FLYING THE WEATHER MAP

AEROLOGY SERIES ☆ NUMBER EIGHT

KEEP THIS BOOKLET

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THIS *is the eighth of a series of booklets on aerological subjects prepared for Naval Aviation Cadets by the Aviation Training Division, Office of the Chief of Naval Operations.*

Holes have been punched in these pages so that you can bind this booklet with the others, either with string, or better, in a ring binder. When the entire series has been bound in this way, you will have a complete text on aerology. Keep these booklets in your possession. They constitute a text that will be of value to you throughout your entire flying career.

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AEROLOGY SERIES ☆ ☆ NO. 8

FLYING THE WEATHER MAP

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

INTRODUCTION

This series of booklets and the motion pictures which they supplement are not designed to make an aerologist out of you. All they are intended to do is teach you enough so that you will be a weatherwise aviator. You have insufficient *time* to become an aerologist. Your job is to fly airplanes. In order to do that intelligently you must know enough about weather to interpret intelligently what the aerologist tells you—as well as what you observe.

You've come a long way in absorbing the knowledge which will enable you to understand the aerologist's language. When you started this series, probably you didn't know clear ice from rime, or the difference between advection and radiation fog, or that a cumulonimbus cloud is a thunderstorm, or the characteristics of air masses and the three principal types of fronts. But you have studied all these now, and you should know the kind of weather to expect when you encounter the various types of air masses and frontal zones.

INTRODUCTION

Now it's time to go a step further and learn the most practical side of the weather business. It's time to find out specifically just what the aerological office can do for you, as an aviator—how it can enable you to draw up an intelligent flight plan, how it can make your flying safer and more comfortable, how it can keep you from getting yourself into trouble.

The pilots who have flown weather on the most rugged duty in the Navy—in the sub-zero temperatures of the Arctic, in the Aleutian fogs, in the typhoon regions of the South Pacific, will tell you that it's a form of self-preservation to make the best possible use of the aerological office.

You should never walk to your plane without passing through the aerological office. Remember that!

INTRODUCTION

DON'T BE BLIND *and* DUMB TOO!

If you start out on a flight without adequate weather information, you're starting out blind. (And *dumb*, too, for that matter.)

This pamphlet is a guidebook to the aerological office—to show you *what* information you can expect to get there, *when* you can get it, *how* to go about getting it, and *why* you need it.

Once you realize what the weather man can do for you, with his maps, charts, instruments, teletype, and radio reports, you'll realize that the only proper path for you to follow in getting into your plane is within easy reading distance of the weather map, and within easy hearing distance of the aerologist.

WHAT YOU WANT TO KNOW ABOUT THE WEATHER

In planning any flight, you need specific information about the weather at your take-off point, at your destination and on the intervening route. You also want information about the weather off your course, in case it should be necessary to alter your flight plan for any reason.

It isn't enough to know what the weather is *now* at your destination. You want to know what the weather is going to be when you get there. Likewise, the current status of the weather at your base isn't enough. You must know what the weather is going to be when you get back.

YOU MUST BE A FORECASTER

So, in one sense, you must be a forecaster. By reviewing what the weather is like now, and what it has been in the past, you will have to figure out what it's going to be in the future, when it will become most important to you.

This is quite a problem, but it is one you won't have to work out alone. The aerologist will help you by giving you the weather information at your own station, at your destination, and along your route as well as at any alternate airports where you might decide to land.

Now, what is the specific weather information you should know?

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First, you want to know the direction and the velocity of the wind. It will influence your flight from take-off to landing. It will have its effect on your E.T.A. (estimated time of arrival) and it may increase or decrease your range materially, depending upon whether it is a head or tail wind. In any event, it will affect your navigation and will require accurate drift computations.

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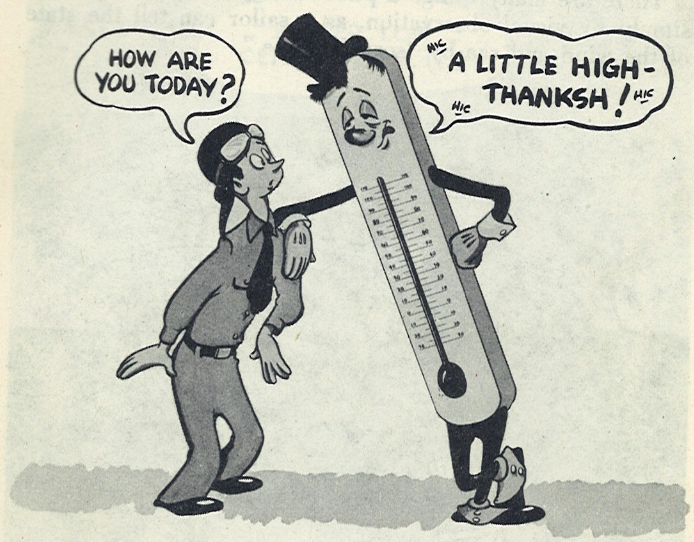
Second, you want to know about clouds—the amount, their type, and the direction of their movement. From your study of cloud types you already know how significant their various forms can be to a pilot: that altostratus means good cover and smooth flying; that cumulus over a front means rough going, and that cumulonimbus means danger with a capital D. Direction of movement is no less important, for it shows you not only where the clouds lie now, but where they are likely to be later on. Once you are in the air they may help or they may hinder you.

You need to know about ceiling and visibility—the distance you can see aloft from all angles—straight ahead or either side and below. (Always bear in mind that the ceiling for a particular airport is the actual number of feet between the field and the cloud base—a ceiling of 1000 feet is actually 1000 feet above the airport, no matter what the altitude of the field above sea level may be). You also want to know the amount and nature of precipitation, for this can be an obstruction to vision.

You need to know about ceiling and visibility



You need to know the temperature. It has its effect on operating conditions, of course, and in addition it may warn you against icing or indicate to you the passage of a front. In relation to dew point, the temperature tells you whether you should expect fog at your station or at your destination.

Pressure and barometer tendency—whether rising or falling—are important to you because they indicate the speed and movement of fronts.

All in all, you want to know what the weather is now and what it has been—what's been going on for the past 6 hours—so that you can figure out what may happen next at your base and at other nearby stations.

There are many things a pilot can tell about the weather simply by visual observation, as a sailor can tell the state of the wind and sea by "seaman's eye."

Smoke, tree branches, wind socks, and weather vanes show which way the wind is blowing.

Ceiling and visibility can be estimated by sight from the ground.

Cloud types and direction of movement can be recognized by sight.

But these are not all the weather factors, and in order to get a true picture the pilot must supplement what he sees with the accurate information of the aerologist's instruments.

HOW THE WEATHER STORY IS TOLD ★ ★

Weather information is collected and exchanged among thousands of weather stations all over the world. You want the information about your own station and those nearby, but even so, the information must be accurate and the facts that must be exchanged between stations are so voluminous that the weather men have evolved a "shorthand system" or code. With it they pass the word to one another.

This system of symbols is used in transmitting or receiving weather information on the teletype. It is important for you to learn these symbols so that when you step into any weather office, you can read the weather for any station which has filed its teletype report.

The teletype symbols follow an established pattern and once you have learned this pattern, you will have little difficulty in decoding this esperanto which is used by aerologists. You can count on getting the teletype reports at any Navy, Army or Department of Commerce airport in the United States, and along the airways of Canada.

HOW THE WEATHER STORY IS TOLD

You will find the reports on the file boards in the weather office, and as soon as you know how to make their seeming gibberish make sense, they'll be very helpful to you.

The teletype system is changed from time to time, but you can count on this much:

Each line represents the hourly report of some airport weather station.

The first group of letters (two or three letters in each case) identifies the reporting station. *Table A* shows the call letters for Naval Air Stations. A list of call letters usually is posted in the weather office.

TABLE A · CALL LETTERS · NAVAL AIR STATIONS

NAC	Atlantic City, N. J.	NGY	De Land, Fla.
NAG	Squantum, Mass. (NRAB)	NGZ	Alameda, Calif.
NAS	Pensacola, Fla.	NHA	Fort Lauderdale, Fla.
NAZ	Anacostia, D. C.	NIG	Miami, Fla.
NBF	Beaufort, S. C.	NIP	Jacksonville, Fla.
NBC	New Orleans, La.	NKZ	Chincoteague, Va.
NCO	Quonset Pt., R. I.	NNA	Annapolis, Md.
NCQ	Atlanta, Ga.	NOH	Norman, Okla. (NRAB)
NCR	Cape May, N. J.	NPB	Banana River, Fla.
NCX	San Pedro, Calif.	NQU	Perei, Indiana
NEJ	Seattle, Wash.	NSQ	San Diego, Calif.
NEL	Lakehurst, N. J.	NST	Astoria, Ore.
NFB	Grosse Ile, Mich.	NTA	Clinton, Okla. (NRAB)
WFG	Elizabeth City, N. C.	NTB	Los Alamitos, Calif.
NFW	Sanford, Fla.	NTS	North Bend, Ore.
NFS	Tillamook, Ore.	NUQ	Sunnyvale, Calif.
NFU	Lake City, Fla.	NWG	Wagner Field, Oakland, Calif. (NRAB)
NGA	San Clemente Island, Calif.	NWR	Charleston, S. C.
NGH	Tongue Pt. Ore.	NXW	Olathe, Kansas
NGL	Philadelphia, Pa.	NZK	Hutchinson, Kansas
NGP	Corpus Christi, Tex.	NZT	Glenview, Ill.
NGU	Norfolk, Va.	NZY	North Island, Calif.

If the reporting station is the control station for a locality: the next letter will be C, N, or X. C means that contact conditions prevail at the airport. N indicates instrument conditions, i.e., you can't take off or land without permission except in case of emergency. X signifies that the airport is closed to all aerial traffic.

The next figure indicates the height of the ceiling in hundreds of feet.

Then follows a series of figures and symbols showing the state of the sky.

Next comes visibility, or how far you can distinguish objects horizontally.

Then state of the weather, shown by one or two code letters, modified by plus and minus signs.

Obstructions to vision are the next item, shown by one or two code letters with plus or minus signs, meaning dense (/) or light (-).

The next three items are always figures, separated by slant lines. The first shows barometric pressure in millibars and tenths of millibars, but to save space, only the last three numbers are shown. The second shows temperature in Fahrenheit, and the third shows dew point in Fahrenheit.

Wind direction and velocity are shown by a combination of arrow symbols and numbers representing miles per hour. Plus and minus signs are used to show strong gusts or light gusts.

Altimeter setting is indicated by three figures, the last three numbers of the inches and hundredths of inches.

Remarks are entered in English abbreviations which are easily translatable (and anyway there's usually a table of them posted at weather stations). They are always the last item in a station's teletype report.

So you don't understand it?

All right, here's an example of a batch of hourly weather reports on the Cleveland-Washington airway:

240030E

CV C 85⊕ 037/56/45↑↗14/962
AX C E60⊕8 051/54/46↑12/976
TEZ E50⊕3K− 061/55/46↑↗7/970
PT N⦶/21/2K− 071/57/48↑10/973
BQ −⊕/6 081/52/40↗7/981
MR ⊕/ 088/47/40↑5/978
WA C −⦶/4K− 108/58/43↑13/984

Take the first line:

CV means the report is from Cleveland. It's O.K. for contact flying. There's an overcast at 8,500 feet. Visibility is at least 10 miles since no limit is reported. Barometric pressure is 1003.7; temperature is 56° F. and dew point 45° F. Winds are southwest, blowing at 14 miles per hour. The altimeter setting is 29.62 inches. Nothing out of the way is happening, so the aerologist didn't send any "remarks."

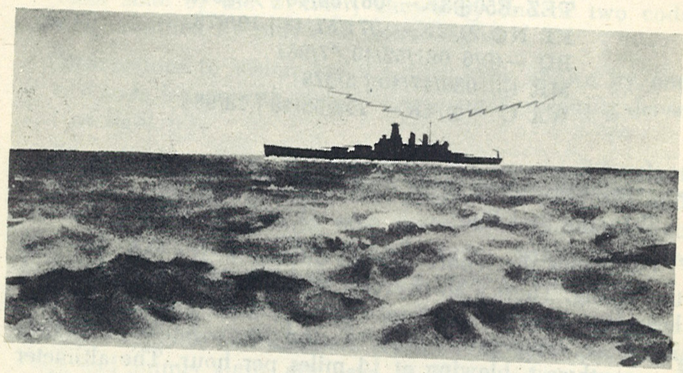
Now, if you refer to circular N, which is found in every aerological office, you can read the reports of the other stations that reported at the same time. And with a little practice, you'll be able to read the teletype reports at any air station where you happen to be.

BUT THAT ISN'T THE WHOLE STORY

There are two drawbacks to the teletype system from your point of view. In the first place, it tells you only what the weather *was* when the reports were made at the various airports.

In the second place, you're a naval aviator, and while the system is fine for continental pilots, there aren't many teletype stations in midocean, so you're going to have to depend upon something else.

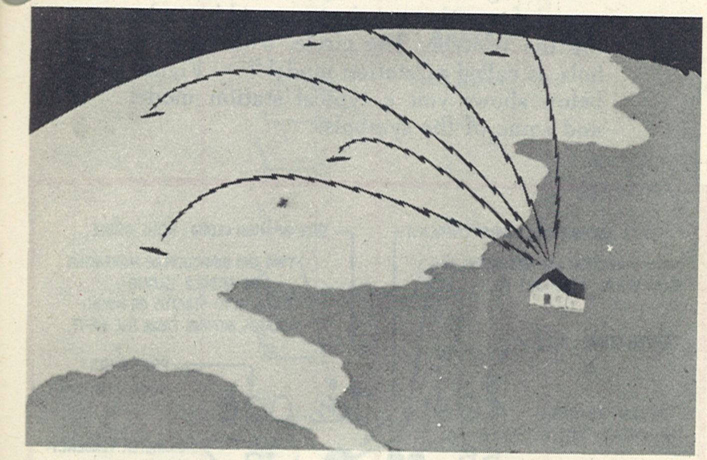
That's why it is so important that you learn about the weather map.



You see, although an aerologist doesn't get regular reports from weather stations out at sea, he does get weather information that enables him to forecast. Given a knowledge of past and present weather, he can predict its movement, so that he can give you an idea of what it's going to be like over a given point at a given time.

