MARCH 1953

FLYING SAFETY

UNITED STATES AIR FORCE

TIME and PLACE

. . . see page 25

Minus Oxygen Equals X

Air Force Regulation 60-16 sets forth the rules for use of oxygen in flight. It is part of your duties, as pilot of the aircraft, to be familiar with the provisions of this regulation; and to enforce the regulation during periods of flight.

Don't stretch your luck. If in doubt, use oxygen. Before every flight, include the oxygen system as part of your regular preflight check. Be sure there are enough masks aboard, and that they are in working order. You never know when you, and your passengers, may need oxygen.

. . . Lack of Oxygen Makes Jack a Dull Boy

VOL. 9 NO. 3 MARCH 1953

FLYING SAFETY

Department of the Air Force The Inspector General USAF

Major General Victor E. Bertrandias,

Deputy Inspector General

☆

Brigadier General Richard J. O'Keefe, Director

Directorate of Flight Safety Research

Norton Air Force Base, California

☆

Lt. Col. John R. Dahlstrom

Supervisor of Flight Safety Publications

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If you've ever had an accident, your story is in these files. **See "This is Flying Safety," page 25.**

Now It Can Be Sold . . . Starting with this issue, the Government Printing Office has put FLYING SAFETY magazine on the open subscription list. Now you can have your own personal copy of FLYING SAFETY mailed to you each month for the reasonable price of $2.50 per year. Send your subscription to the Superintendent of Documents, Washington 25, D. C., enclosing check or money order. Add seventy-five cents for overseas mailings. Single copies may be obtained for twenty-five cents.

Flying the Thunderstorm (page 9) may be "old hat" to some of you more elderly hands, but we feel that this kind of information cannot be repeated too often for the younger set. The thunderstorm holds no terror for the pilot who is physically and mentally prepared to joust with it. *Tailor Made Weather* (page 14) gives you the Weather Service picture on specialized weather.

☆ ☆ ☆

Well Done— FLYING SAFETY's Well Done feature has become famous throughout the Air Force. The editors feel that only exceptionally outstanding feats of airmanship are worthy of comment, and standards are necessarily high. Keep your weather eye out for *outstanding* examples of airmanship, and send them to us, with the *complete* story of the action, plus photographs.

....TAKE THE HIGH ROAD

Call it minimal flight path, pressure flying, or going direct, it all boils down to knowing how to find the best winds aloft. A good tail wind is a joy to all flying men.

EVERY pilot dreams of a Never-Never land where the winds are always behind him, and the weather is always CAVU. Until the time when we reach that Promised Land, we have to make the best of what we have here below, and use our noggins to hunt those tail winds. To date, little if anything has been done about declaring a constant state of CAVU.

For many years pilots and metro boys have bitten the ends of pencils and scratched their balding domes to find the best way to fly from here to there, the fastest with the leastest fuel. What they were looking for was the shortest time flight path between two airports separated by wide expanses of air. Naturally, the ultimate was the maximum use of tailwinds.

Recently, the USAF, after researching this theory, came up with a formula which has proven highly successful from a practical standpoint. The formula, which is highly mathematical, and which uses Geostrophic winds, Bellamy drift, PLOP, and other mystical jargon, selects the route under variable wind conditions most conducive to the quickest flying time and the least amount of fuel. To those of you who understand the fuel flow of a jet engine, the importance of this planning is obvious.

The key to the minimal flight path theory is knowing the direction of the wind and its velocity; and that winds follow the isobars clockwise about a high pressure center, and counter clockwise about a Low. (In the Northern Hemisphere, that is, son.)

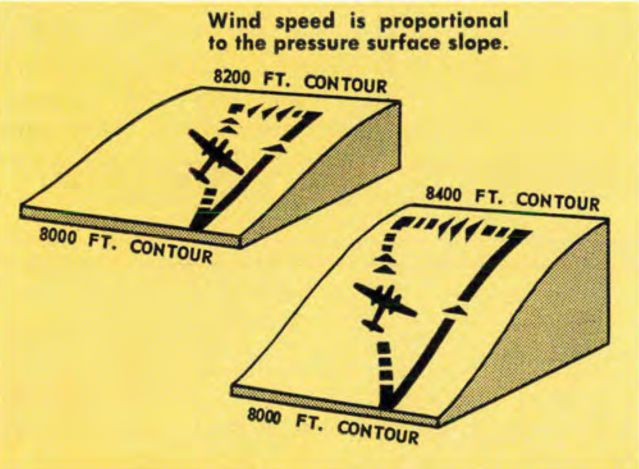
Of course, there are some limitations to the use of this system. Unless the winds are of rather high velocity, and non-uniform in strength, your great circle course will be better to use, as this in itself will be the minimal flight path. However, over on the Atlantic side, you have a different cup of tea. Here we have a great amount of metro activity, and you can really use the MFP (minimal flight path).

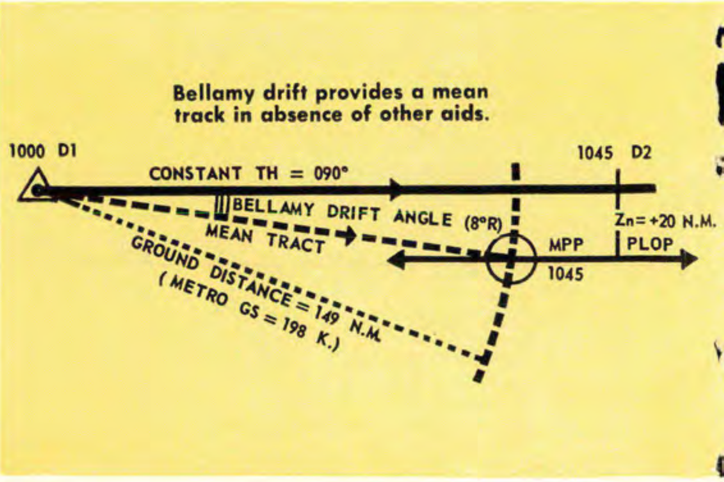
Let us suppose that we are planning a flight from Belfast to that haven of beautiful women, Newfoundland. The first thing we should do is to wrap a sheet of paper in a tube around the globe, and tangent (at right angles) to the great circle route between these two points. When we unfold this tube, and spread it out, we have what the cartographers term an "oblique-mercator" projection of the proposed route. Now the metro chap plots the great circle route on this map, locates the existing pressure canters, and plots these pressure patterns for any chosen flight altitude. When he finishes this plotting, he must consider two factors. Strangely enough these factors are crosswind and tailwind (metro men never call winds names like Maria).

The meteorologist then considers crosswind effect. Here the drift correction angle may be large, and may vary from right or left of the great circle flight path, yet the net drift may be small. If it was necessary to compensate only for drift by flying a single heading, fuel and time could be saved by eliminating the crabbing of an airplane. Crabbing to hold a great circle track would cut down the speed of the airplane considerably.

