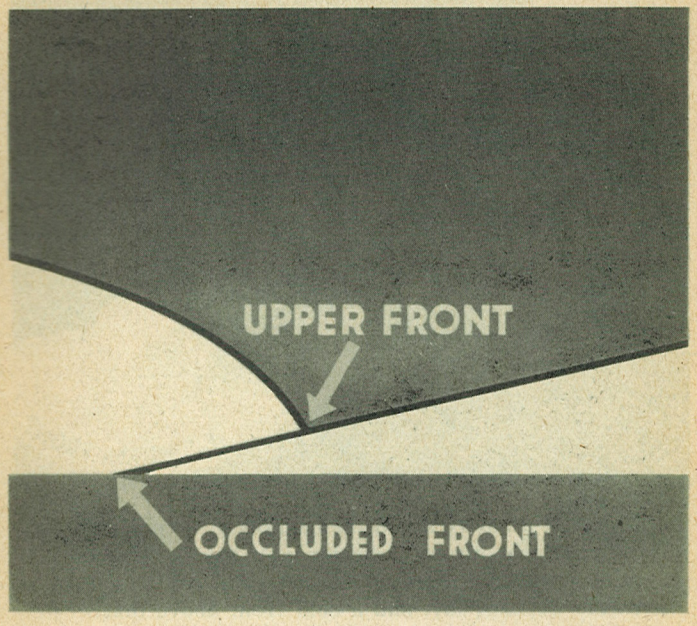
TYPES OF OCCLUSIONS



The front which remains at the surface is the "occluded" front. The front which is raised aloft is the "upper" front of the system. It is this upper front which is of primary importance to aviation because it is held aloft where it is a danger along the aviator's flight path. It is difficult to locate on the weather map and impossible to identify from an airplane.

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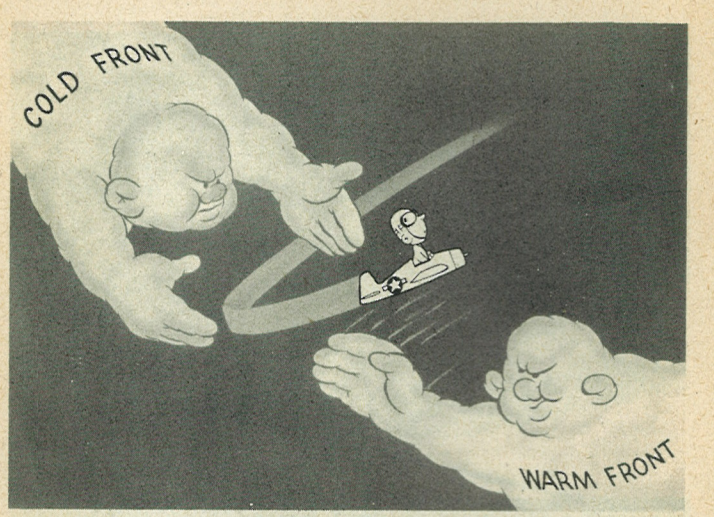
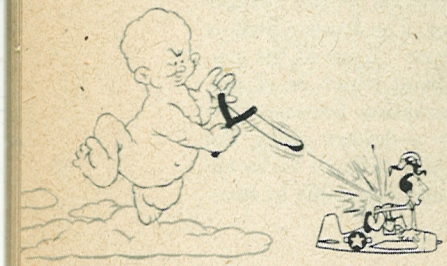
THE UPPER FRONT



Already you have learned the hazards of a cold front and of a warm front. In an occlusion you have a combination of the two working together against you—a warm front at the earth's surface, say, and a cold front above that!



YOUNG VIGOROUS
UPPER FRONT

An important thing for you to remember is this: The most violent phase of the occlusion from the standpoint of the aviator is in the early stages of the cyclone, because at this time the weather along the upper front is raising cain.