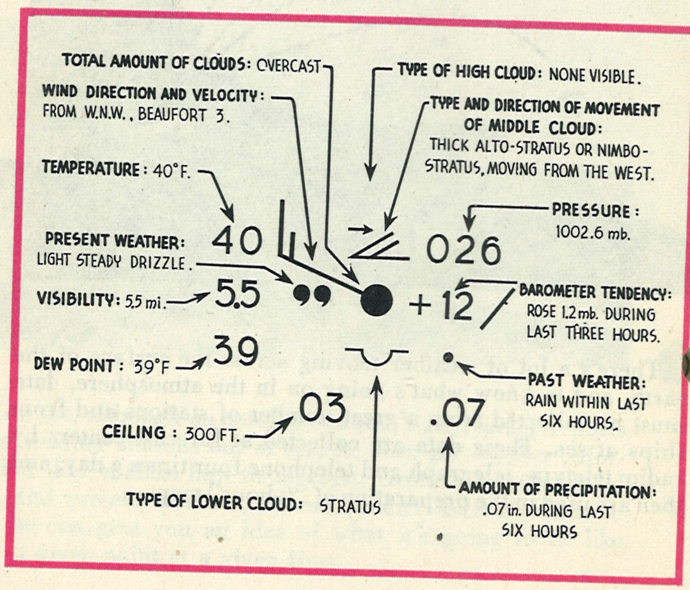
BUT THAT ISN'T THE WHOLE STORY

The process of forecasting the movement of weather is called "extrapolation," and it's part of the aerologist's job. It's a highly interesting job from your standpoint, and what's more, when you get out with the fleet you'll be helping him, because the weather reports you'll be bringing back to your base will enable him to make his predictions.



There's a lot of weather moving across the surface of the earth, and to know what's going on in the atmosphere, data must be collected from a great number of stations and from ships at sea. These data are collected at forecast centers by radio, teletype, telegraph and telephone four times a day, and then are used in the preparation of "6-hour" maps.

This adds up to considerable information, and so to save space on the map a formula has been worked out to show all the essential information in a relatively small space. Symbols are used in specified positions around a small circle to indicate what the weather is at any particular station at a given time. In general, this is the same information you just covered in studying the teletype. The circle, with its symbols, is called a "station model." Figure below shows you a typical station model and some of the symbols.

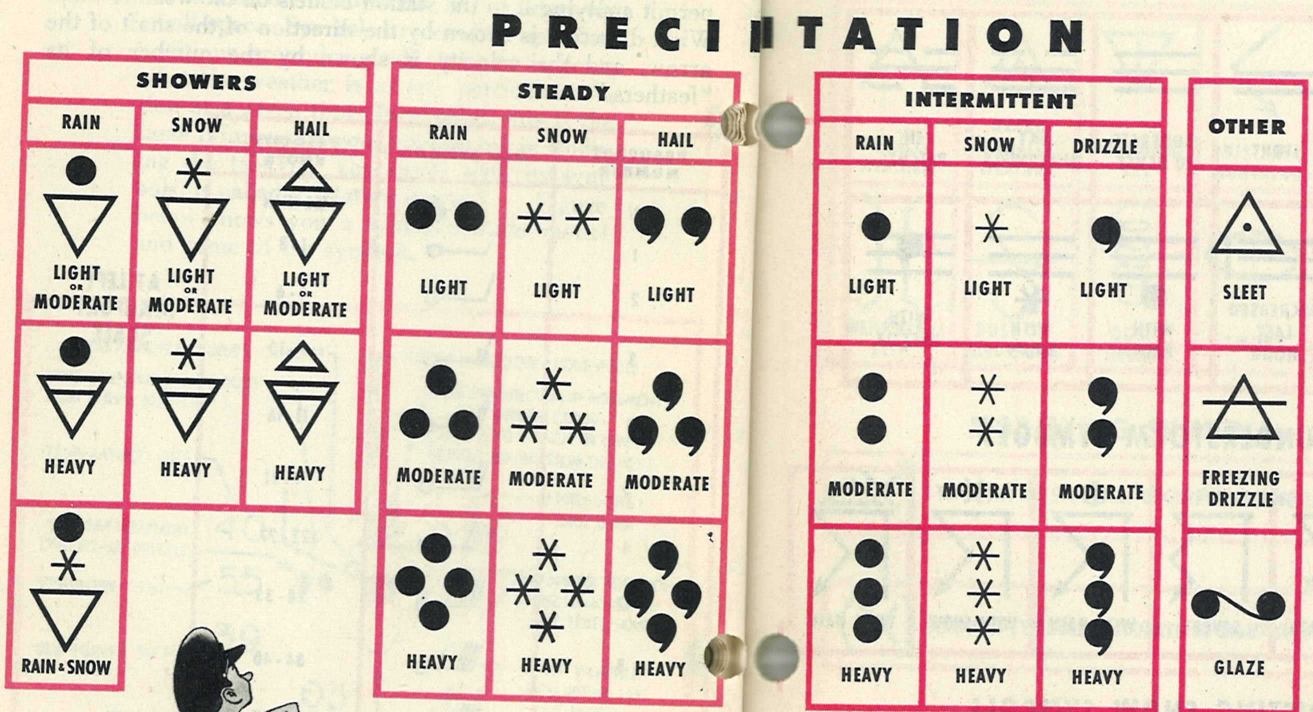


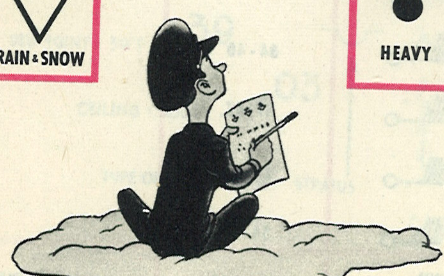
In order to record wind velocities on a standard basis, Admiral Sir Francis Beaufort of the British Navy developed the Beaufort scale, and symbols have been worked out to permit applying it to the station models on the weather map. Wind direction is shown by the direction of the shaft of the arrow, and the velocity is shown by the number of its "feathers."

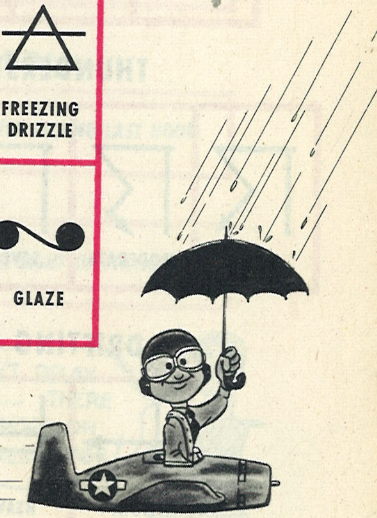
BEAUFORT NUMBER	MAP SYMBOL	VELOCITY KNOTS
0		LESS THAN 1
1		1-3
2		4-6
3		7-10
4		11-16
5		17-21
6		22-27
7		28-33
8		34-40
9		41-47
10		48-55
11		56-65
12		ABOVE 65

AT LEFT BEAUFORT SCALE

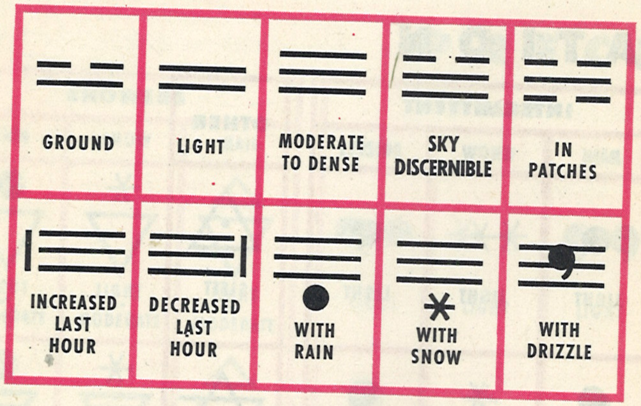
By the use of symbols, all other factors of present and past weather can be shown in the circle of the station model.





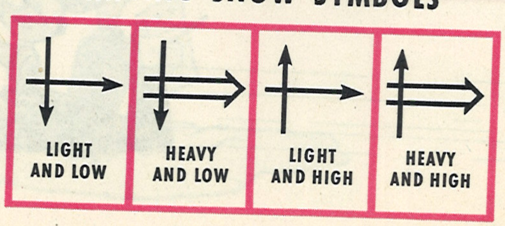


FOG SYMBOLS

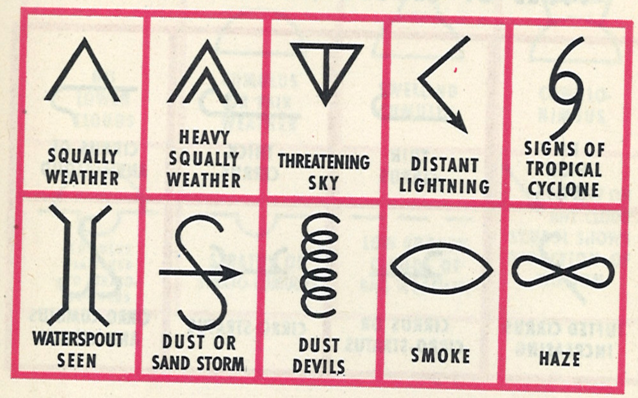


THUNDERSTORM SYMBOLS

DRIFTING SNOW SYMBOLS



MISCELLANEOUS SYMBOLS



MODIFYING SYMBOLS

×] TO RIGHT OF SYMBOLS: OCCURRED DURING LAST HOUR.

(×) AROUND SYMBOLS: OCCURRED IN SIGHT OF STATION.

TYPES OF CLOUDS (HIGH CLOUDS)

NO HIGH CLOUDS	THIN CIRRUS	THICK CIRRUS	CIRRUS OF ANVIL CLOUD
TUFTED CIRRUS INCREASING	CIRRUS OR CIRRO-STRATUS	CIRRO-STRATUS	CIRRO-CUMULUS AND CIRRUS

MIDDLE CLOUDS

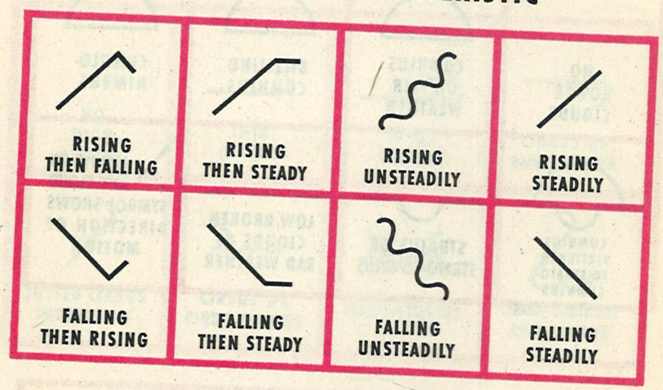
NO MIDDLE CLOUDS	THIN ALTO-STRATUS	THICK ALTO-STRATUS OR NIMBO-STRATUS	ALTO-CUMULUS
ALTO-CUMULUS IN SMALL PATCHES	ALTO-CUMULUS IN BANDS	ALTO-CUMULUS WITH ALTO-STRATUS	ALTO-CUMULUS IN TUFTS

LOW CLOUDS

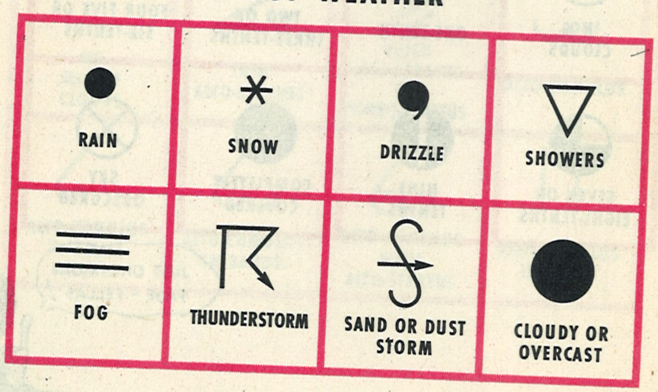
NO LOWER CLOUDS	CUMULUS OR FAIR WEATHER	SWELLING CUMULUS	CUMULO-NIMBUS
CUMULUS FLATTENED TO STRATO-CUMULUS	STRATUS OR STRATO-CUMULUS	LOW BROKEN CLOUDS OF BAD WEATHER	ARROW ON ANY CLOUD SYMBOL SHOWS DIRECTION OF MOTION

NO CLOUDS	ONE-TENTH	TWO OR THREE-TENTHS	FOUR FIVE OR SIX-TENTHS
SEVEN OR EIGHT-TENTHS	NINE TENTHS	COMPLETELY COVERED	SKY OBSCURED

BAROMETER CHARACTERISTIC



PAST WEATHER



When the symbols have been filled in on the circles for each of the reporting stations, all essential information is on the weather map. But there are literally hundreds of these stations, and you haven't time to study each circle in detail. So the aerologist summarizes and further abbreviates the weather information for you.

First, he analyzes the past weather, types the air masses, studies windshifts, pressure changes and precipitation areas. With this information, he knows where the fronts lie on his weather map, and he draws these fronts in with a pencil.

Then he studies the existing pressures at the various stations and pencils in lines connecting all the points which have the same pressure. These lines are called "isobars," and they are drawn at intervals of three millibars of pressure, for purposes of standardization. When all the isobars have been drawn, they automatically outline the shapes of the pressure fields, and thus they locate the high pressure and low pressure centers on the map.