Now at this point, metro decides whether a single heading track will do the trick, or whether the single heading track must be corrected to compensate for tailwind.

It has been proven that the system is far more accurate than any other known method. If the meteorologist finds that the MFP cuts through some gloomy weather, he can prepare a new MFP from any point on the original track. Each major leg of the new track will be a separate minimal path.





To summarize, the minimal flight technique is based on the theory that the general wind circulation is determined by pressure distribution in the atmosphere. This pressure distribution is measured at strategically located weather stations, where weather flow charts may be prepared. With a calculated choice of flight routes to take maximum advantage of the wind-flow pattern, flight time is considerably reduced. In addition, fuel consumption is decreased, and aircraft and crew fatigue is reduced, points of utmost concern to maintenance people and flight surgeons. In addition, reduced requirements for fuel will enable aircraft to carry greater payloads over longer distances.

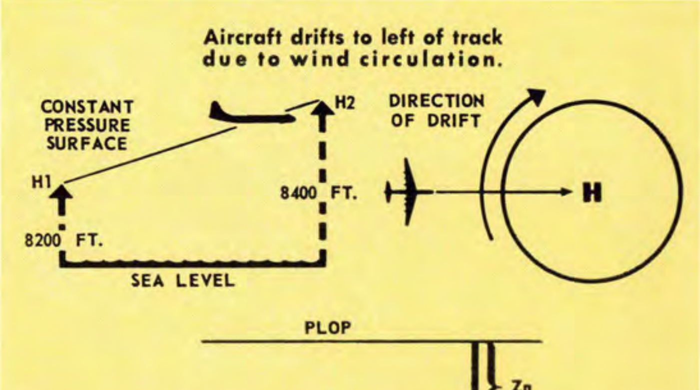
Actually, pressure flying is a simple technique that enables pilots to make the best possible use of winds aloft at various flight altitudes. One of the reasons that pressure pattern flying is simplified, is because pressure information is more easily obtained, and is more accurate than metro winds.

For discussion purposes, pressure-pattern flying falls into two categories; as an aid to dead reckoning, and as an aid to flight planning. By application of the pressure pattern formula to inflight use, the cross-wind effects can be utilized to calculate pressure lines of position (PLOP), and to determine drift over a past period of time. This last use, which is known as "Bellamy drift," is an excellent aid to navigation, as it gives you an extremely accurate reading on actual wind effect. In the flight-planning phase, the pressure pattern theory enables you to plan your flight so as to take the best tail-wind push. It also allows you to simplify your navigation problem by setting up a single heading flight, and to calculate the best path of your airplane from takeoff to destination in terms of minimum time in the air.

The basic principles behind pressure-pattern flying are dependent upon your familiarity with pressure lines of position, Bellamy drift, single heading flight, and the minimal flight path. In order to understand these factors, you must know a few things about the causes, effects and characteristics of the geostrophic wind, which is explained lucidly in AF Manual 51-43 (Air Navigation for Pilots).

The constant pressure charts show the various heights of pressure surfaces above sea level. The lines connecting the equal points of pressure form a contour line, every bit like the contour lines you studied in basic map reading. In fact they are called pressure contours, and they may be interpreted in the same manner.

On a ground map, wherever you see the contour lines close together, you will find a steep slope. Where you see lines of pressure close together, you will find steep slopes of pressure surfaces.

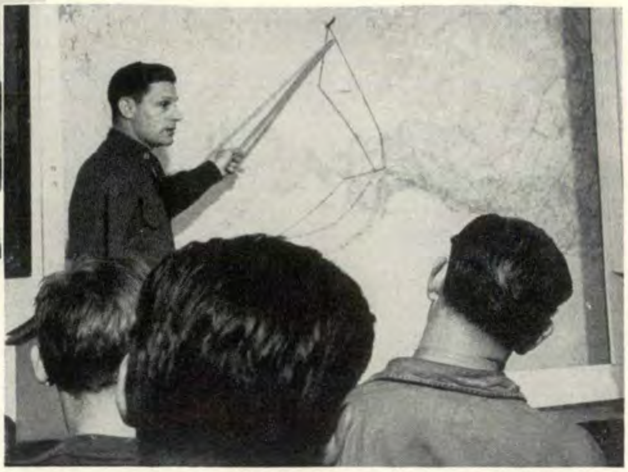


Pressure contours and isobars are essentially the same. These contours are isobars drawn on a constant pressure surface, and the *winds tend to blow along the contours* just like they blow along isobars. Also, the same rules for estimating the direction and speed of the wind from the examination of isobars hold true on the constant pressure chart.

The speed of the wind is proportional to the slope of the pressure surface, so where you see the contour lines close together, you'll find high winds.

One thing to keep in mind, is that there is no effective way of determining when the airplane is flying in the direction of the maximum slope, so windspeed cannot be determined. However, the drift effect can be determined. The drift effect is directly proportional to the slope flown. If you fly parallel to the contours, you do not get the tailwind effect, but you may experience either a head wind or cross wind effect. The cross wind is proportional to the slope flown in flight measured along the flight path of the airplane, but the entire wind effect is proportional to the slope measured perpendicular to the contours.

Knowing these things is part of your job as an aircrewman, as this kind of knowledge gives you confidence in yourself. And in closing, it shows you that Air Weather Service is an important part of the world-wide USAF team, and that they are pretty much on the ball when it comes down to brass tacks! ●



"Ptarmigan Flight" is just another way of saying over the North Pole. Each mission demands the kind of briefing being given here to old Alaska hands of the 58th Strat. Rec. Sq. (Weather).

.....over WASTE

Weather Recon Makes Flying Safety Pay Off by Emphasizing Crew Training and Aircraft Preparation.

At 31,000 feet, this is how the top of a hurricane appears.

THE shining silver WB-29 taxiis slowly into a circle of floodlights, the propellers four silver disks of revolving light. The airplane creeps to its parking spot, and comes to a full stop with a slight squeal of brakes. The engines growl deeply for a few seconds, cough once or twice, and then are still. The silence of the night is broken by the slam of the air pistons dropping the twin bomb-bay doors, and one by one the flight-weary crew of weathermen drop from the belly of the big bird.

This can be Eielson AFB on the edge of the Arctic Circle, it can be Kindley AFB in the Bermuda tropics, it can be Yokota in Japan . . . it can be California. Day after day the crews of the strategic reconnaissance squadrons ply their way across waste and water . . . 2600 . . . 2800 . . . 3000 nautical miles . . . 12 . . . 14 . . . 16 hours in the air! These recon squadrons are covering the world, plotting weather from the North Pole to the Equator to gather, log and in-

From takeoff until the WB-29 touches down hours later two navigators, like Capt. John H. Frank (left above), gather important wind information for the weatherman.

and WATER

By Maj. R. L. Crozier, USAF, Chief Aircraft Engineering Div. Hqs., Air Weather Service

terpret weather information for the USAF, so that you as an aircrewman will have at your fingertips the best weather information of any flying outfit in the world.