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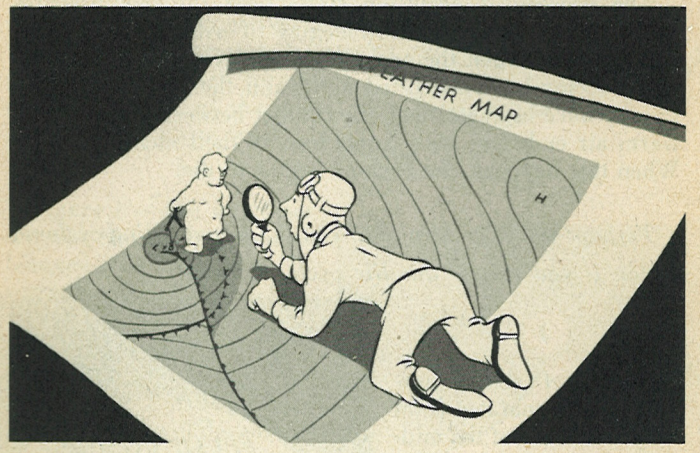
THE UPPER FRONT

(Before you complete this course of study you will learn how to locate this danger area on the weather map so that you can avoid it.)



In the latter stages of the cyclone, when the surface winds are at their maximum, the upper front no longer presents a serious aviation problem. Nevertheless, the safest thing to do is to assume the presence of an active upper front in every occlusion.

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OLD TIRED
UPPER FRONT

TYPES OF OCCLUSIONS

But, to complete the parallel between the life cycle of a cyclone and the life cycle of a human, the maturity of the cyclone begins its death.

The process of occlusion starts near the low pressure center, when the cold front begins to overtake the warm front. This is when the cyclone's maturity begins. After the warm sector has been lifted aloft, and the requirements of gravity have been satisfied, the conflict between the cold and warm air ends and both fronts lose all their characteristics. When this happens, the cyclone begins to die.

Perhaps it will be helpful to you in understanding cyclonic action if you review this life cycle pictorially:

Figure A shows how polar air is separated from the warmer air of the middle latitudes by the polar front, and how opposite winds prevail in the two separated regions.

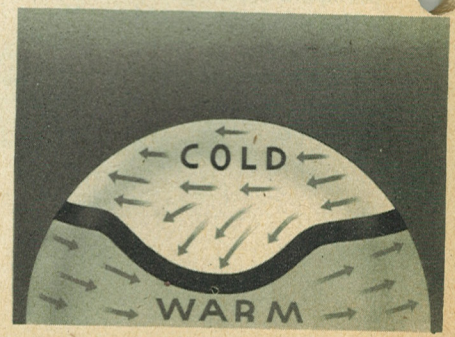

Figure B — The polar front has begun to bulge, and a portion of it is moving into the region of westerly winds as a cold front.

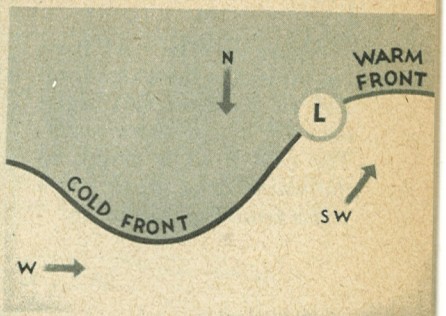

Figure C—In this closeup the cold front has moved farther southward and the change of the westerlies to southwesterlies has caused a warm front to form. A low pressure center has formed at the junction of the cold front and the warm front.

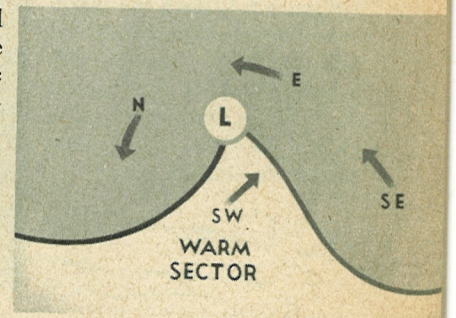

Figure D—The warm sector has become pronounced between the cold and the warm fronts and the cyclonic action is well under way. Notice that, characteristically, winds in the cold air which precede the warm front are easterly. Those in the cold air behind the cold front are northerly. Winds in the warm sector blow from the southwest.