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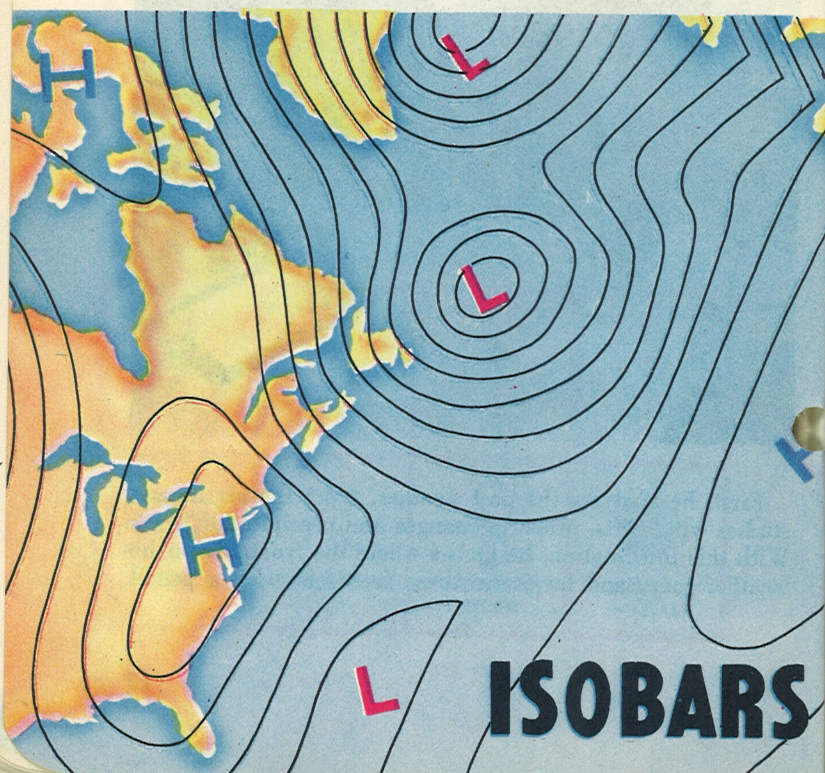
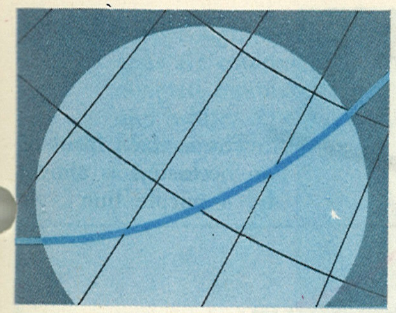
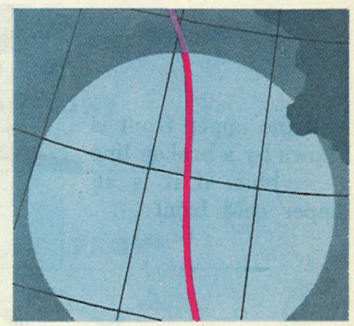
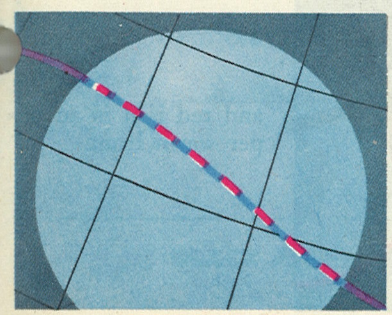




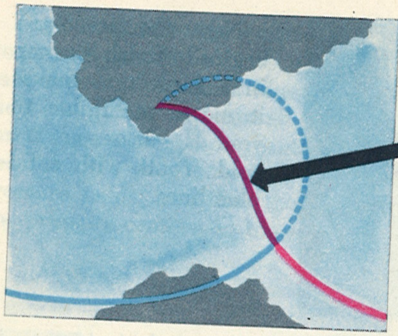
Now the aerologist begins to finish his map in a form that makes it more intelligible to you. He draws in the cold fronts with solid blue lines.

Warm fronts are shown by solid red lines. If a front is stationery—that is, if the wind behind the front nearly parallels the dis-



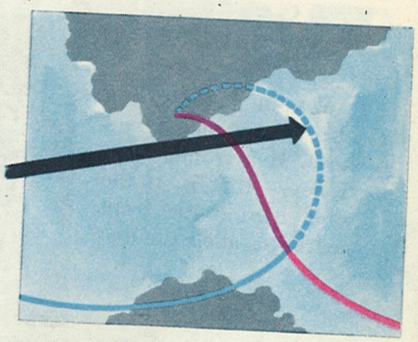


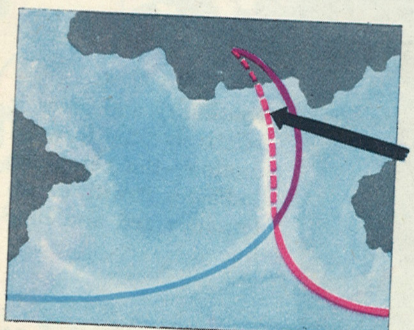
continuity and gives it relatively little forward motion—the aerologist indicates it with an alternately red and blue line.



The surface front of an occlusion is shown by a purple line . . .

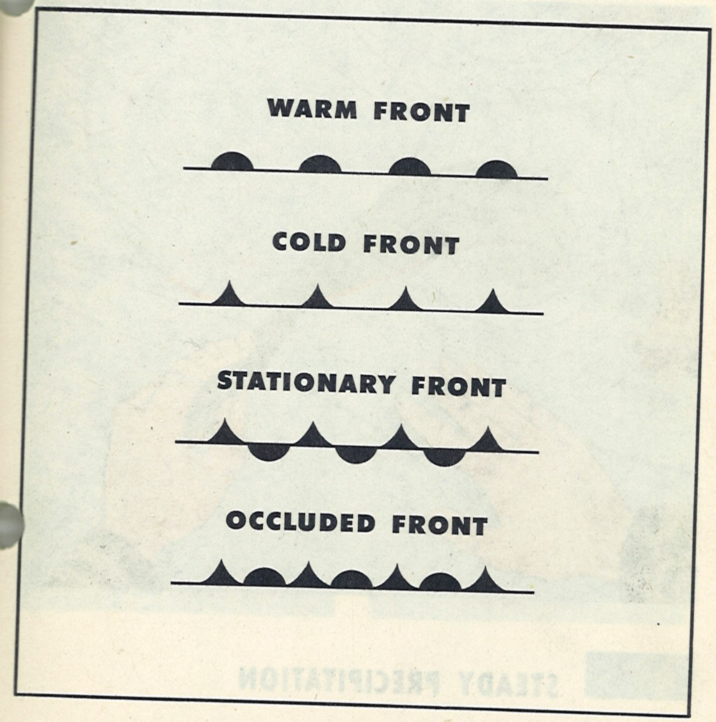
and the upper front is shown by a broken line . . . blue, if it is an upper cold front . . .





and red if it is an upper warm front.

Although weather maps drawn by aerologists are colored, standard symbols have been adopted for maps which are printed in black and white. The table below shows you the black and white symbols for the various types of fronts.



BLACK AND WHITE SYMBOLS

Next the aerologist sketches in the precipitation areas which are associated with the fronts. He indicates precipitation with the color green and, if it is steady, fills in the area with solid green shading. If it is intermittent, he uses hatched shading.

STEADY PRECIPITATION

INTERMITTENT

In addition he shows the type of precipitation by using these symbols in green:

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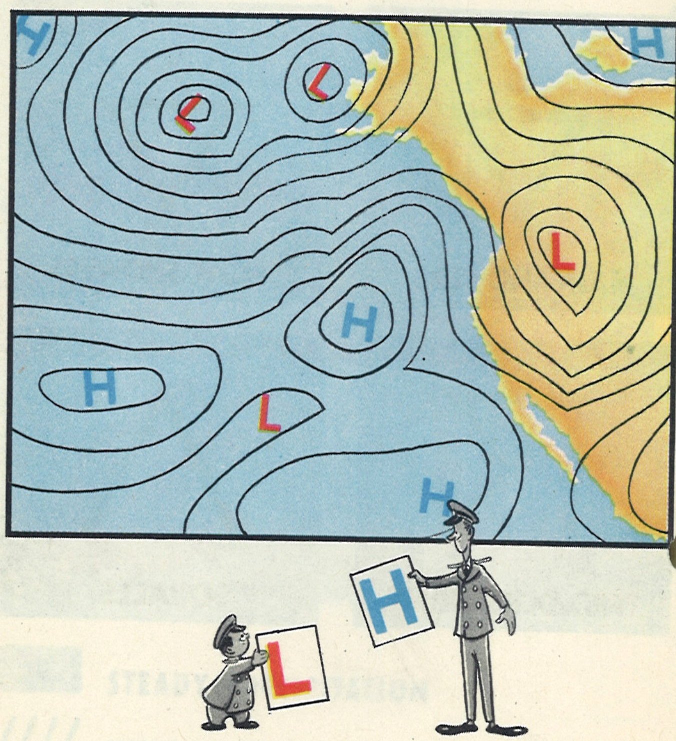
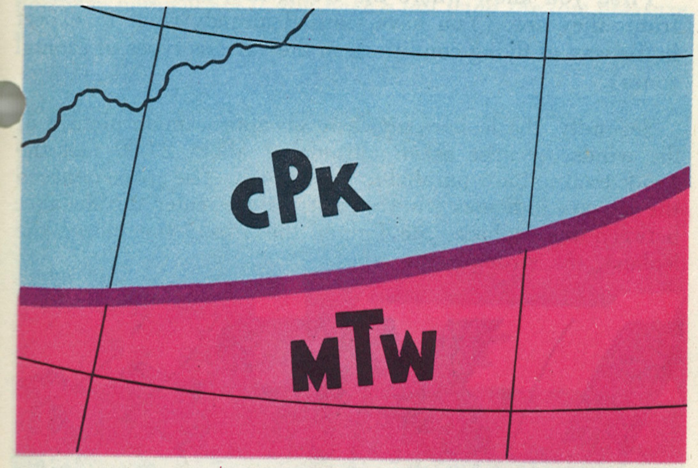
The aerologist's next move is to indicate the high and low pressure centers in such a way that you can pick them out quickly on the map. He uses a red "L" to mark the center of a low pressure area, or cyclone, and a blue "H" to represent the center of a high pressure area, or anti-cyclone.



Now he wants to show you something about the air masses between the frontal systems, and for this he uses a very simple three-letter code:



The large letter in the center indicates the source of the air mass. "P" means that it came from the cold Polar regions, and "T" means that its origin was in the warm Tropics.

The small letter on the left indicates the type of surface over which the air has traveled, "c" if its course was continental; "m", standing for maritime, if it moved mostly over water.

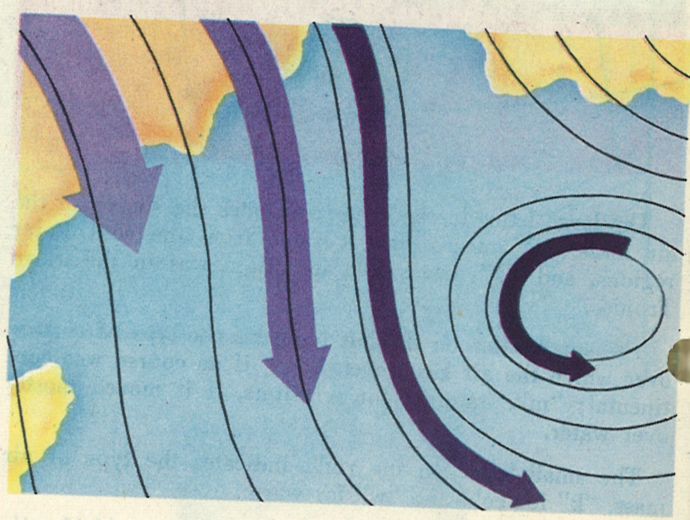
The small letter on the right indicates the type of air mass, "k" for cold and "w" for warm.

Thus the symbol cPk on the weather map would identify an air mass as cold Polar continental air.

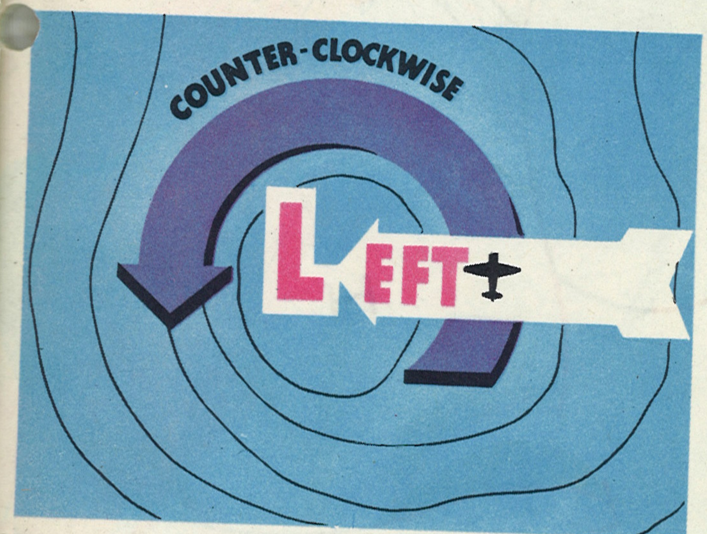
Now let's add up what you know from the colored lines and symbols the aerologist has drawn on his map.

First, you know where the fronts are, and what kind of fronts they are. (You have learned already what to expect in the way of flying conditions in the various types of frontal zones).