Recon Squadrons

At Eielson AFB the 58th Strat Recon flies the Ptarmigan run up into the lonely wastes of the North Pole, and the Loon Echo track over the Bering Sea to Shemya. Leagues of icy blue water lie below . . . little in the way of navigational aids and rescue facilities at any time. Spread throughout the world are other strategic reconnaissance squadrons, each doing its lonely bone-tiring job day after day. Down at Kindley AFB, Bermuda, the 53rd Strat Recon flies the Gull Item and the Gull Hotel tracks. In the winter months it's the Gull Item track to the north; from July to November, they fly the Gull Hotel track to the south, the hurricane track, where storms are followed and pinpointed for your safety.

Out on Guam, consorting with the gooneys, is the 54th Strat Recon, flying Vulture Metro and Vulture Lima. These are the typhoon hunters tracking the big winds to the north and to the south. Stateside, at McClellan AFB in California, the 55th Strat Recon flies the Lark Golf and Lark Foxtrot tracks out into the lonely stretches of the Pacific; while at Yokota AFB in Japan, the 56th Strat Recon flies the Buzzard Delta towards the Arctic and the Buzzard King, tracking to the West over Korea. Down near the beach at Waikiki, the 57th Strat Recon out of Hickam flies the Petrel Coca and Petrel Delta tracks to the north and to the northwest.

Because each recon flight is over water or barren wasteland, the subject of flying safety is of primary importance to the supervisors and to the crews who actually fly the runs. By the very nature of the mission each strat recon flight takes a lot out of the airplane and its crew.

In the first place, each normal mission averages 2700 nautical miles and lasts from 12 to 16 hours. The outbound track is usually flown at 1500 feet altitude, with a return at 18,500 feet. Add to this typhoon and hurricane penetrations at 10,000 feet with descents made to 1500 feet inside the disturbances and it is evident that flying safety is a must.

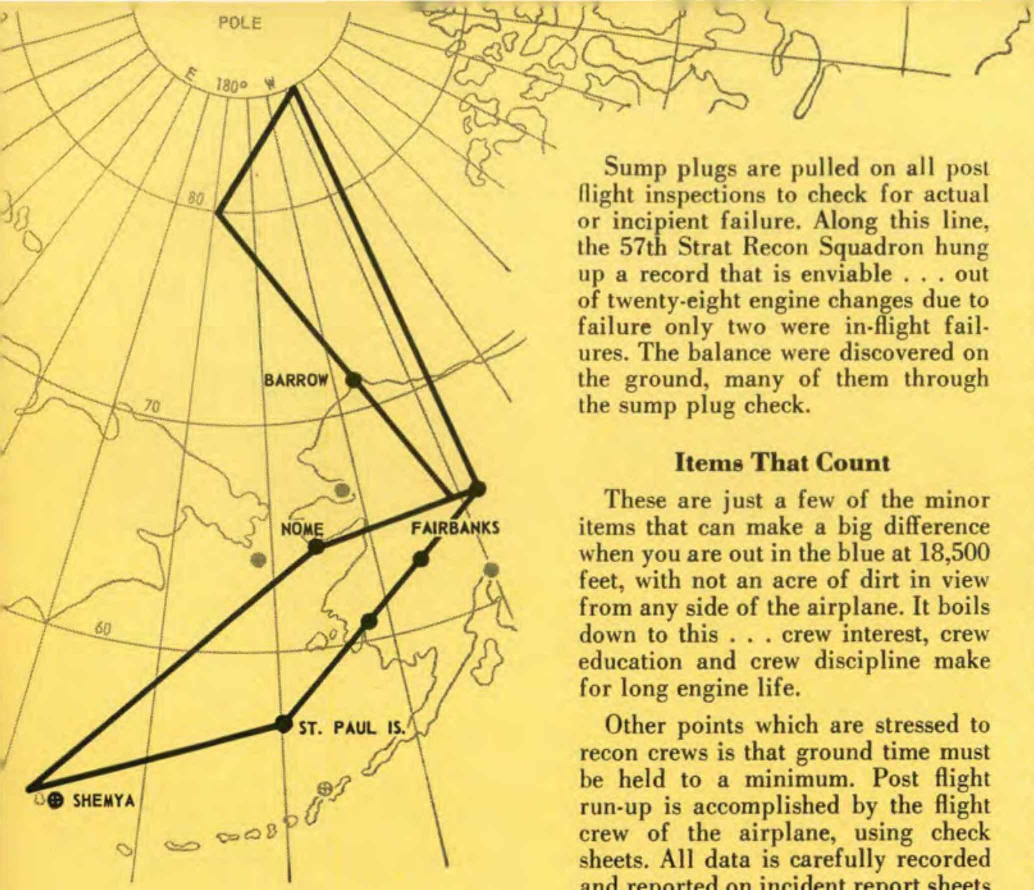
In 1951, Air Weather Service estimated that the government was saved about $1,900,000 on engine life, with an added $750,000 in 1952. These savings were realized through exacting engine conditioning procedures, operational procedures improvement and complete coordination between flight and ground crews.

The average service life of AWS R-3350 engines between overhaul for 1952 was 448 hours, with 31 per cent of the engines used operating for the full allowable time of 600 hours. As a result of this, the AWS has received from Air Materiel Command permission to operate their WB-29 engines 700 hours between overhauls using only 25 PSI as the minimum compression value required. Air Weather Service proved to AMC that its superior engine maintenance and operational procedures would stand the test between changes . . . and it has paid off to the tune of many dollars a year savings to the taxpayers. This in itself is a worthwhile story in the overall saga of strat recon operations.

Maintenance Record

There is nothing hush-hush or "superman" about this outstanding maintenance record. The secret is just common sense adherence to tech orders plus rigid crew discipline . . . any outfit can do the same if they follow the rules to the letter . . . and impress it on all crew members, air and ground, that treating those engines with fatherly care pays off in the long run, in terms of flying safety.

In the first place, AMC standards



receive most careful adherence in all phases. One item of interest to all engineers is the fact that oil is changed every 100 hours, using an oil dilution and flush-out procedure during change. One of the big sources of engine failures on the B-29, that of main bearing failure, was greatly reduced by this procedure. Another bug that was licked by the strat recon engineering people was the failure of exhaust valves. This was done through pilot education and changes in operating procedures. Recon crews now use auto-rich mixture above 2100 RPM. In addition to licking that exhaust valve problem, it has been proven that fuel consumption is not increased.