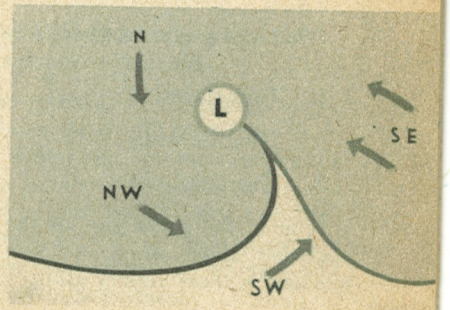

Figure E—The cold front has begun to overtake the warm front, and therefore the warm sector is beginning to narrow.

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TYPES OF OCCLUSIONS

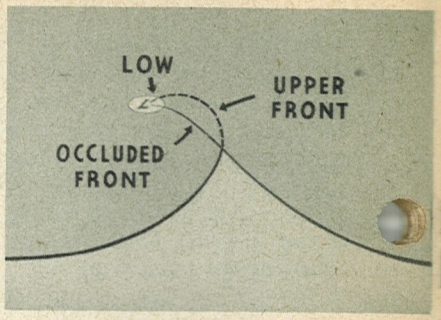

Figure F—The cold front has overtaken the warm front and an occlusion has begun near the low pressure center. The cold front is riding up the warm front, so this is a warm front type occlusion.

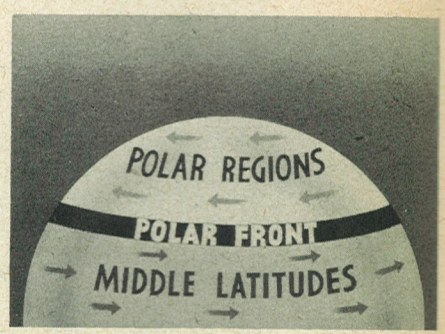

Figure G—Here the warm sector between the fronts has vanished. The conflict between the winds is over and the cyclone dissipates and is gone. We are right back where we started.

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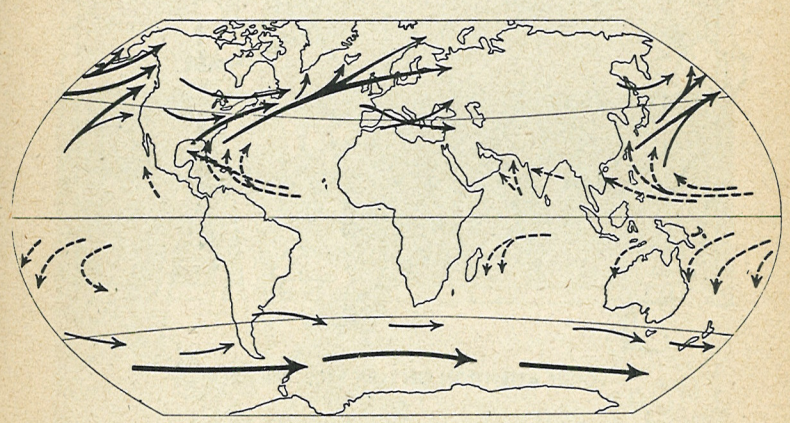
The three stages of the life cycle of the cyclone are these:

1. They form.
2. They occlude.
3. They die.

It is in the early part of the occluded stage when cyclonic weather is most violent aloft.

CYCLONES FOLLOW ROUTES

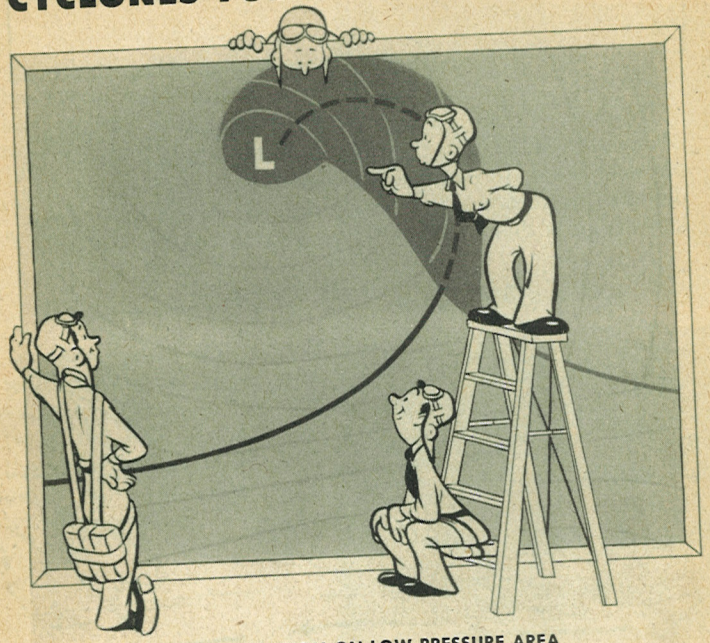
By now you are well aware that weather is no chance occurrence—it follows certain definite patterns based on physical laws. Aerology is still an inexact science, but our definite knowledge is increasing steadily. And a part of this knowledge is that cyclones follow certain courses, or paths.