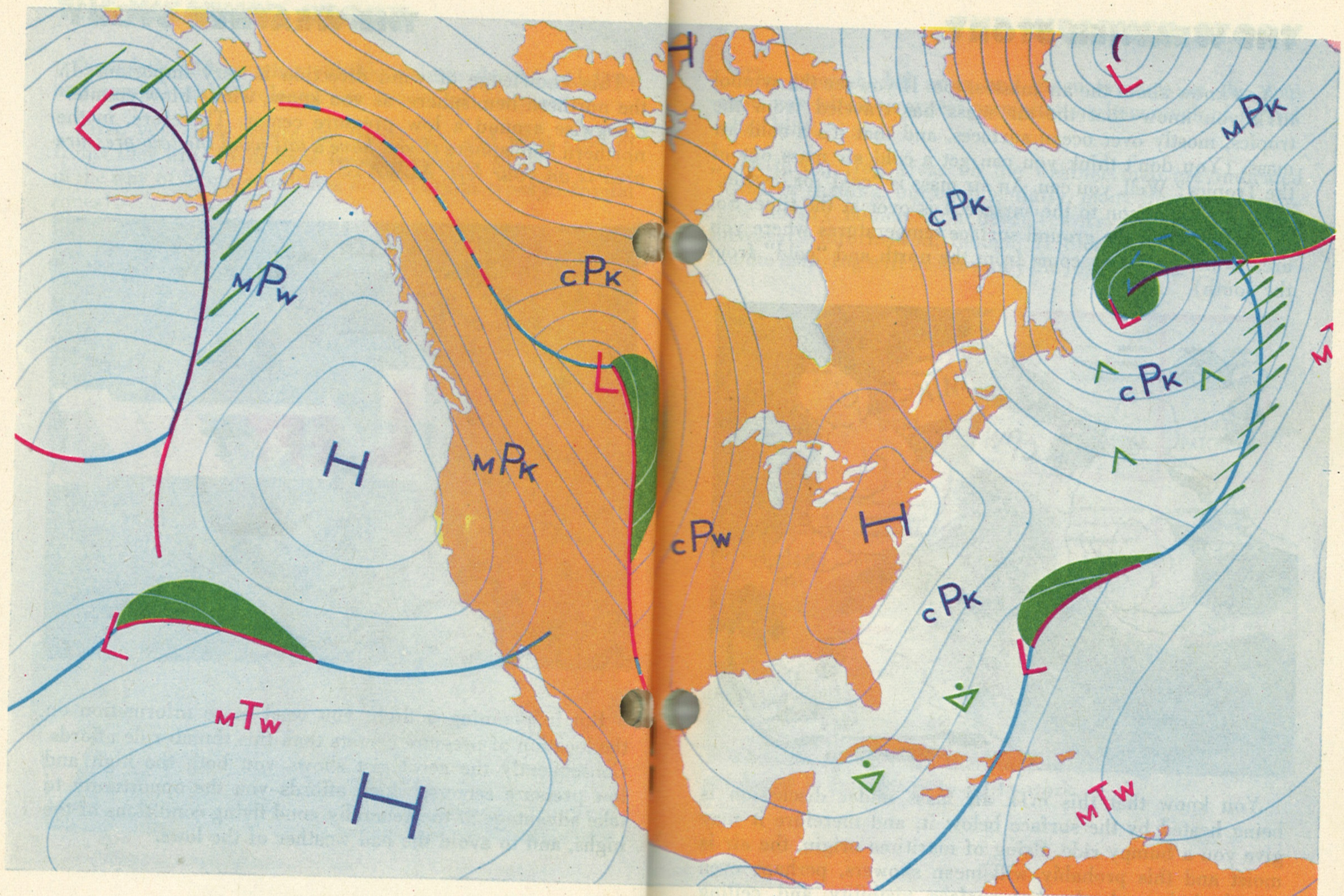
Secondly, the isobars give you an approximate picture of the winds, because at an altitude of about 2,000 feet the winds tend to blow parallel to the isobars. The space *between* the isobars indicates wind velocity; the greater the distance between the isobars, the lighter the wind; the closer the isobars, the stronger the wind.



This knowledge of wind direction is very important. In the northern hemisphere, as you know, winds blow counter-clockwise around a low pressure center. Therefore, in the northern hemisphere *if you have a tail wind the low pressure area is on your left.* ALWAYS!

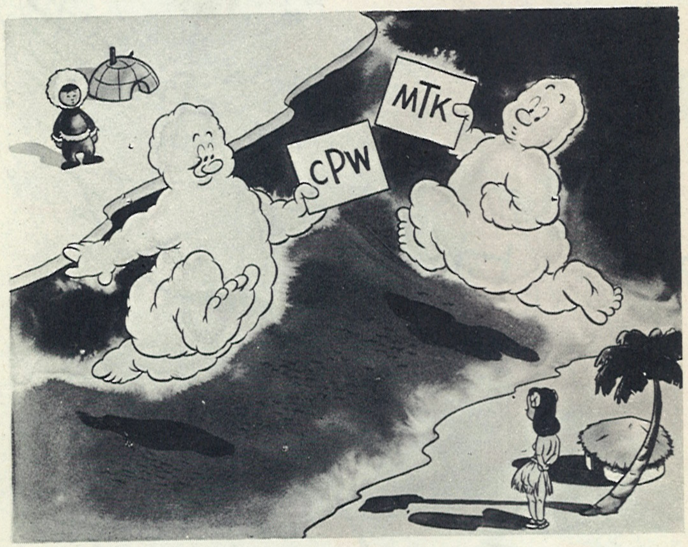


But in planning a flight you need more information on the location of pressure centers than this thumb rule affords. Consequently the aerologist shows you both the high and low pressure centers, which affords you the opportunity to take advantage of the generally good flying conditions of the highs, and to avoid the bad weather of the lows.



THE COMPLETE WEATHER MAP

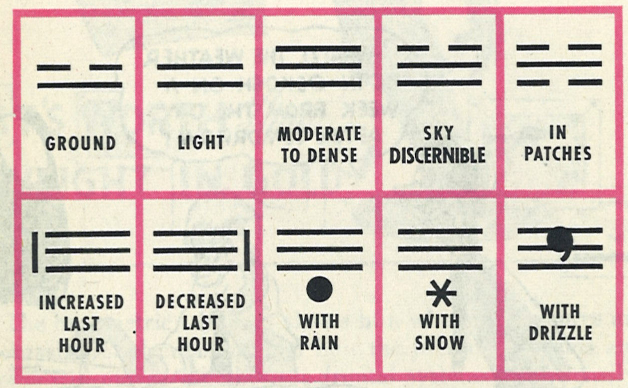
You know about the air masses, too. If you see the symbol mTk you know that the air mass has traveled from the tropics, mostly over ocean surfaces, and that it's a cold air mass. (You don't think you can get a cold air mass out of the Tropics? Well, you can. An air mass is "cold" or "warm" only in comparison to the surface it is over at the time. So, depending upon the ground surface temperatures where you are, "warm" air may come from the north and "cold" from the south).



You know that this mTk air mass under discussion is being heated by the surface below it, and therefore it may give you a bumpy ride. Being of maritime origin, the air is moist and this probably will mean showers, perhaps even cumulonimbus clouds, but surface visibility and ceiling probably will be good.

The green-shaded areas and green symbols on the map show you where to expect precipitation, how much of it, and what kind.

In theory, fog areas on the weather map are indicated with red shading, but confidentially, many times the aerologist doesn't bother. You needn't worry about getting the necessary information, though. If there is no red shading on the map, fog will be shown by the fog symbols.



Isn't that about all you want to know from the aerologist about weather?

IT IS NOT!

When he has reached this stage of his map drawing, the aerologist is just ready to go to work.

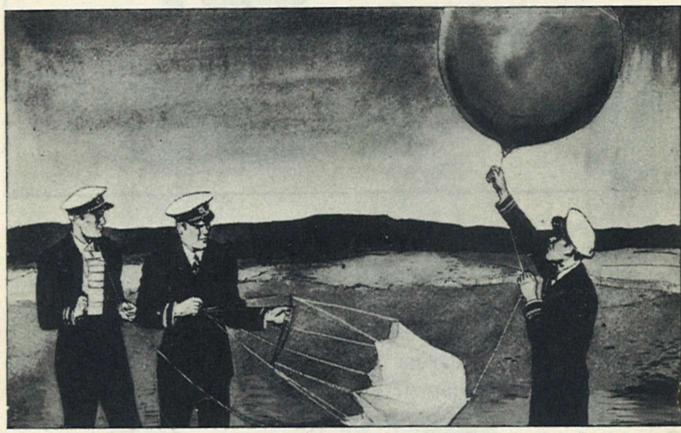
☆

All he has done so far is show you current weather. You want to know what the weather is *going to be*. So now the aerologist takes the map you watched him draw and compares it with previous maps, the maps that were prepared at six-hour intervals from the regularly-assembled station reports. From this comparison he can tell how the weather has moved, and from his analysis of its movements he can make his estimate of how it will move in the immediate future.

The barometric tendency shows him whether pressures are increasing or decreasing, and how the pressure systems and fronts will move—whether the frontal systems are intensifying or dissipating. From his meteorological knowledge, coupled with his current information on weather over a widespread area he can determine what changes in the existing weather will take place during the next 24 or 36 hours. On this basis he makes his forecast, and this forecast, in addition to what you already have read on the weather map, shows you the weather to be expected along any course to be flown. This is what enables you to make an intelligent flight plan.

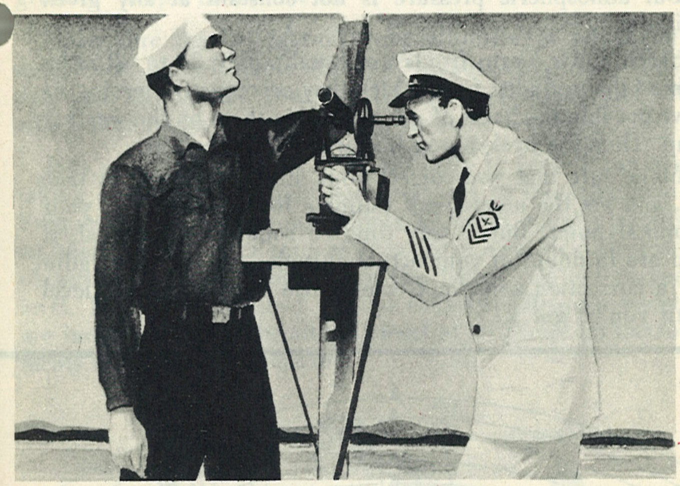
There is one additional factor that is helpful to you in planning your flight. You know that generally winds become more westerly with increasing altitude, except in the tropics, and therefore you ought to make any extended westbound flight at relatively low altitudes whenever possible to avoid the high level head winds.

But there are other things you want to know about high level winds, and this information is available in the weather office. Make use of it! There is no more important information for successful flight planning.



More than 100 stations in the United States, and all the Navy's carriers, make six-hourly pilot balloon runs to determine the direction and velocity of the upper winds. These winds aloft are different from surface winds—they are not impeded by friction with surface objects and therefore usually are stronger.

The rule that winds parallel the isobars holds true only up to 2,000 or 3,000 feet. The pressure distribution changes above those levels, and consequently the direction and velocity of the upper winds are not determined by the pressures shown on the surface map.



But unless there is an overcast so great as to preclude observation, the force and direction of the upper winds are measured, reported, and charted so that you can tell what the winds are at any altitude from 1,000 feet to 12,000 feet.

Get this information before you take off. Unless some weather obstruction intervenes (and the weather map should tell you if it is going to) the winds aloft chart is your guide to the best altitudes at which to fly a given course, your insurance against the danger of running out of fuel, and your indicator for sending an accurate E.T.A.

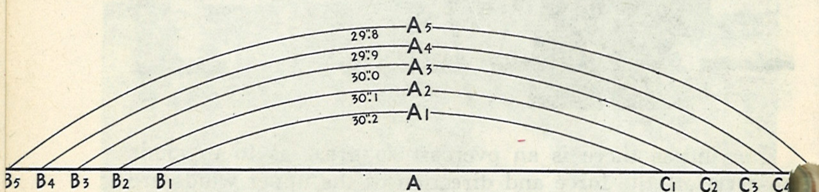
A FEW WORDS OF CAUTION

Don't ever forget that your altimeter setting is a part of your necessary weather information. Your altimeter is nothing but a pressure gauge that reads less as your height from the earth increases and the pressure decreases.

But atmospheric pressure is not constant at any given altitude.

Since upper warm fronts are usually only 20 to 30 miles behind the occluded front which they accompany, aerologists have got into the habit of not indicating them on the weather map. Thus the broken red line will seldom be seen.

Make sure that you correct your altimeter setting at take-off, and get the aerologist's estimate for the setting at your terminal point. But at any time en route or on arrival, if you are in doubt of your actual altitude, ask on voice radio for a correction and don't come down to a dangerous level until you've got it!



A plane taking off at A, will have correct altitudes indicated on the altimeter at A1, A2, A3, etc. However, in flying toward B or C, unless the altimeter setting is corrected, the plane will fly along one of the isobars. Thus a plane at A1 would intersect the ground at B1 or C1, etc. A good thumb rule for making approximate corrections when no contact with ground stations is possible is "When flying toward low pressure, you are lower than your altimeter indicates". The reverse also hold true but is not as vital: "When flying toward high pressure, you are higher than your altimeter indicates".

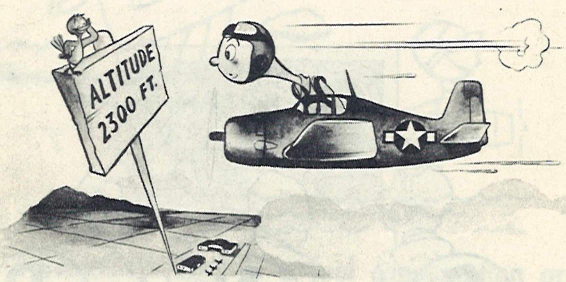
The distance between isobars represents roughly 100 feet of altitude. In the above case, the distance from A to B or C could be as little as 300 miles and the altimeter error 1000 feet.

A FEW WORDS OF CAUTION

When you fly with a constant reading on your altimeter, you are not flying at a constant altitude. You *are* flying at an elevation where the *pressure* is constant—in effect, flying along an isobar. During periods of high winds (which usually means bad weather) the isobars are closely spaced and it is quite possible to ride an isobar right into the ground—people have done it.

Make sure that at take-off your altimeter is set at the actual field altitude above sea level, because only in this way can you standardize your altitude with all other aircraft which may be on instruments on the same airway.

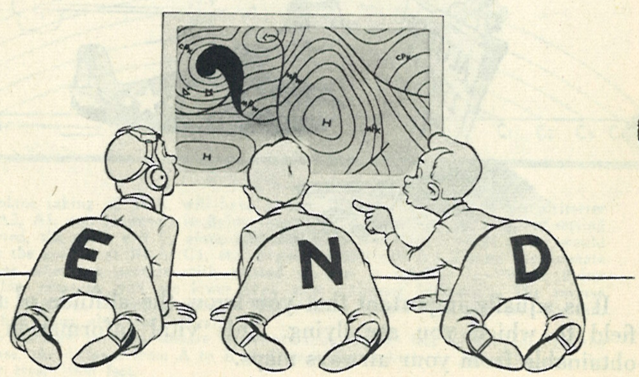
It is quite proper to set your altimeter to zero if you are taking off for a local flight and returning to the same field. Frequently, however, young pilots on cross country flights set their altimeters to zero as they leave each field, instead of setting it to compensate for the field's relation to sea level. This is an excellent way of causing collisions, which are inevitable unless the altitude level of all planes on instruments is maintained constant.