Other maintenance methods that have resulted in longer engine life on the strat recon airplanes include continued emphasis on the point that the use of dial indicators is mandatory for valve checks, and that spark plugs must be carefully installed. This last item seems to be the source of much trouble in B-29 engines. The recon people insist that each plug be bomb-tested and gap-checked prior to installation, that each plug bushing be cleaned so the plug can bottom properly, and that each plug be torqued correctly.

Sump plugs are pulled on all post flight inspections to check for actual or incipient failure. Along this line, the 57th Strat Recon Squadron hung up a record that is enviable . . . out of twenty-eight engine changes due to failure only two were in-flight failures. The balance were discovered on the ground, many of them through the sump plug check.

Items That Count

These are just a few of the minor items that can make a big difference when you are out in the blue at 18,500 feet, with not an acre of dirt in view from any side of the airplane. It boils down to this . . . crew interest, crew education and crew discipline make for long engine life.

Other points which are stressed to recon crews is that ground time must be held to a minimum. Post flight run-up is accomplished by the flight crew of the airplane, using check sheets. All data is carefully recorded and reported on incident report sheets to augment Form I write-ups. This precludes additional ground checks by the ground crews. Pilots do not make full-power ground checks except when an instrument takeoff is called for and then at the discretion of the aircraft commander. Normally the full-power check is obtained during the first third of the takeoff run. Preplanning is stressed. One engine-time-saver is the procedure of requesting the ATC clearance prior to starting the engines and making the preflight check.

Operating temperatures are held to a minimum not only on the ground but also in flight. When the airplane is being run up on the ground, air and ground crews are trained always to head the ship into the wind. Runup time is held to an absolute minimum. Auto-rich is always used above 2100 RPM, with climb-out at higher than usual airspeeds (200-205 mph).

Another factor that has played a big part in the efficient and safe operations of strategic reconnaissance is gross weight reduction. There is no dead weight aboard a strat recon airplane. Minimum gross load and safety factors are carefully computed. They don't burn fuel to carry fuel. Loads are streamlined to approximately 117,000 gross. Bomb racks are removed, as are bomb-bay tanks and other non-essentials. A survey pointed towards further weight reduction is presently under way that will result in an estimated additional reduction of 1500 pounds of gross weight.

Crew training is stressed, with all crew members being taught to accept responsibility for safety in flight. Briefings are complete and detailed, and take place the day before the mission. Before the actual takeoff, the aircraft commander again briefs the crews. Instrument proficiency is stressed as are emergency procedures and ditching. Each crew member carries a small plastic-encased card which spells out his part in the event that ditching, bailout or crash landing becomes necessary. He is always well-briefed and well-trained, but in case of a minor panic, he has the proper procedures in his breast pocket.

Ditching drill is held at least once each month by the entire crew. This is extremely important because, as we have pointed out, every strat recon mission is over the worst terrain in the world . . . either blue water or barren wasteland, where rescue would take hours, sometimes even days.

Along the survival line, much clear thinking has been done on keeping survival equipment to a usable minimum. Here again, weight is the deciding factor. It was found that the Arctic recon airplane went out with as much as 2000 pounds of survival equipment aboard . . . some of it so bulky that the crew had trouble crawling around over it. By screening the actual usability of the equipment on board, this weight was reduced to about one-half. Everything was cut to the bone, including rations, which were reduced one-half.

Flight Safety Stressed

Because of the nature of the strat recon mission, because of the importance of the mission, and because there can be no compromise with efficiency, flying safety is constantly stressed among crew members, through crew training in every facet of operation. Strategic reconnaissance squadrons fly an equivalent of many trips to the moon. Let's look at just one of the many recon units . . . the 56th Strat Recon Squadron out of Japan. In 1952 this outfit logged better than 12,000 hours over the Pacific, flying in all kinds of weather and under every known condition. At the cruising speed of a B-29, this means about five trips to the moon and return . . . a lot of miles any way you look at it. ●

THE UPPER AIR CHALLENGE

A MINIATURE weather station, dangling from a parachute as it floats earthward, affords Air Weather Service a new method of exploring the upper atmospheric regions over remote areas of the earth.

Known as the dropsonde, this instrument is parachuted from high altitudes and explores the upper air regions as its source for weather data.

Until the introduction of aerial weather reconnaissance and the employment of the dropsonde for exploring the upper atmosphere, the military forecaster was limited to weather information obtained by ground observation stations.

Until several years ago, meteorological data was obtained primarily by use of the mercurial barometer, the wet and dry bulb thermometers, the recording anemometer and wind vane. For upper winds, a hydrogen-filled balloon was followed in its flight with an instrument resembling a surveyor's transit.

The balloon method of determining upper air winds was followed by new methods recently developed for recording upper air observations. These new techniques include the use of the "Radiosonde" and "Dropsonde."

Radiosonde is a device involving small pressure, temperature and humidity measuring instruments which are carried aloft from the ground by a free balloon with a radio transmitter attached to relay information to a ground receiver.

The balloon borne radiosonde is used by ground weather stations while the dropsonde is employed by reconnaissance aircraft operating over long range "weather tracks." The dropsonde is designed to be launched from an aircraft to obtain the atmospheric pressure in millibars, the temperature in degrees Centigrade, and the percentage of the relative humidity of the mass of air through which it falls.

Today, in certain areas of the world where weather data is not readily available from other sources, weather reconnaissance aircraft are operated by the Air Weather Service to observe and report surface and upper air weather conditions by flying a fixed track and making weather reports at predetermined positions. In effect, a series of weather stations are originated at each of the fixed positions along the weather track where observations are recorded.

The 56th Strategic Reconnaissance squadron is one of the six recon squadrons which fly these "weather tracks" in search of elusive upper air data. Operating WB-29's flying weather laboratories, the 56th flys over thousands of miles of the Western Pacific in search of upper air data.

Each weather track is about 2600 miles in length, and consists of approximately 26 fixed weather reporting positions. Normally four dropsondes are released at predetermined positions along the fixed track and the data transmitted is transcribed and recorded by the dropsonde operator.

As the dropsonde descends to the surface, it actually is examining a column of air from the altitude of the drop to sea level. In the case of drops made by the 56th, this is usually from 18,000 feet.

As the dropsonde floats to the earth, meteorological data is recorded by three weather measuring devices:

- a twin aneroid cell to measure pressure,
- a bi-metallic temperature element which expands and contracts with changes in temperature, and,
- a human hair hygrometer to determine relative humidity.

A continuous record of data is relayed to a radio listening post in the aircraft by a self-contained transmitter in the dropsonde which sends coded messages designating the readings of the three weather recording devices. As each condition of weather changes a different series of coded signals are transmitted.

The series of coded signals are imprinted on a plastic disk. A record arm which rides on the disk changes its position on the disk in response to changing weather conditions and emits a series of signals. A separate record arm and a separate series of signals are used for each of the three weather elements. As the disk rotates the three record arms, positioned by their response to the weather data, send out the signals, a triple coded series, to inform the listener of the desired weather information. The dropsonde transmits approximately 12 code groups per minute while descending at a rate of approximately 1100 feet per minute.