——→ PRINCIPAL TRACKS OF CYCLONES
– – –→ PRINCIPAL TRACKS OF HURRICANES

The map above shows storm tracks that are typical of the movements of cyclones. Cyclones generally travel in "families" of three to five, which follow one another across the weather map. Cyclones in the northern hemisphere have a tendency to reach their period of greatest violence and then to disappear in the low pressure area near Iceland or the Aleutian Islands, which makes those localities particularly important as sources of weather information.

CYCLONES FOLLOW ROUTES



FOCUS ATTENTION ON LOW PRESSURE AREA

The cold front, the warm front, and the occluded front result from the movement of a low pressure center across the face of the earth. It should be your constant aim as an aviator to be wary of these fronts and their weather bands, and this is the reason that the indication of the low pressure center of a cyclone should receive the focus of your attention when you see it on the weather map.

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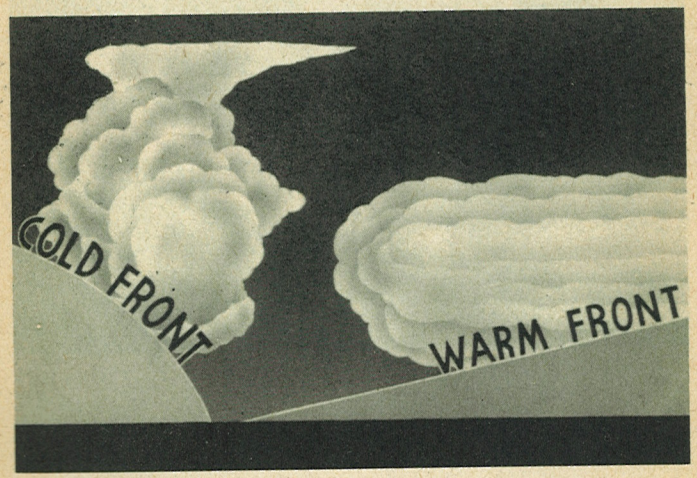
WEATHER OF THE OCCLUDED FRONT

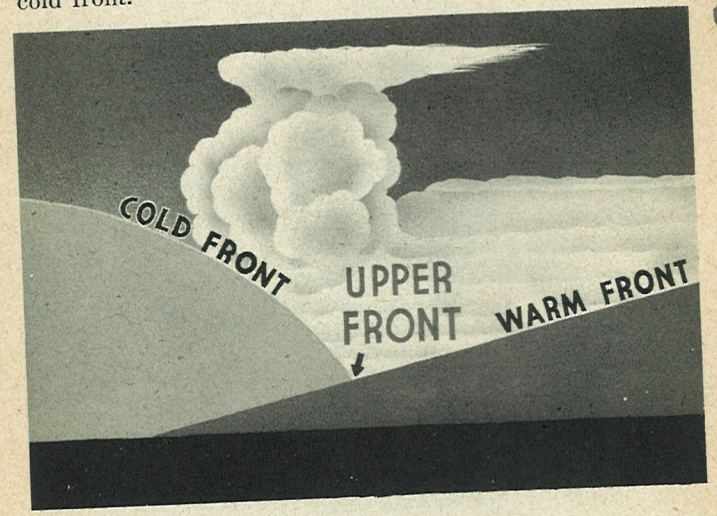
Because the occluded front is a combination of a cold front and a warm front, the resulting weather is a combination of conditions that are associated with both fronts. The cold front's narrow band of violent weather, and the warm front's widespread weather area occur in combination along the occluded front.