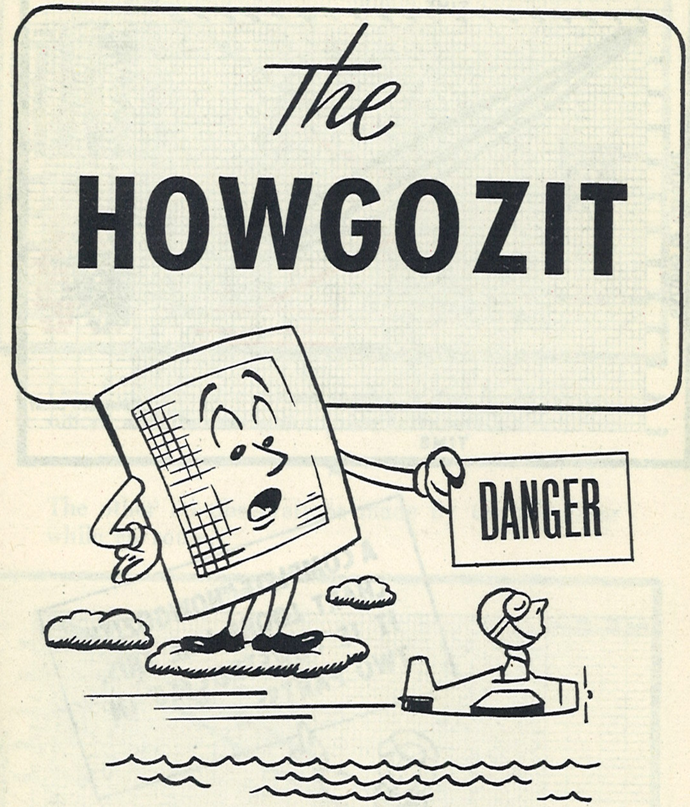


It is equally important that you know the altitude of the field to which you are flying. This vital information is obtainable from your airways maps.

ANOTHER THING!

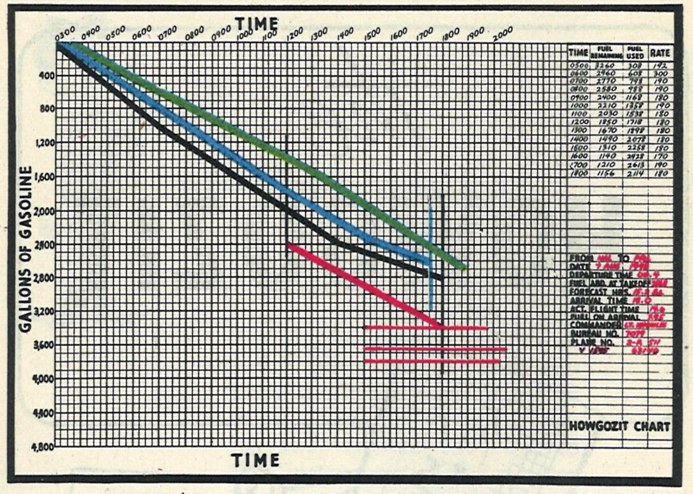
Contact flying conditions are variable, so if you get a report that you have a 1000-ft. ceiling and 3 miles visibility at an airport, don't rely too much on their staying that way. If ceiling and visibility are close to the instrument limits, better play it safe and don't depend upon contact conditions to remain.

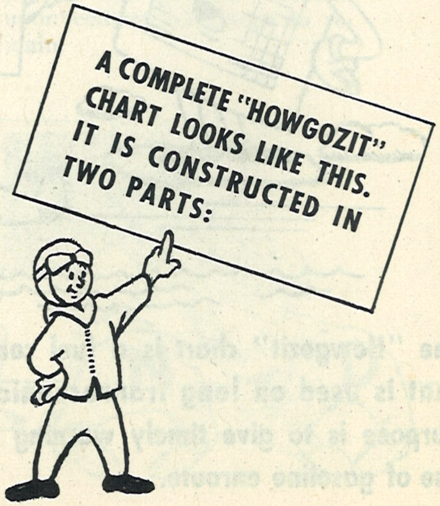


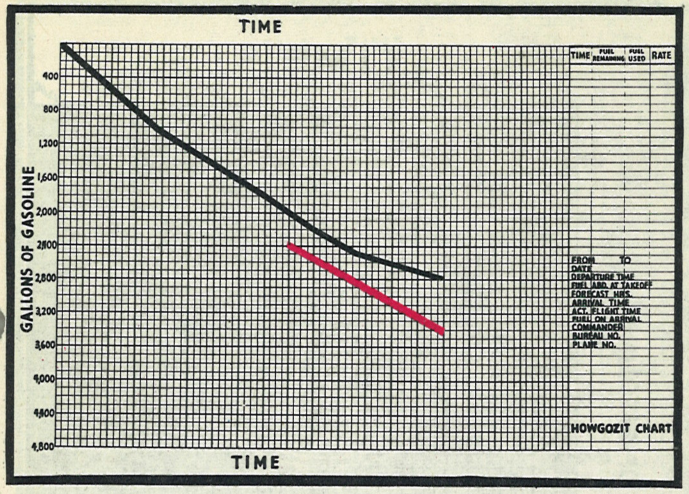


The "Howgozit" chart is a fuel consumption graph that is used on long transoceanic flights and its purpose is to give timely warning of the excessive use of gasoline enroute.

THE HOWGOZIT







One built on predictions made by the flight control officer and the navigator prior to take-off.

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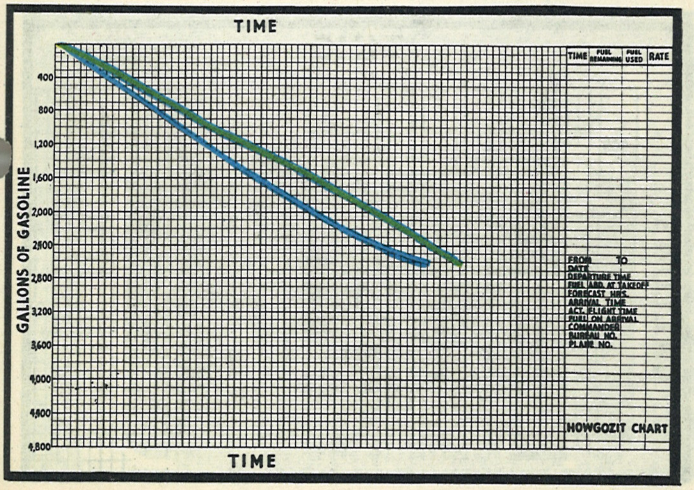
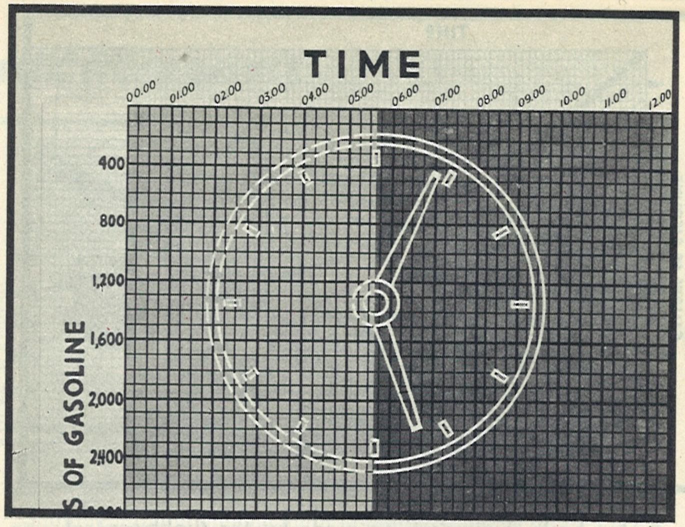
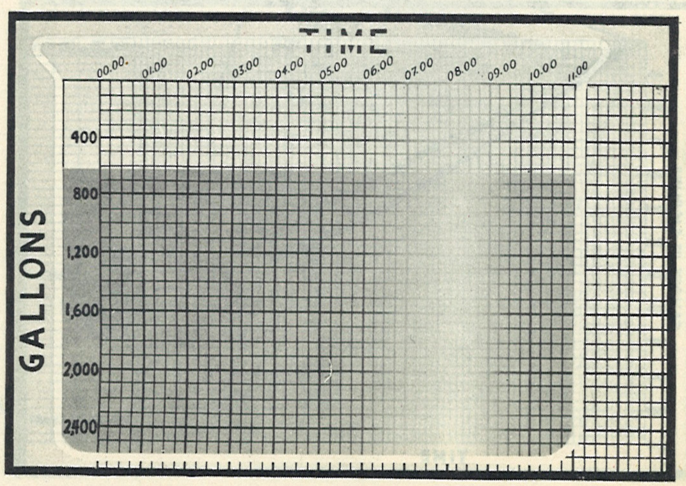
The other on observations made by the navigator while en route.

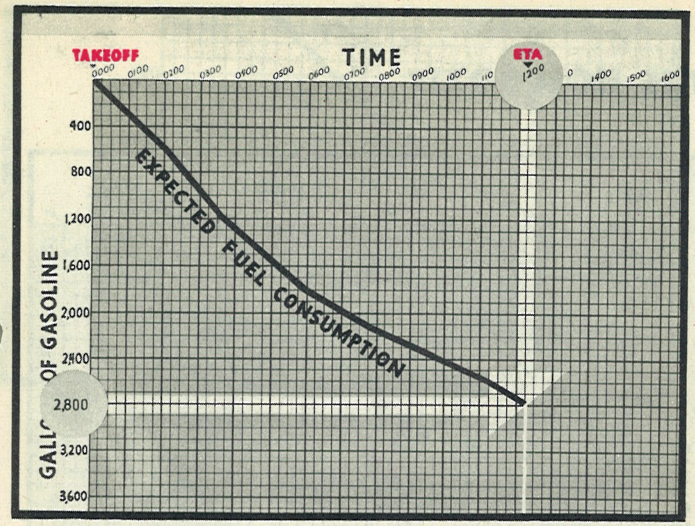




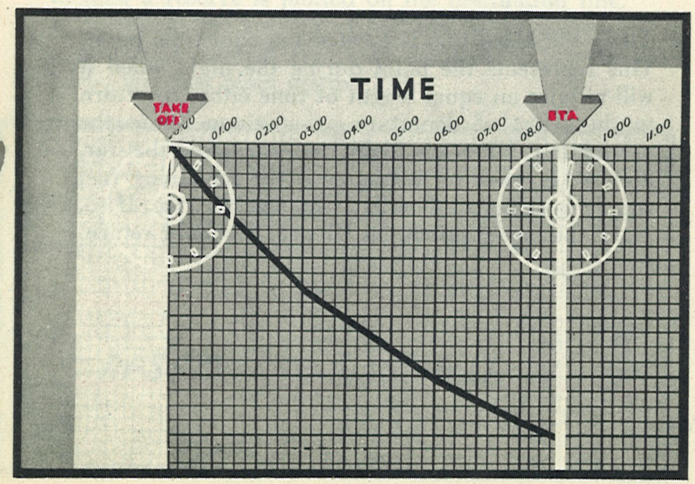
The chart is based on flight time, in hours, measured horizontally,

And gasoline consumption, in gallons, measured vertically.

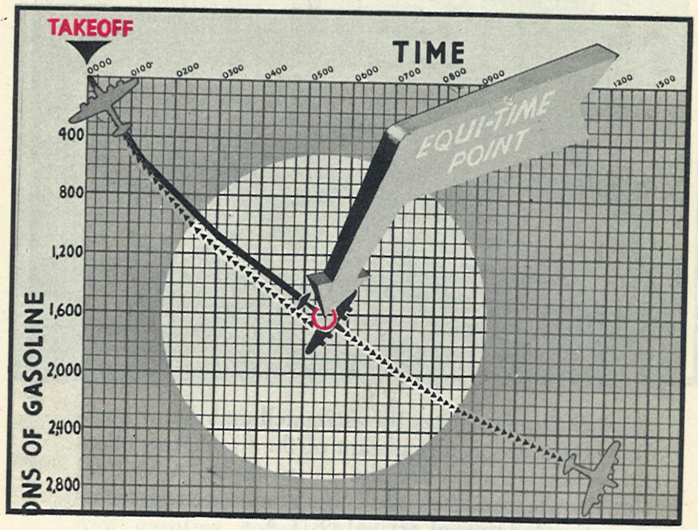




A black line indicates the estimated amount of gasoline consumed at any instant of the flight, as well as the estimated total for the entire flight. A vertical line drawn from the end of this black line represents the estimated time of arrival (E.T.A.).



THE HOWGOZIT



Along the black line is located the equi-time point. This represents the point during the flight when it will require an equal length of time either to return to the point of departure or continue on to the destination. When the flight has progressed this far, a check is made to determine if the remaining fuel supply is sufficient to safely complete the trip. If so, the plane can continue on. If not, it should return.