The instrument is factory checked for accuracy and checked again before each flight by the dropsonde operator. The dropsonde is launched from an airlock chamber in the reconnaissance plane. It is equipped with a static line parachute opening device which "pulls the ripcord" to open the chute.

The coded data received by the dropsonde operator is recorded, and when the drop is over, the information obtained is decoded against a master calibration chart. Data thus obtained is plotted on an adiabatic chart, recorded into usable data which is verified by the aerial forecaster in order to check the validity of the information before it is transmitted over weather communications circuits.

With newer methods being made available, the upper atmosphere is becoming less and less of a mystery to the meteorologist. While the challenge offered by the upper air has not yet been conquered, instruments like the dropsonde offer a method, which in the future, may make meteorological data from the upper air more readily available to the weather forecaster. ●

When you

By Major H. A. Jacobs,
Weather Recon. Division
Headquarters Air Weather Service

THE sage advice, "Avoid thunderstorms at all costs" is not very helpful to the pilot who inadvertently gets involved in a large, dark type thunderstorm. When the intrepid aeronaut encounters a storm, he should know the rules and the reasons behind the rules. Advice on flying thunderstorms is "old hat," but the subject is important enough to repeat it again for the new pilots who have yet to encounter this phenomenon of Nature, and for the older types who may have forgotten the rules.

When planning flight through storm areas, keep in mind the "*Three A's*":

- What *A*ltitude?
- What *A*irspeed?
- What *A*ttitude?

These are the three factors at the head of the list, though everything is important when flying under such severe conditions. There are also pertinent questions, like:

- What is the alignment of storm and terrain?
- What to avoid, besides bumps?
- Choice of course and what to do next?

Altitude

Lower level altitudes are slightly less turbulent and are chosen whenever terrain permits. Ocean practice has been to fly underneath, which doesn't mean right on the deck. (Visibility isn't good enough.)

You can expect instrument time anyhow in the scud beneath the main base or in the precipitation where you have only vertical visibility. Also, you will be on instruments, if caught in a strong updraft, for you will be carried up into the cloud. As a rule 2000 feet above the surface is taken as the minimum clearance altitude on account of the downdrafts to be expected.

It's the higher altitudes that give the higher turbulence. Your anatomy may report it's rough at all levels but it is shown statistically that the altitudes around 15,000 feet have, on the average, greater turbulence and bigger up-drafts. The higher altitudes have other disadvantages too, around the freezing level precipitation static gets worse and the probability of a lightning strike is greater. Likewise, heavier hail is to be expected and wing icing would be a maximum at wing temperatures just below freezing.

Choice of Airspeed

Next on the list, *Airspeed, Indicated*. Recommended airspeed is between cruise and stall with a margin of 30 to 40 mph above the stalling speed for the altitude flown. There are several good reasons for this. As you know, gusts impose greater loads at higher speeds. A glance at an accelerometer will show why you don't want to hit a big bump at placard, or red line speed. The engineers com-

fly into a thunderstorm . . . . .

puted that red line speed as the point where structure begins to show signs of failure upon encountering the severest bump likely, according to data available to them.

The speed limit is chosen to avoid stall problems, also. The rule, maintain 40 mph over normal stall speed, is no guess, as consideration of the cloud and gust structure will later show. Also present is a possibility of a high speed stall, which leads to the most severe loading condition. Since such stalls would occur sooner in turns, the rule is, maneuvering in turbulence should not be abrupt.

There is a very practical reason, too, why a certain range of airspeed is specified. In turbulent air, the airspeed needle flickers rapidly through a range directly proportional to the gustiness. When you have to fly by an average reading of the vibrating needle, you don't want to crowd the limits of the desirable speed. Some charts have been published showing these limits for a variety of large ships. They are useful to get the idea, but it is more important to know what the actual stalling speed and the red line are for your own ship, load and altitude.

What Is Your Attitude?

You are not flying rough air very long before the *Attitude* problem comes up. For longitudinal attitude, watch the behavior of an autopilot and you'll see why. Pick up an updraft and it will put the nose down and the airspeed goes up; change to a downdraft and the nose comes up and the speed falls off. Since the standard model of autopilot is a constant attitude device it is acting as it was designed to, but since the drafts usually alternate, your ride is like that on a roller coaster. Since the mechanism doesn't know anything about airspeed limits, you don't use it.

What attitude should you take? Old pilots think it is a good plan to ride with the storm, changing altitude slowly with the elevator to offset the effects of the drafts, using the throttle at the same time to maintain airspeed. No extreme action is wanted in either of these controls.

The attitude then should be such as to counter the effect of the airspeed and here you depart momentarily from SOP, that is, you let the altitude take care of itself. The airspeed changes due to attitude can be anticipated from the artificial horizon. The rate of climb indicator is definitely ignored and the sensitive altimeter becomes the rate of climb indicator in strong drafts. The maximum rates recorded on a recent project were 6,000 feet per minute. Extreme as these have proven to be, we'll bet you have heard someone tell of bigger ones.

However, it is not a question of ignoring the deviations from assigned altitude; it's a case of pilot judgment in flying the airplane safely during these displacements forced by nature. The average change in altitude in crossing a storm tends to even out as shown in thousands of traverses on the same project where net change would be but a few hundred feet. When an exceptional displacement was experienced it meant circling in the clear to return to the scheduled altitude. This gives a controlled sawtooth flight path which is desired rather than a roller coaster ride.

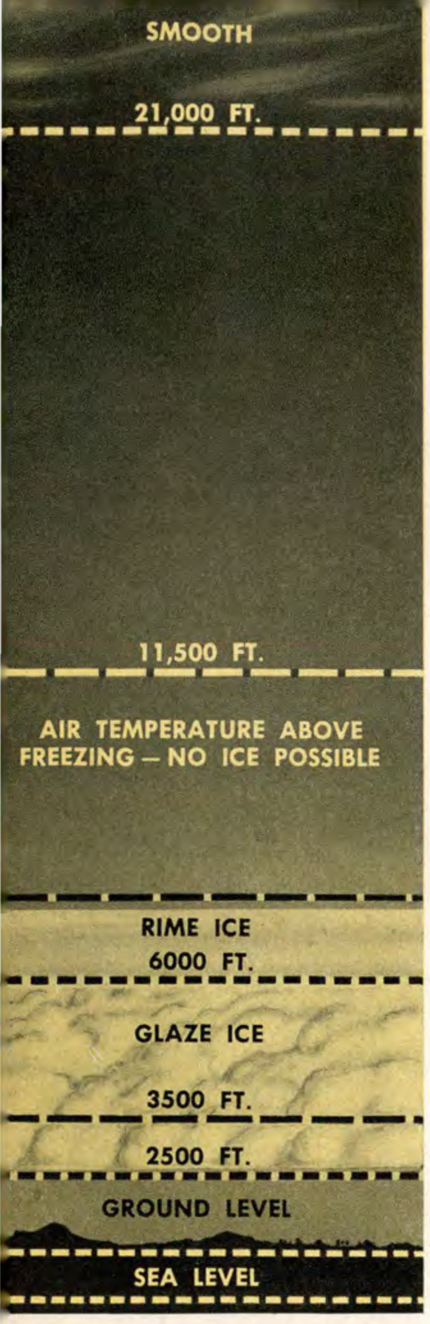
The figures on typical storm measurements indicate drafts of roughly half a mile across as about the maximum. You can figure out from your own airspeed how much change in altitude you are going to get if you hit such a maximum as just mentioned above. More is to be said about this later, but it is obvious that you don't have to worry about being blown out the top. Careless handling, tumbled gyros, vertigo and rumor can account for the tall tales you may have heard about what drafts can do.