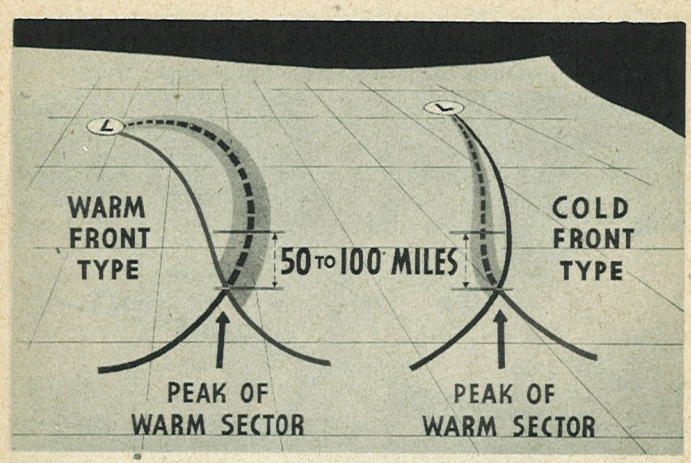
Therefore the flight problems of both the cold front and the warm front must be met when flying an occluded front.

WEATHER OF THE OCCLUDED FRONT

Weather conditions accompanying both the warm front type of occlusion and the cold front type are about the same as far as flight operations are concerned. Both are preceded by a widespread area of warm front weather, and each has an upper front along which the weather is typical of the cold front.



WEATHER OF THE OCCLUDED FRONT

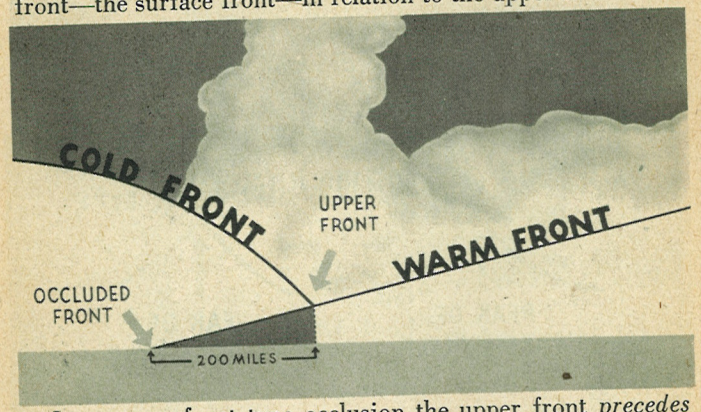


Along this upper front, the activity is particularly severe in either type of occlusion for a distance of fifty to one hundred miles north of the peak of the warm sector.

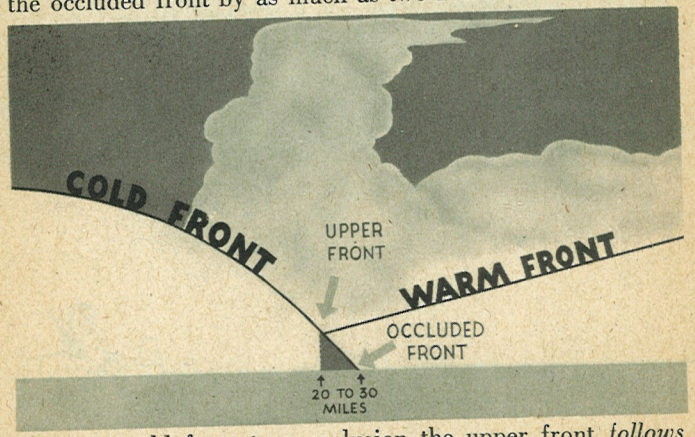
This particular area contains some of the *worst possible* flying conditions. It MUST be avoided.