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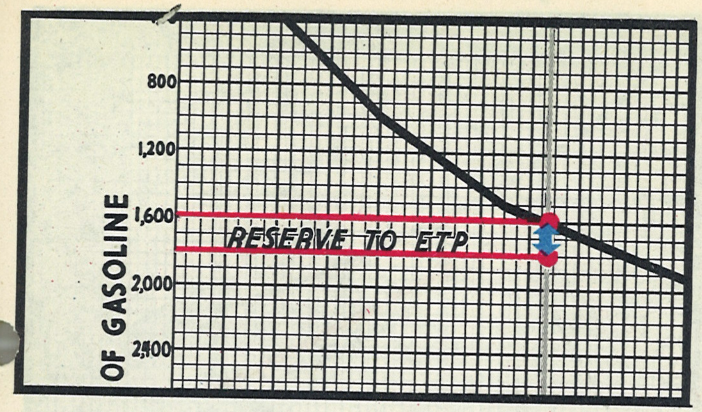
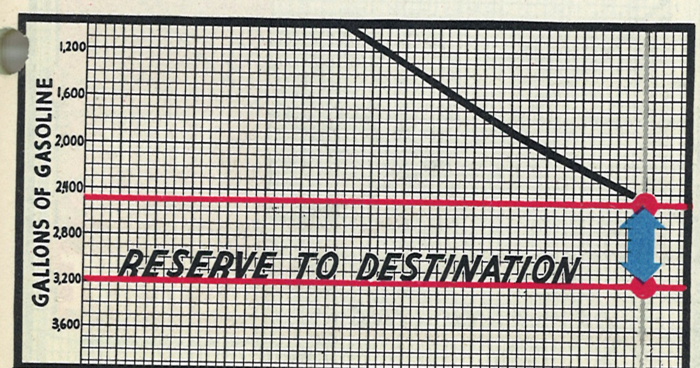
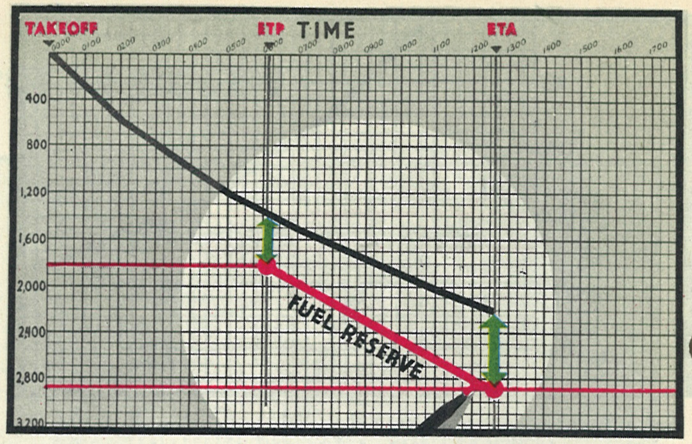


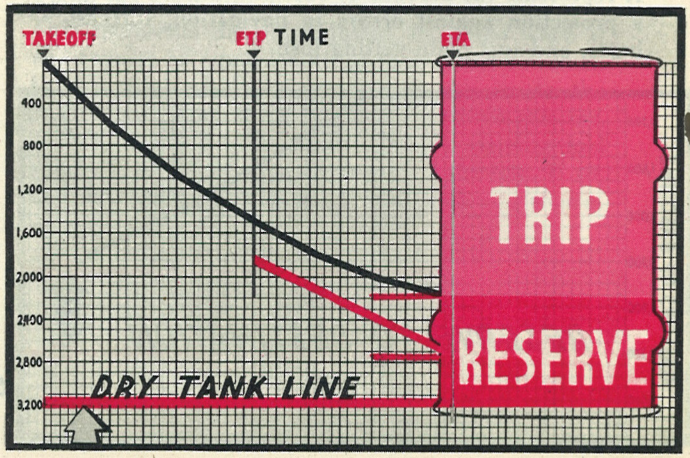
A fuel reserve is plotted down the equi-time line. It shows the maximum fuel consumption at the equi-time point which will allow the plane, to reach either the destination or the point of departure at the most economical flying speed. This amount of fuel that is set aside depends upon the total time of the flight altitudes to be flown, type and gross loading of the plane.

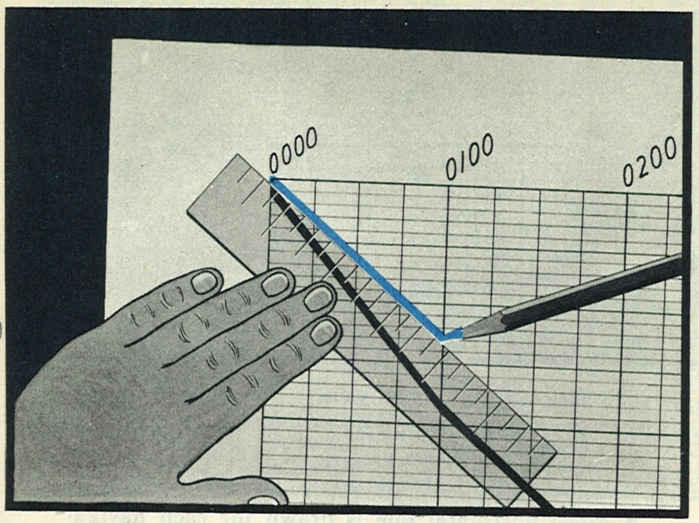
In a like manner, and depending upon the same factors, a reserve is plotted on the destination line. It represents the amount of fuel that is set aside as a protection against errors in navigation, forecast busts, and just plain getting lost.



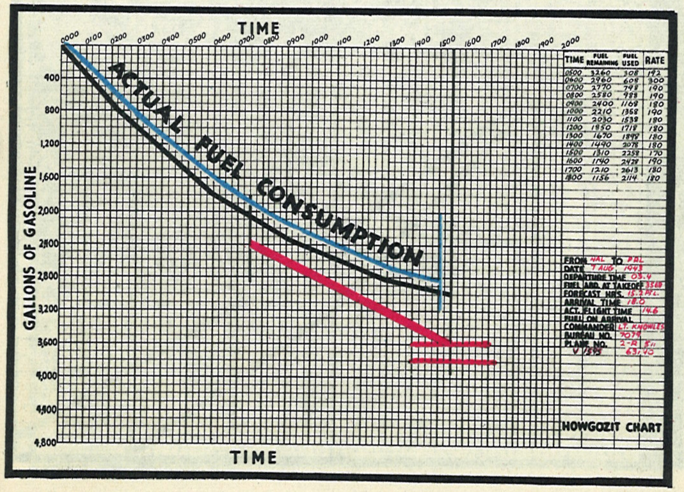


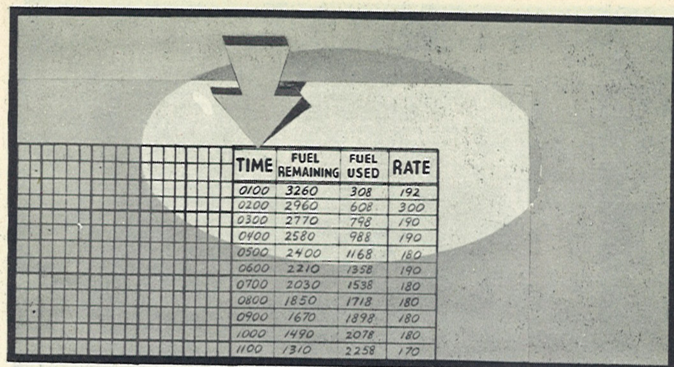
A line connecting these two points shows at any time after passing the equi-time point the maximum amount of fuel that can be used and still reach the destination. This is called the "fuel reserve curve" and is drawn in red. As an additional safeguard, in case weather or other factors prevent an immediate landing upon arrival at the destination, sufficient fuel is set aside to permit one hour's cruising at minimum fuel consumption. This is shown on the chart by a red line, known as the "dry tank line."





The remaining curves are constructed by the navigator during the flight. A blue line is plotted at intervals, showing the actual amount of fuel consumed as the flight progresses.



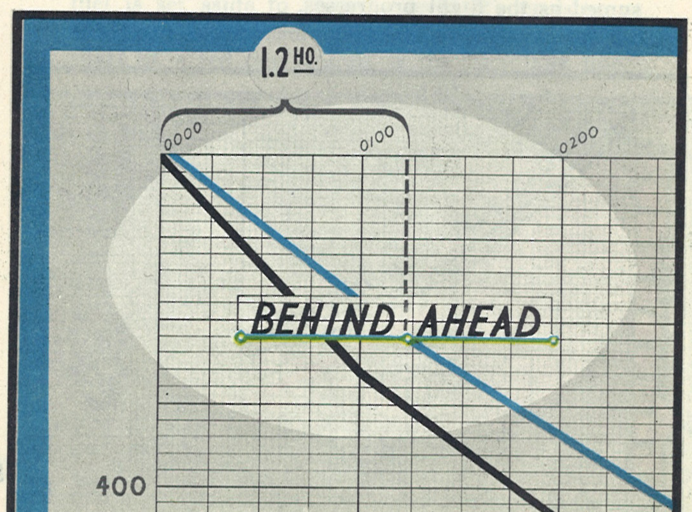


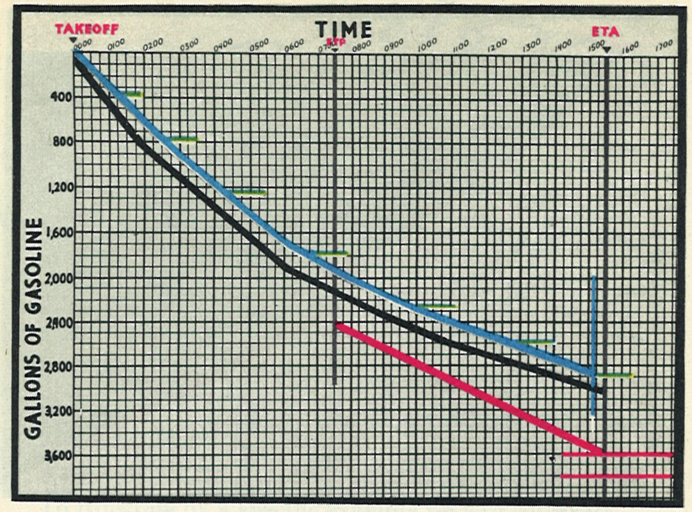
TIME	FUEL REMAINING	FUEL USED	RATE
0100	3260	308	192
0200	2960	608	300
0300	2770	798	190
0400	2580	988	190
0500	2400	1168	180
0600	2210	1358	190
0700	2030	1538	180
0800	1850	1718	180
0900	1670	1898	180
1000	1490	2078	180
1100	1310	2258	170

The data for plotting this curve are taken from the engineer's hourly record and entered on the Howgozit.

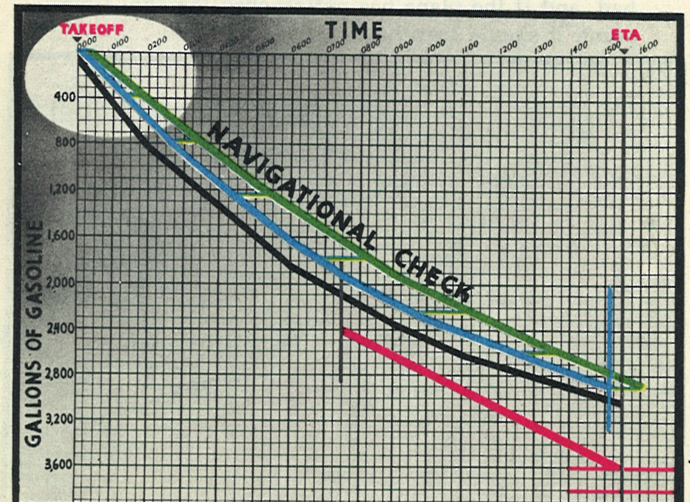
★

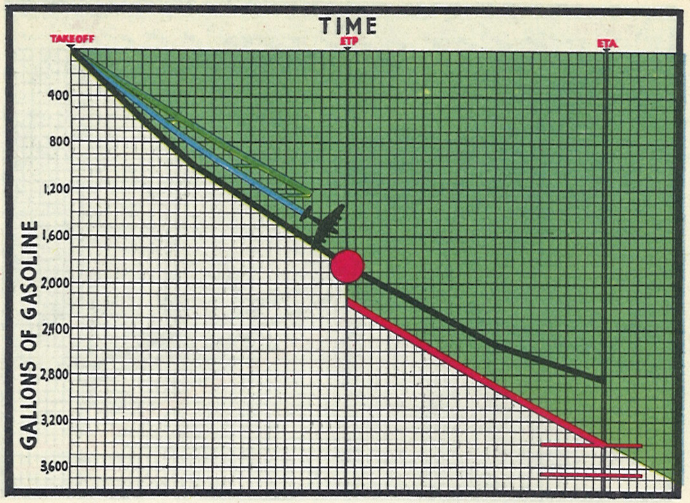
A green horizontal line is drawn for each navigational fix. Its length, measured from the blue line, represents time in minutes that the flight is off schedule, to the left of the blue line if the flight is behind, to the right if the flight is ahead.





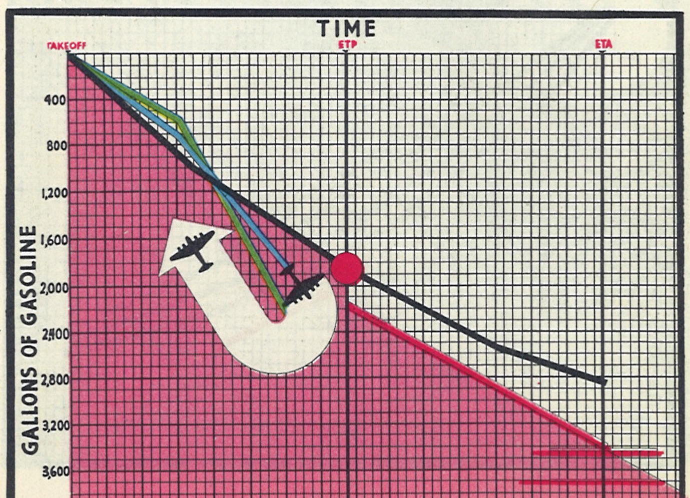
A green curve connecting the ends of these lines gives a continuous picture of the flight's progress. For a perfectly executed trip, the green and the blue lines should coincide with the black line. However, this will seldom be the case on a long flight.

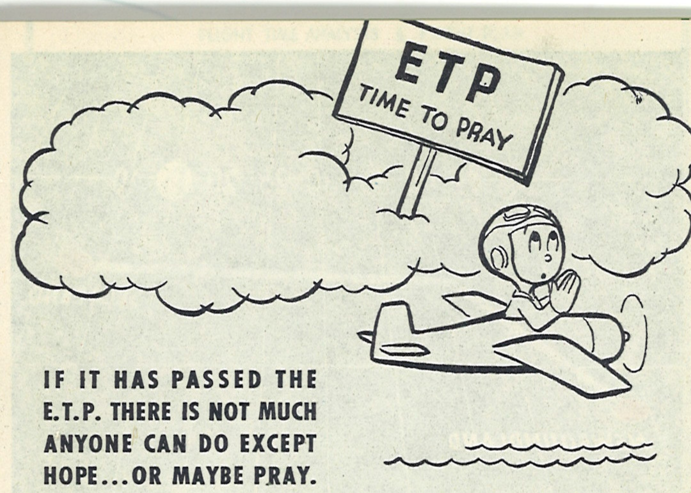




When these lines are to the right of the black line, a safe trip can be expected.

When the green and blue lines fall below the black line and approach the red line, things are getting bad. When they cross the red line, things are really bad, and if the plane has not reached the equi time point, it should turn back.