There is more concern about being carried out of the bottom of the storm, which occasionally can happen. This is where the terrain counts. Naturally, the altimeter should be set to the minimum pressure reported en route. Altimeter changes caused by pressure changes in the storm itself can amount to a few hundred feet. It is well worth noting that this is but a tenth the altitude error resulting from wind action crossing mountain ranges.

One thing disconcerting about longitudinal attitude when you first encounter a maximum updraft is the startling readings of the instruments. Moving pictures of the panel verify the fact that the altimeter shows a rate of climb of several thousand feet at the same time that the nose is down and the airspeed is increasing. Just then it may not be natural to control so as to bring the nose up and ease off on the speed. That's the thing to do, though, so that you won't slam into a high speed stall if you should run into a nose gust on the way out. Such an experience is rare; more people have reported a strong downdraft that they could not outclimb. Too low an airspeed is not good in such a climbing attitude since a tail gust gives you a stall that drops the bottom out of things. This is where the minimum of 2000 feet above terrain is useful, plus a horizontal maneuvering distance sufficient to clear obstacles.

Next, discussion about *lateral attitude* is just as provocative. Level heads and level wings seem to be the rule. Whether or not you "pick up a wing" immediately is unimportant. It is important, however, not to go into a high rate turn as the wing goes down. Shallow turns are wanted in rough air skidding around if necessary. Fifteen degrees is considered a

Major Jacobs is a former MATS pilot, with actual thunderstorm flying experience on the Atlantic, Asia, European and Africa-Middle East runs. The Major knows whereof he speaks, and contends that a pilot who has the necessary preparation plus a sound psychological outlook can weather the most mature thunderstorm . . . unless he can avoid it!



Cross section of a weather situation where soundings have found icing levels.

good bank in turns. The reason is that steep turns invite trouble as the greater wing loading and turbulence increase the stalling speed.

The glider pilots are the ones to ask about the spiral dives which occur at this stage. Their technique of getting out of a thermal in an emergency is to spin down completely stalled. A sink of 20 feet per second is achieved without a high forward speed. Some spectacular losses of altitude are reported when this sink is added to the downdraft velocity. This is brought about because the right spiral of 200 feet or less in diameter kept the glider in the downdraft for over a minute at a time.

There is another meaning of the word "attitude" that you have heard of before. How about your *psychological attitude?* It will certainly be better if you know what to expect and why, but it isn't going to make up for lack of equipment. Maybe you have flown instruments with a primary group, but did you every try it in rough air? A directional gyro is essential and an artificial horizon is desirable. Similarly the question: *Have you got enough power?*

This can be best answered by knowing the performance of your own plane and comparing the records of similar airplanes, under storm conditions.

To review, for a moment, the processes behind the choices being made:

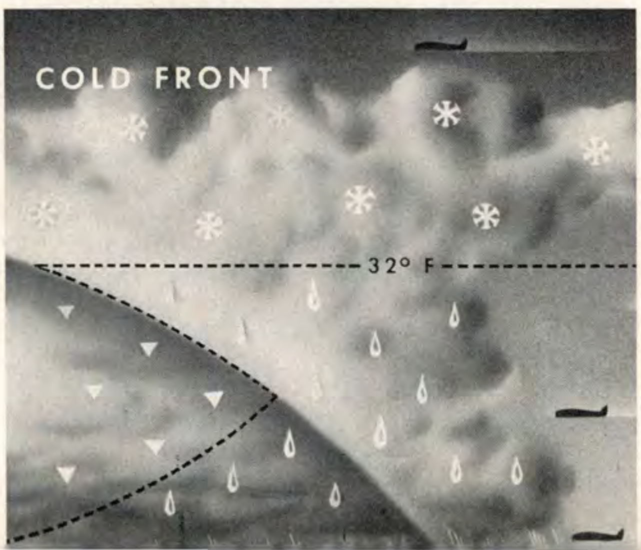
A pilot would like to avoid the worst part of the storm. If he had a radar he could scan the surrounding turbulent clouds and take a course to avoid the big fat echo he calls the core. In fact, measurements show that if he can stay over three miles from such echoes, he will not experience thunderstorm conditions even though he still is on instruments. That is, the big echo in clouds comes from the precipitation area and the findings show the most activity goes with the heaviest precipitation. It is not accidental that the precipitation goes along with the strongest drafts since the vertical cloud is built upon the energy coming out of the condensation process.

When you see a thunderstorm in the mature period of development, it is a fully developed cumulonimbus, complete with anvil top and squall line at the surface. The turbulence therein will be but little different from the initial stage from which it grew in about 20 minutes. In fact, as long as unstable conditions remain, some parts of the cloud will continually be in the most active building stage, usually on the leading edge.

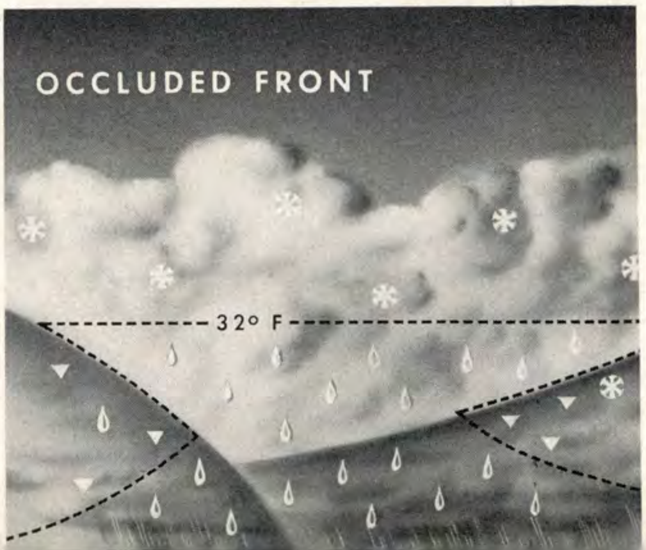
Only when there is no more warm moist air being fed into such a thunderstorm does it reach a dying stage. By that time, the cloud may look about the same but the traverse encounters mostly downdrafts and turbulence on a reduced scale. Actually, if you could follow the entire life cycle of a storm visually you would pick this last stage as the time to fly through it with the least trouble.