WEATHER OF THE OCCLUDED FRONT

The primary difference between a warm front occlusion and the cold front occlusion is the location of the occluded front—the surface front—in relation to the upper front:

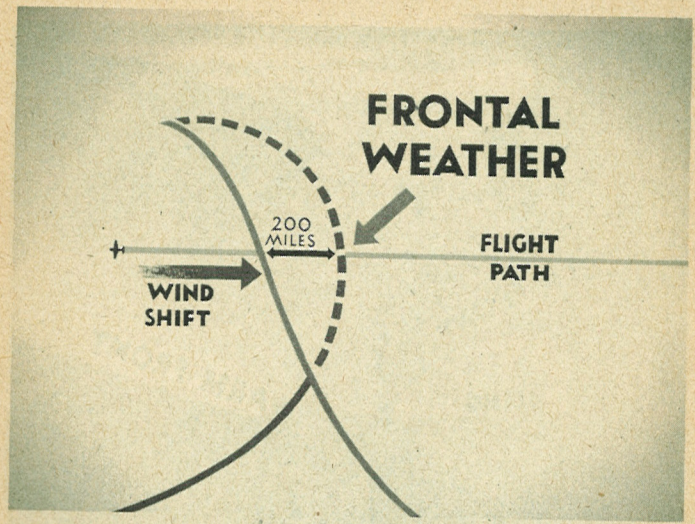


In a warm front type occlusion the upper front *precedes* the occluded front by as much as two hundred miles.



In the cold front type occlusion the upper front *follows* the occluded front by twenty to thirty miles.

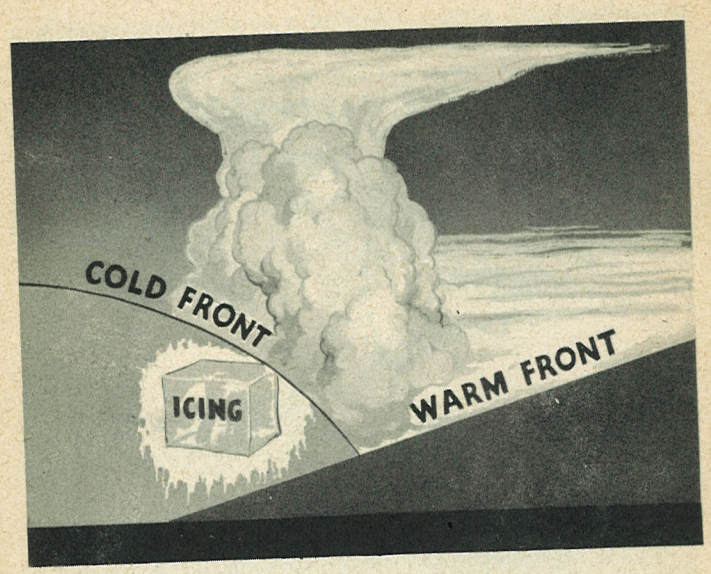
WEATHER OF THE OCCLUDED FRONT



Because of the counterclockwise rotation of winds around the low center, there is a distinct wind shift associated with the occluded front. If you are flying at a low level from east to west through a cold front type occlusion, you will encounter the wind shift very shortly after you run into the weather of the upper front. In the case of a warm front type occlusion, you will encounter the upper frontal weather as much as an hour before the wind shift.

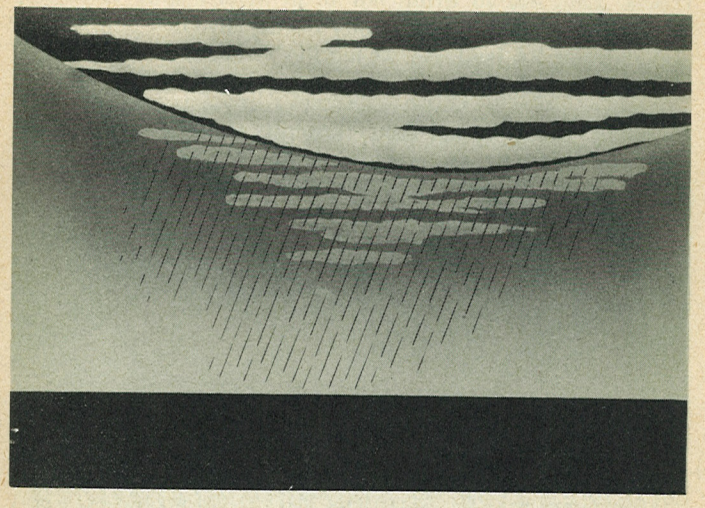
In the early stages of either type of occlusion the wind shift is abrupt, but as the occlusion process progresses toward its later stages the shift becomes more gradual and consequently is less intense.