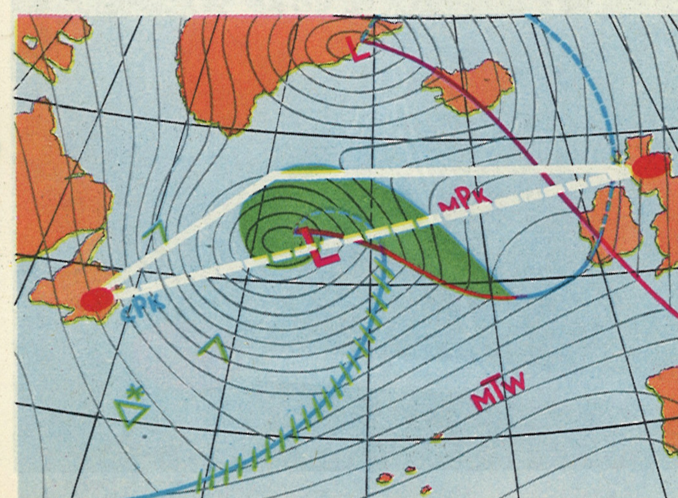


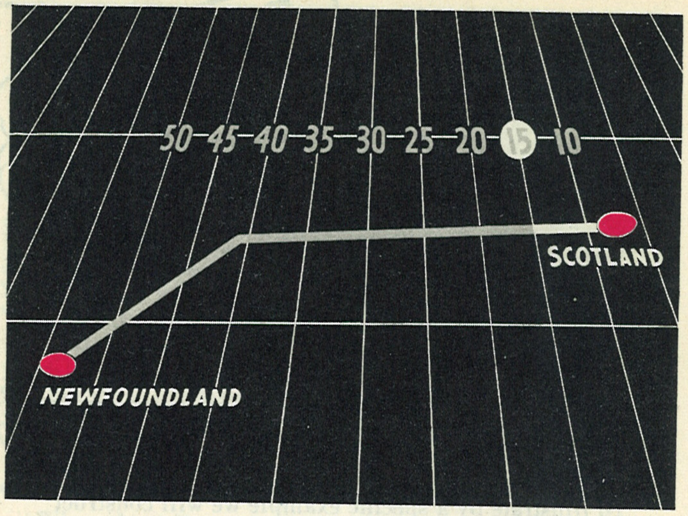


IF IT HAS PASSED THE E.T.P. THERE IS NOT MUCH ANYONE CAN DO EXCEPT HOPE...OR MAYBE PRAY.

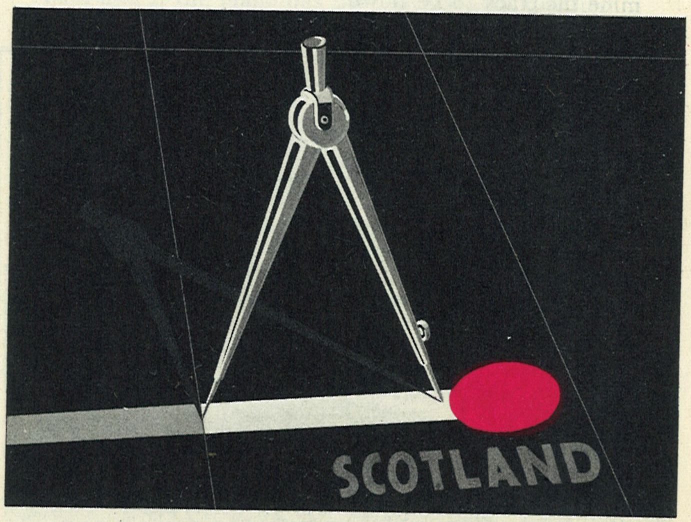
To illustrate by a specific example we will construct a "Howgozit Chart" for a flight from Scotland to Newfoundland. A study of the latest weather map will show the existing and expected weather between these two points.

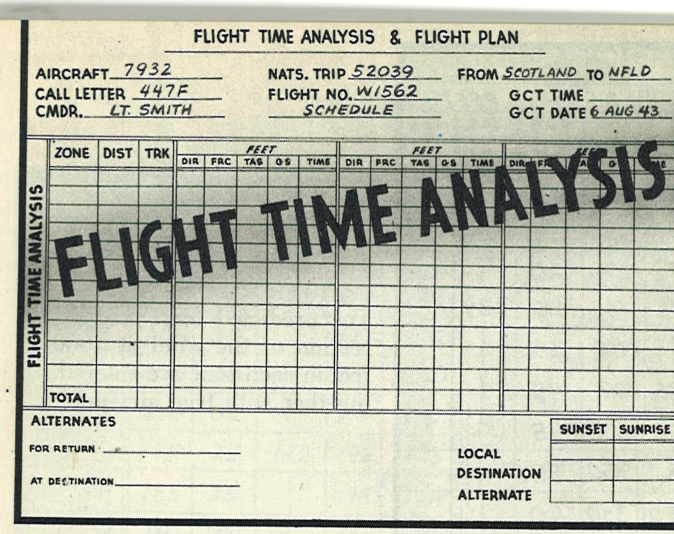
From this information the navigator is able to determine the track to be flown.





This track is divided into zones, each zone representing five degrees of longitude.




FLIGHT TIME ANALYSIS & FLIGHT PLAN

AIRCRAFT 7932 NATS. TRIP 52039 FROM SCOTLAND TO NFLD
CALL LETTER 447F FLIGHT NO. W1562 GCT TIME
CMDR. LT. SMITH SCHEDULE GCT DATE 6 AUG 43

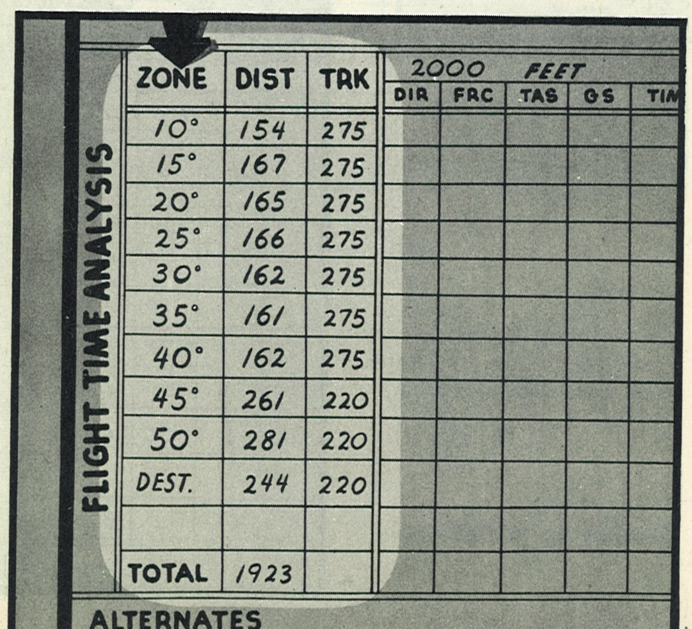
FLIGHT TIME ANALYSIS

ZONE	DIST	TRK	DIR	FRC	TAS	GS	TIME	DIR	FRC	TAS	GS	TIME
TOTAL												

ALTERNATES
FOR RETURN
AT DESTINATION

	SUNSET	SUNRISE
LOCAL		
DESTINATION		
ALTERNATE		

The track and distance for each zone are taken off the chart and entered on the flight time analysis.


FLIGHT TIME ANALYSIS

ZONE	DIST	TRK	DIR	FRC	TAS	GS	TIM
			2000 FEET				
10°	154	275					
15°	167	275					
20°	165	275					
25°	166	275					
30°	162	275					
35°	161	275					
40°	162	275					
45°	261	220					
50°	281	220					
DEST.	244	220					
TOTAL	1923						

ALTERNATES

DIST	TRK	2,000 FEET DIR	FRC	TAS	GS
154	275	180	35	129	
167	275	180	40		
165	275	240	25		
166	275	230	20		
162	275	165	20	134	
161	275	110	35		
162	275	090	45		
261	220	030	45		
281	220	350	50		
244	220	340	40		
923					
S					

The predicted force and direction of the wind at 2000 feet in each zone are entered, together with true air speed.

★

FEET FRC	TAS	GS	TIME	DIR	FRC
35	129	127	1.22		
40		126	1.33		
25		108	1.53		
20		114	1.47		
20	134	139	1.17		
35		167	.97		
45		179	.90		
45		178	1.47		
50		161	1.75		
40		150	1.63		
			13.44		

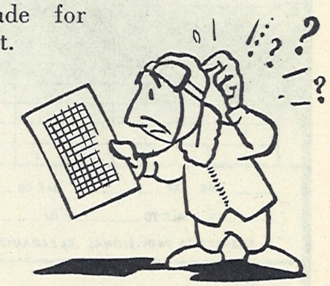
★

From these figures, ground speed and time to transit each zone are calculated.

THE HOWGOZIT

S	TIME	6,000 FEET DIR	FRC	TAS	GS	TIME	10,000 FEET DIR	FRC	TAS
7	1.22	210	35	137	117	1.32	220	40	145
6	1.33	200	30		127	1.32	220	40	
8	1.53	220	30		118	1.40	230	45	
4	1.47	210	35		118	1.41	230	50	
9	1.17	180	25	142	142	1.15	240	50	150
7	.97	165	25		148	1.08	240	45	
9	.90	110	30		170	.95	250	40	
8	1.47	045	50		191	1.37	270	60	
1	1.75	340	50		161	1.75	290	60	
0	1.63	320	45		144	1.70	290	60	
	13.44					13.45			
								SUNSET	

In a similar manner these calculations are made for 6,000 and 10,000 feet.



This completes the flight time analysis.

NAVAL AIR TRANSPORT SERVICE
FLIGHT TIME ANALYSIS & FLIGHT PLAN

AIRCRAFT 793 NATS. TRIP 52039 FROM SCOTLAND TO NFLD
CALL LETTER 447F FLIGHT NO. W1562 GCT TIME
CMDR. LT. SMITH SCHEDULE GCT DATE 6 AUG. 4[illegible]

FLIGHT TIME ANALYSIS

ZONE	DIST	TRK	2000 FEET DIR	FRC	TAS	GS	TIME	6000 FEET DIR	FRC	TAS	GS	TIME	10,000 FEET DIR	FRC	TAS	GS	TIME
10°	154	275	180	35	129	127	1.22	210	35	137	117	1.32	220	40	145	119	[illegible]
15°	167	275	180	40		126	1.33	200	30		127	1.32	220	40		119	[illegible]
20°	165	275	240	25		108	1.53	220	30		118	1.40	230	45		110	[illegible]
25°	166	275	230	20		114	1.47	210	35		118	1.41	230	50		106	[illegible]
30°	162	275	165	20	134	139	1.17	180	25	142	142	1.15	240	50	150	[illegible]	[illegible]
35°	161	275	110	35		167	.97	165	25		148	1.08	240	45		[illegible]	[illegible]
40°	162	275	090	45		179	.90	110	30		170	.95	250	40		113	[illegible]
45°	261	220	030	45		178	1.47	045	50		191	1.37	270	60		105	[illegible]
50°	281	220	350	50		161	1.75	340	50		161	1.75	290	60		120	[illegible]
DEST.	244	220	340	40		150	1.63	320	45		144	1.70	290	60		120	[illegible]
TOTAL	1923						13.44					13.45					[illegible]

ALTERNATES
FOR RETURN
AT DESTINATION

	SUNSET	SUNRISE
LOCAL		
DESTINATION		
ALTERNATE		

From this information we are now able to construct the specific flight plan.

FLIGHT PLAN

DIST. ( ) × GS_{3R} ( ) / GS_{3R} ( ) × GS_{3C} ( ) ( ) DIST. TO ETP_3 WHICH ÷ GS_4 ( ) = HOURS TO ETP_3

3 ENG. TAS ____ AT ____ FT. ____ AT ____ FT.

ZONE	ALT.	TIME	TOTAL TIME	GPH	GAL.	TOTAL GALLONS	TOTAL POUNDS

GAS & OIL SUMMARY

GALLONS	FUEL	POUNDS
	RESERVE TO ETP	
	RESERVE [illegible]	
	[illegible]	
	[illegible] EXTRA	
	RESERVE TOTAL	
	FUEL REQ EPT.	
	FUEL TAKEOFF	
	TAXI & WARMUP	
	FUEL TOTAL LOADED	
	OIL	
	GAS INDEX OIL	

FLIGHT PLAN

____ HRS. AT ____ FT. ALT. TO ____ & ____ FT. ALT. TO ____ &
____ FT. ALT. TO ____ IN ____ CRUISING AT ____ LBS. GROSS WEIGHT
SUBJECT TO PROVISIONAL CLEARANCE TO ____ WHILE ENROUTE

FLIGHT CONTROL OFFICER NAVIGATOR PLANE COMMANDER

THE HOWGOZIT

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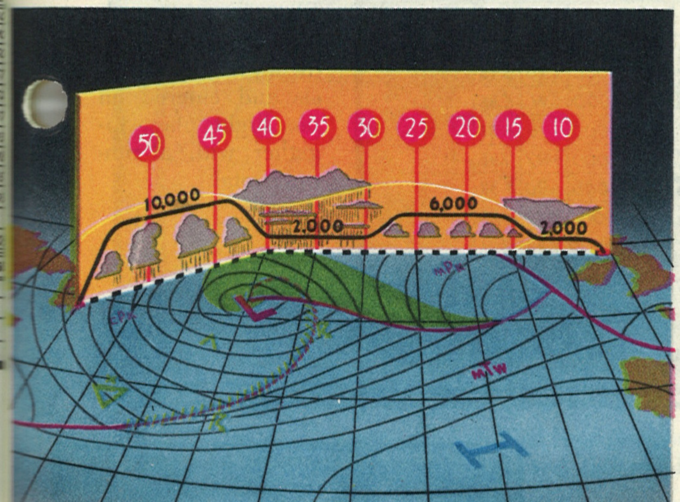

From the weather forecast the altitude to be flown is determined for each zone and entered on the flight [illegible]n.

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ZONE	ALT.	TIME	TOTAL TIME	GPH	GAL.
10	2000	1.22			
15	2000	1.33	2.55		
20	6000	1.40	3.95		
25	6000	1.41	5.36		
30	6000	1.15	6.51		
35	2000	.97	7.48		
40	2000	.90	8.38		
45	10000	2.48	10.86		
50	10000	2.35	13.21		
DEST.	10000	2.03	15.24		
		15.24			

The time in each zone is taken from the flight time analysis and entered on the flight plan, together with a running total.