When conditions are right, the instability is "triggered" — the forecaster says—and the cumulus boils over, as it were. The pilot can sense this if he sees the turbulent cloud while approaching in the clear. This building stage of updrafts is already very rough and it takes the part of the cloud but a few minutes to pass to mature stage with both up and down-

Higher altitudes can mean more turbulence. Keep storm penetration low.



A good rule of thumb to observe in thunderstorm flying is avoid dark areas.



drafts with various forms of precipitation present. Meanwhile new cells are growing, some of them created by downdrafts of the same storm. Only when the supply of moist air is cut off will the storm start dying out. From then on the turbulence decreases although strong downdrafts will continue in the cumulus of precipitation.

Avoid Dark Areas

Whenever a storm whose immediate history is unknown is encountered in flight, the pilot has to be the final judge. If he has just a close-up view to go on, the rule is *Avoid Dark Areas*. These are the regions of densest clouds and probably heaviest precipitation, though all clouds look dark if shielded from light. Some dark recesses may be just shadowed by the main cloud and its overhanging clouds; some pilots profess to tell the main cloud by a slight difference in the color. Glider pilots in circling under a cumulus looking for lift report a difference in color, also. They find the maximum updraft leads to the blackest part of the base when no precipitation is yet present. Light plane pilots who do not wish to go on instruments can keep this in mind.

At night, the rule is to avoid the areas of heaviest lightning. In particular vertical lightning and cloud to ground lightning are the tip-off that strong vertical currents and precipitation process are present. They are the mechanism for producing the discharges. Research points to the formation of ice as a hitherto unknown mechanism for developing the charge. This refers to the ice-water phase of precipitation. Actually on the aircraft, wing icing is not so commonly encountered, apparently because so much water is present that the slush ice is washed off during short traverses. But throughout cloud flight carburetor ice has to be expected, of course. The fact that a hail stage is going on in cumulonimbus clouds more commonly than reported at the ground is indicated by the fact that the soft slush just mentioned is frequently found to contain small pellets of hail. We are just lucky that the final hard hail stage is not as common but the hazard is always present in a thunderstorm.

Wherever you fly, cloud to cloud lightning is to be expected. It is nice to know that this is considered mainly psychologically upsetting, in case it bothers you. It is from a physiological standpoint that another rule is handed down. When you go through a thunderstorm, turn up all the cockpit lights. The reason is that if lightning strikes close to your windshield (it has an affinity for props and pitot heads) the flash will not blind you momentarily as it would otherwise. Dark glasses can be worn instead, and are particularly useful at low altitudes where windshield reflections and ground lights are confusing. The object is to be able to stay on instruments.

Lightning is useful in one respect, at least. It produces static crashes heard on all except UHF radios; if these increase in noise and frequency, the nearness to the storm source is evident. Nature provides another sort of warning that can be seen as well as heard. Continued rapid-fire cloud to ground lightning strikes have been observed to accompany tornado development.

What is useful about *alignment of storm and terrain?* Well, to start with you have a single symmetrical thunderstorm, five to ten miles in diameter, like a typical overgrown cumulus. This is no problem. You can fly around it — circumnavigate is the word if you don't want a position report to read like you were going around in circles. Even then you would want to know which direction it was moving; as it would likely be softer on the rearside.

Actually the winds at the surface can blow out of the storm in all directions so they do not fix the direction the storm is moving. The winds aloft, if they are strong enough, will govern the direction of motion. The slope of the cloud and the character of the streamer out of the cloud point the direction of motion if they can be observed. Shelves of cloud often build out of the storm in several directions to obscure the view, however.

Even isolated storms have a tendency to become elliptical in shape. This is probably from the continued development of new cells as seen on the radar screen where these rain echoes often appear as blots that become elongated as the cells line up. As mentioned later, due to the movement of the air mass in one direction with the wind, there is a preferential system of cloud formation that leads to the arrangement of storms in a line. These so-called squall lines may be ten or a hundred miles long. The terrain plays an important part in the alignment that such storms take. This can be observed by the pilot when he becomes familiar with the topography and interprets it to his personal advantage.

Another factor influencing the development of such squall lines will hardly be obvious to the pilot. This is the convergence of the air which

The smart pilot will stay clear of this typical line squall. As always in this cloud formation it comes equipped with the usual hazards of heavy turbulence, severe rain and continual lightning flashes.

Over the wing of this AWS weather recon plane is a big build-up of cumulonimbus heralding some rough flying weather to come. Weather Control will plot and track the storm from reports sent back by the recon flight.

can only be determined from a study of the weather map. An airline uses this as one factor in computing the turbulence to be expected.

The point is that such elongated storms should logically be flown crosswise. This is the same technique as applied to crossing a front, which is often just more such clouds and lines on a larger scale. It pays to know the alignment of the weather, if for no other reason than if you deviate from course to avoid storms, it is not a random operation. Some clues to the alignment are given by the weather map and more by observation and knowledge of the effect of the local terrain. Hills and valleys, islands and streams are some of the features giving the so-called orographical effects.

Although not always noted on weather maps, a shore line can be a boundary marking a difference in up and down motions so that cloud boundaries often parallel coastlines. A storm moving off-shore may lose its lift rapidly, and a different air mass moving on shore may start its vertical development there. This reversal depends on whether the air mass at the edge of the Gulf stream are a classical example of such a pattern of instability. Obviously, flight planning should take advantage of such natural boundaries.

Turbulence

Another word about terrain applies to mountain regions. Glider pilots have long used upslope winds for soaring on the windward side of mountains and have learned to cross quickly the downdrafts on the lee side. So have mountain pilots. Unstable air develops the same pattern of vertical current distribution which is easiest to see in the standing wave clouds that form on various scales behind mountain barriers. Not recognizing this, it is going to be very discouraging to try to outclimb a downdraft of some thousand-feet-per-minute on the downstream side of a range. The axis of the draft will parallel the range and may continue for the length of the hills while being rather narrow crosswise. Its nearness to the peaks varies with conditions of stability, wind velocity, and elevation. The climb on the lee side has to be made in wide valleys where there is sufficient turning radius to sound out the drafts.

Updraft regions may be found on either side of the range and used to advantage. Pilots in western states find the air is often unstable and more turbulent over mountains than in the valleys where it is smoother because of less mechanical mixing. This can be anticipated from reports on the stability, the clouds and wind velocity aloft. The requirements for flying underneath in the mountains are enough ceiling, enough power and a knowledge of the terrain.