WEATHER OF THE OCCLUDED FRONT



The principal difference between cold front occlusion weather and the warm front type is the width of the weather band. In the warm front occlusion, the cold air which follows the upper front flows up over the warm front surface, causing clouds to form, generally of the cumulus type, within the cold air. In this area precipitation and severe icing may be found.

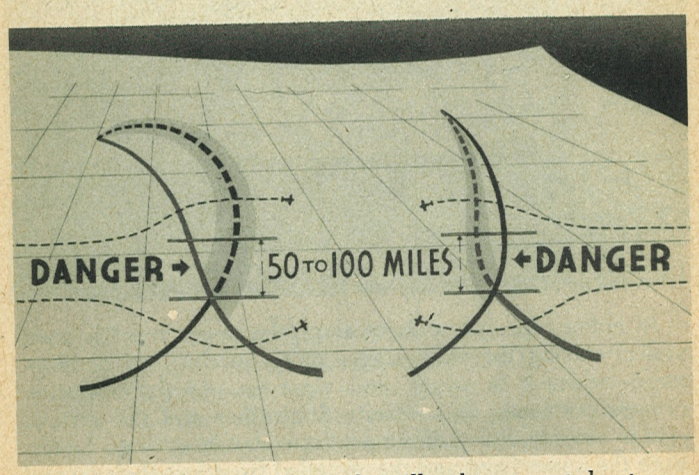
WEATHER OF THE OCCLUDED FRONT



FINAL STAGES PRESENT NO SERIOUS FLIGHT PROBLEMS

In either type, the activity along the upper front is most violent during the early stages of the occlusion's development—when it is young and vigorous. As the occlusion process continues, this activity diminishes and the vertical clouds accompanying the upper front flatten out into layers. Both the upper front and the occluded front lose their frontal characteristics until in the final stages all that is left is a wide area of intermediate cloud decks which present no serious flight problems either at high or low levels.

When you plan a flight through an area of weather brought about by an occluded front, it is imperative that you avoid the dangerous zone which extends fifty to one hundred miles north of the peak of the warm sector.



Choose a flight path which will take you at least one hundred to two hundred miles north or south of this zone. Particularly over oceans or areas where reports are scarce, it is difficult for the aerologist to locate this peak accurately. To protect yourself, take his estimate and keep a safe margin of distance away from the peak.

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If your course is to the north of the peak, select an altitude that will permit you to avoid the activity of the upper front. Usually it will not be practical for you to plan an on-top flight, because the cloud tops generally are above the ceiling of your plane. The best altitude for you, therefore, is at a level below 6,000 feet, if the terrain permits.

If your course is to the south, you face the problem of flying the cold and the warm fronts individually.

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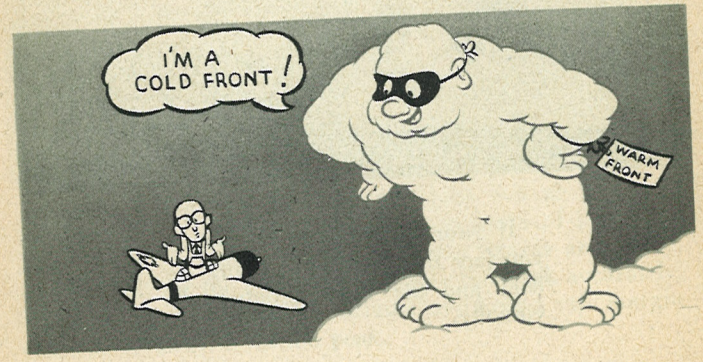
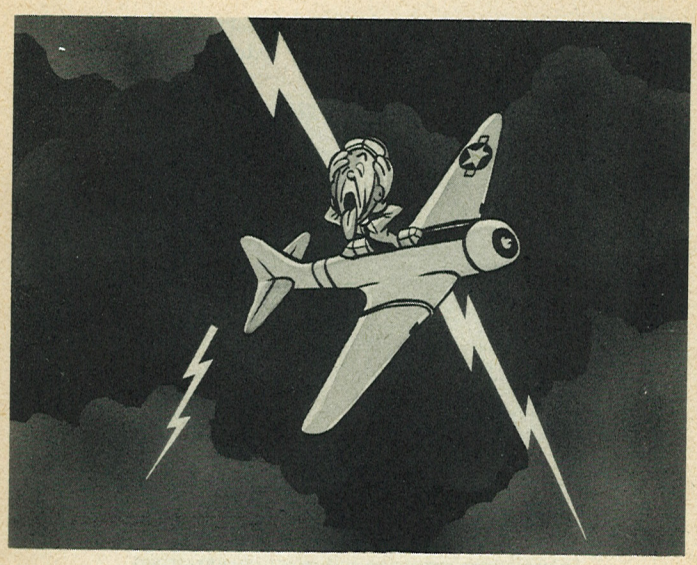
From the air, it is hard to tell when you are approaching an occlusion, because it combines the appearance of both the warm front and the cold front weather. If you are nearing