The fuel consumption for each zone is calculated from tables for the specific type and gross loading of the plane—in this case a 4-engined Coronado.

TIME	TOTAL TIME	GPH	GAL.	TOTAL GALLONS	TOTAL POUNDS	GAS GALLONS
1.22		250	300	300	1800	
1.33	2.55	238	317	617	3700	
1.40	3.95	261	366	983	5900	
1.41	5.36	201	284	1267	7600	
1.15	6.51	178	204	1471	8825	
.97	7.48	100	96	1567	9400	
.90	8.38	139	125	1692	10150	
2.48	10.86	234	583	2283	13700	
2.35	13.21	163	384	2667	16000	
2.03	15.24	163	333	3000	18000	

FLIGHT PLAN

ZONE	ALT.	TIME	TOTAL TIME	GPH	GAL.	TOTAL GALLONS	TOTAL POUNDS	GAS GALLONS
10	2000	1.22		250	300	300	1800	
15	2000	1.33	2.55	238	317	617	3700	
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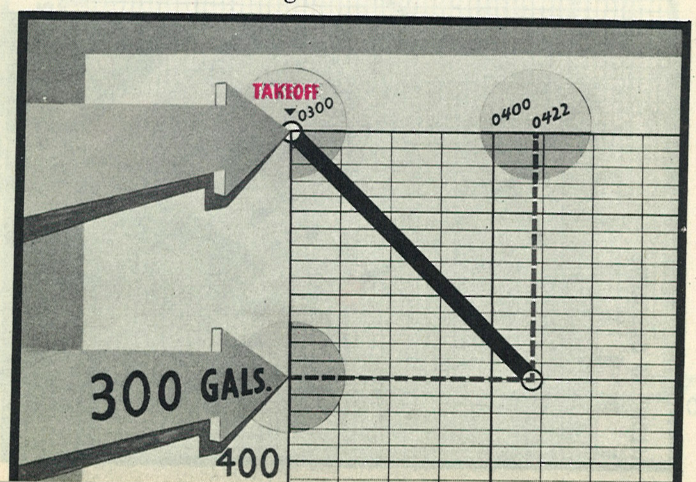
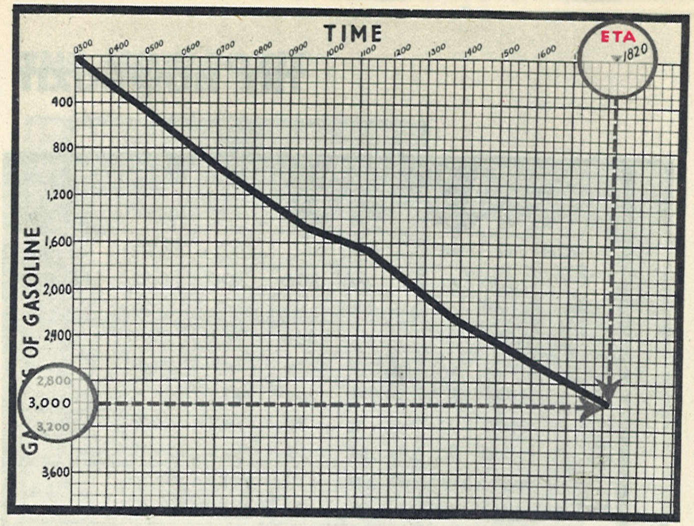
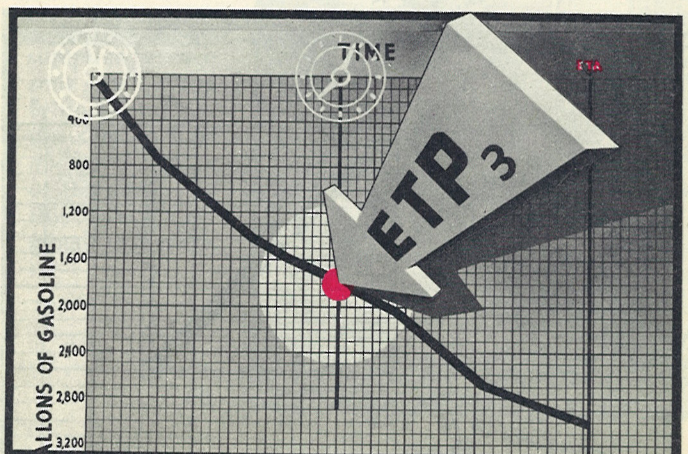
35	2000	.97	7.48	100	96	1567	9400	
40	2000	.90	8.38	139	125	1692	10150	
45	10000	2.48	10.86	234	583	2283	13700	
50	10000	2.35	13.21	163	384	2667	16000	
DEST.	10000	2.03	15.24	163	333	3000	18000	
		15.24						

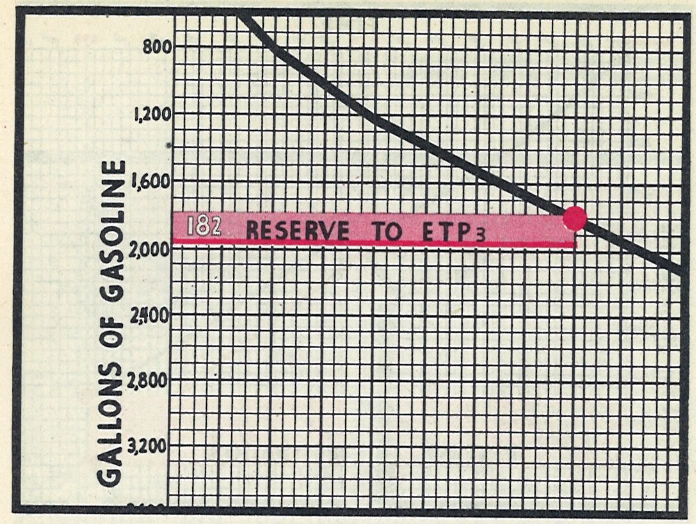
For the first zone the total elapsed time is one and twenty-two hundredths hours, and the gasoline consumed is 300 gallons.



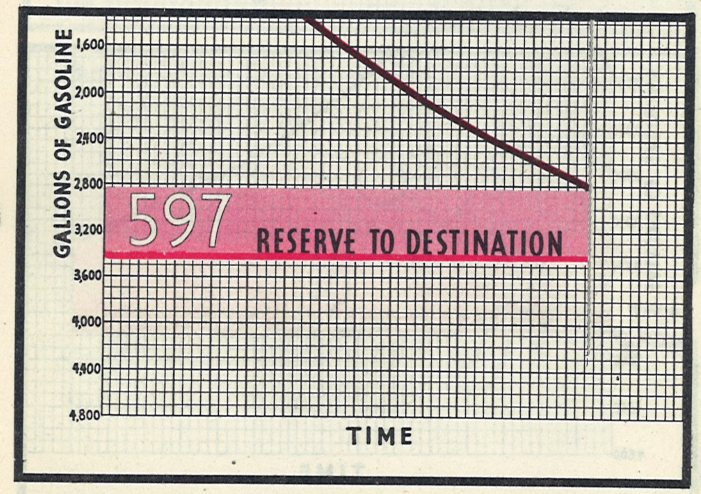


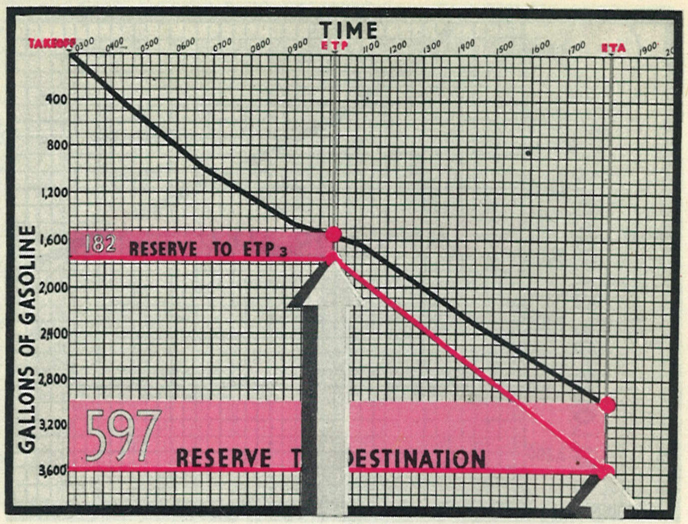
The next step is to locate the equi-time point. In this case its position will be based upon cruising on three engines. . . .



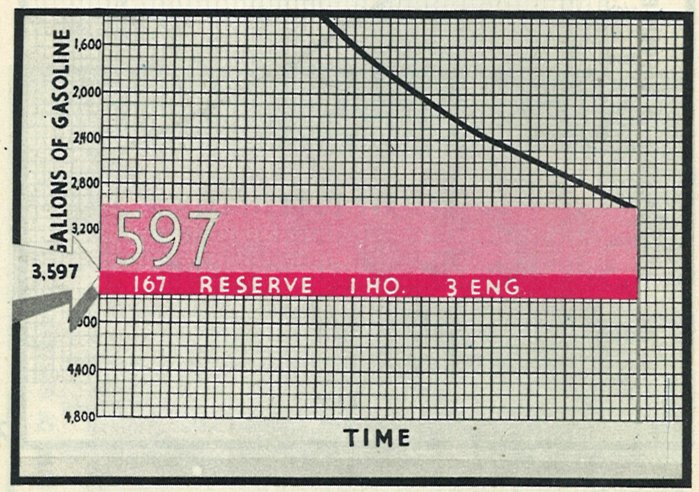


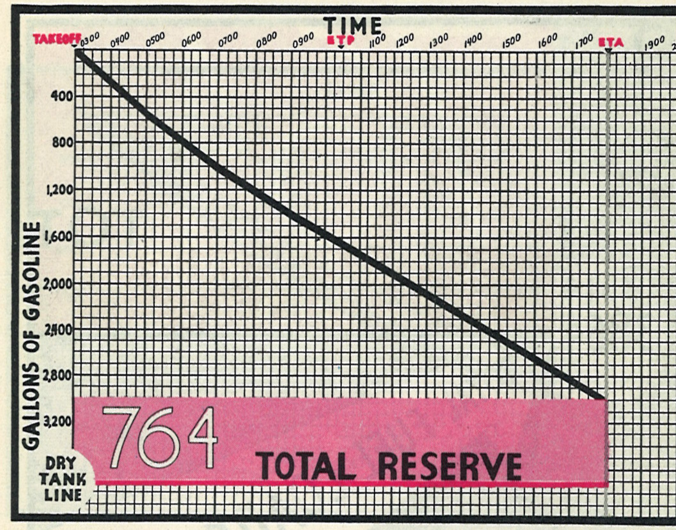
The reserve to the equi-time point—and the reserve to the destination are obtained from tables.



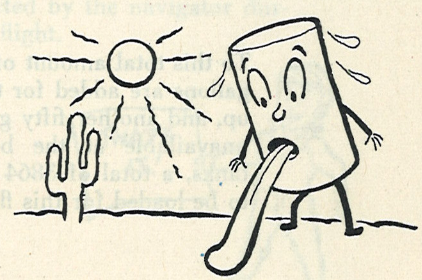


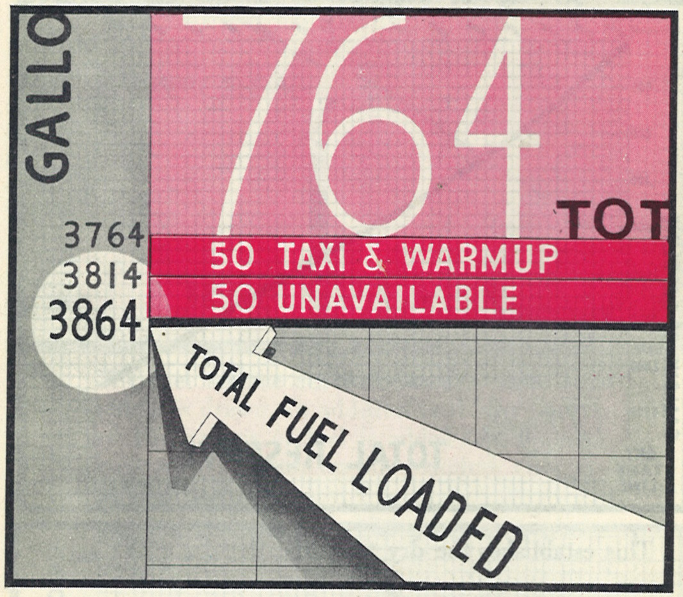
The fuel reserve curve connecting these two points is drawn. In addition to this, a reserve of 167 gallons of fuel is added to allow one hour of flying time on three engines after arrival at destination.



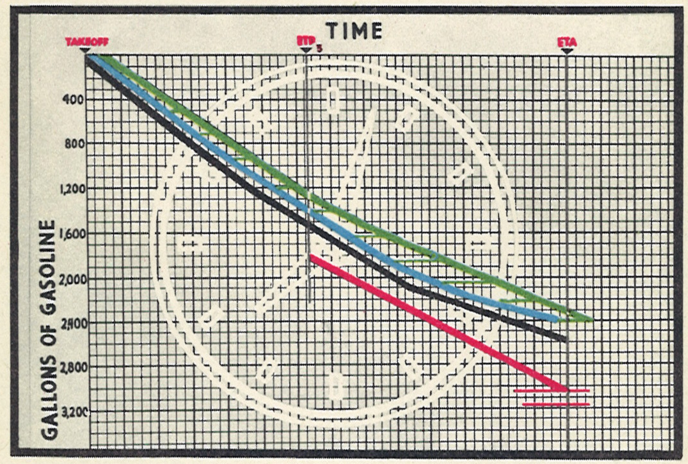


This establishes the dry tank line.

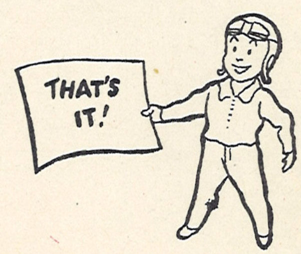




To this total amount of gasoline, fifty gallons are added for taxi and warm-up, and another fifty gallons which is unavailable at the bottoms of the tanks, a total of 3864 gallons of fuel to be loaded for this flight.



The two remaining curves are constructed by the navigator during the flight.



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