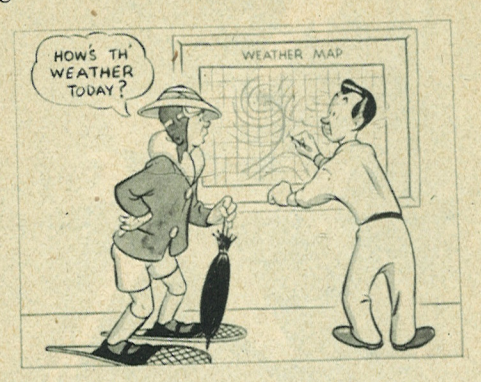


the occlusion from the east, it will look like a warm front. If you approach it from the west it will look like a cold front.

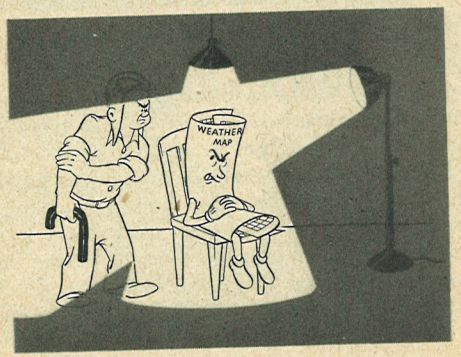


This possibility of mistaking the identity of an occlusion could get you into trouble. You might plan a flight procedure which would cope successfully with a cold front by itself, but which might bring you grief in the widespread area of warm front weather on the other side. On the other hand, you might choose a flight procedure to meet warm front conditions alone, only to meet with the unpleasant surprise of running into the violent activity of the upper front of the occlusion.

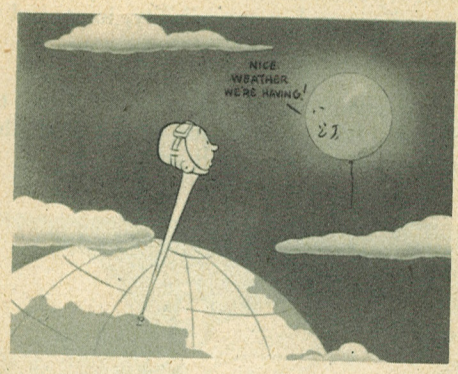
For these reasons, it is absolutely essential that you do four things before taking off on any extended flight:



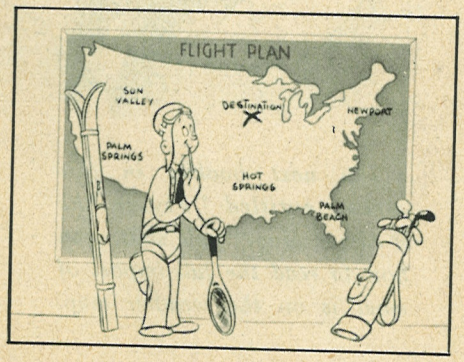
1. Discuss with the aerologist at your station the weather you will encounter.



2. Study the weather map—get from it every bit of pertinent information it presents.



3. Study all upper air data.



4. Make a definite flight plan and include alternate airports.

PILOT COUNSEL

The weather map and upper air data have every bit of essential information you need to fly a cold front, a warm front, or either type of occlusion. It will tell you how to avoid areas of low ceilings and poor visibility, icing and thunderstorms.

It can save your life, if you only learn to understand the significance of all that the weather map is able to tell you.

The next booklet in this series, entitled "Flying the Weather Map," will show you how to read the full import of what is on the weather map.

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