When on instruments and the weather gets rough, a good question to ask is "which direction is crosswise and which is lengthwise, in a storm"? The standard recommendation is to continue on the same course, otherwise milling around increases your turbulence time. However, when flying through this type of weather, if it has been really rough for as long as 20 minutes, one is justified in changing course 90 degrees for several minutes and then trying the original course again.

Some pilots have evolved a probing technique as a result of careful observation and experience than it seems at first glance. They fly into the most promising (?) part of the storm after carefully picking their altitude, then if the turbulence gets particularly severe or if they encounter hail or extreme precipitation, the course is changed 120 degrees and held for two minutes, then the original course is resumed. The intention

With radar installation like this, the USAF measures storm heights and obtains wheather data.

is to avoid the core of the storm, and the assumption is that encountering such severe activity indicates the center of the storm is directly ahead.

The way they turn is influenced by the looks of things at that point. If they guess right they will miss the center because as the measurements of cell size indicate, such a maneuver will go around one development. If there is no good evidence on which way to turn, there is no assurance that they will not turn in to a core instead of away from it. Similarly, since there are many cells in various stages of development other active spots may be encountered. However, such changes in course are practical whenever hail is encountered, but note that a 180-degree turn is not necessarily the best course at that particular time.

A word about turbulence. One can see from the typical cloud motions shown by the arrows in the cloud drawings that horizontal winds will be encountered. They have been referred to as nose gusts and tail gusts. You have felt them on the ground and know their strength. These horizontal motions are but part of the large scale eddies present within clouds, building up to velocities of say 30 MPH. When these varying velocities are encountered in a cloud traverse, the result is a rapidly changing lift on the wings that gives the turbulence its feel. The airspeed indicator tries to record the changes as shown by the resulting vibrating needle. However, it is the prolonged changes in the airspeed when a tailwind is encountered, that drops out the bottom.

The vertical motions started by the instability of the air due to condensation and evaporation processes start the turbulence of course. Drafts are the further development of the instability which can reach velocities of 100 feet per second.

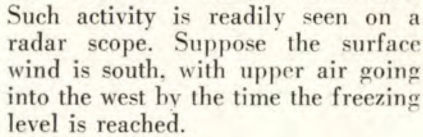
The pilots are often in an unique position to see these and their reports to the weather office furnish valuable information for analyzing the behavior for forecast use. Take a typical case from the weather map. It will be found that the thunderstorms will often develop in a line removed from any surface front. Some part of this alignment and its motion are due to the dynamics of the thunderstorm itself.

Consider Squall

Consider the squall generating capacities of the thunderstorm. We know that thunderstorms move with the average winds in the moist layer. This wind aloft could change more than 30 degrees clockwise in direction from the surface wind in the warm air masses in which we have most of our thunderstorms. As mentioned, these original storms die out as they proceed. New developments form most readily on the small surface front coming out of the storm. This will usually be to the right of the old storms in the northern hemisphere. This gives rise to a translation of the line of thunderstorm activity to the right of the motion of the individual storms themselves. Such activity is readily seen on a radar scope. Suppose the surface wind is south, with upper air going into the west by the time the freezing level is reached.

Storm Movements

The storms individually move to the east, often in a regular southwest northeast line. But these storm areas rain themselves out, as it were, and dissipate while new developments appear to the southeast. The squall line which is made up of continually renewed thunderstorms seems to move to the southeast, in a direction roughly from 90 to 180 degrees from the surface wind. When observing the kinematics of such a storm genesis, information on where the new storms are forming is the most wanted. The pilot can often furnish this to the forecaster. ●



Left, contour lines are labeled on a pressure map. Below, an Army tank stands guard for a mobile AWS team. Right, a storm detection radar in action.

Tailor Made

THIS is the age of the specialist. The man who drives the nail no longer strings the wire and installs the plumbing. As a species, the American handyman is virtually extinct. The jack-of-all trades has given way to the master of one.

The trend toward specialization has been particularly rapid in the Air Force where the need for master craftsmen has had to keep pace with technological advances so swift as to be almost incredible. These advances spelled, in two words, specialized missions for all elements of the Air Force, not the least of which was Air Weather Service.

From its earliest days as the Meteorological Section of the Army's Signal Corps, geography was the key to the operations of Air Weather Service. A squadron headquarters, with an area of responsibility determined by location, supervised AWS detachments. Until the advent of the Jet Age, A-Bomb and Cold War, the system served its purpose well. For even during the trying days of World War II weather service was generally standard for local training and for cross-country flights within the United States.

But the days following War II brought new and more complex equipment—and a very real danger. Within a year of VJ-Day, Strategic Air Command, Air Defense Command and Tactical Air Command—each with a distinctive mission—were born. Net effect was that all major commands of the Air Force were placed on a functional basis of organization. Individual bases and installations of the major commands were scattered throughout the country and in no instance were they lumped together geographically in any single location.

Meanwhile, Air Weather Service continued to operate its geographical system. But now cooperation between supervisors in AWS and operations people of the major commands became increasingly difficult. SAC bases, for example, were served by detachments assigned to nine different weather squadrons, each of which provided service to units of four major commands. For the most part, headquarters of these commands were located outside of the weather squadron's area of responsibility.

There was inadequate liaison between the weather unit and using organization; hence, the weather squadron was not intimately aware of the command's operational requirements, nor could it take decisive action to remedy support deficiencies. Strategic Air Command missions were largely of the high-altitude, long-range type. Tactical Air Command, in contrast, needed special service for missions of short duration flown at low levels.

While it is true that weather observations, surface and upper air analyses and the preparation of forecasts are common to all weather stations, the application of this data differs among the commands.

Maj. Gen. W. O. Senter, Commanding General of Air Weather Service, called attention to the difference more than two years ago in a letter to Lt. Gen. Laurence S. Kuter, then CG of MATS.

Strategic Forecasting

"Strategic forecasting," General Senter wrote, "requires a hemispheric concept of weather conditions and the ability to provide forecasts covering great distances, high altitudes and long periods of time. Tactical forecasting, on the other hand, is generally limited to a much shorter distance, smaller area and the time inter-

Below, on a weather recon flight, a crewmember stands by to release a dropsonde; right, at an airbase in Korea, an officer tracks a rawinsonde.

One of the simpler but important Air Weather operations are the reports that are taken at many small outposts.

weather

val is much less. The weather forecasting problems incident to tactical and strategic operations are as different as the concept of the operation of the two forces. Weather requirements for the Training Command differ from both tactical and strategic operations."

Weather Service had people who knew a little about all of the aircraft Air Force was using and about as much of each command's mission. The critical personnel shortage which followed post-war demobilization made necessary assignment of inexperienced officers and airmen to AWS units. Few were equipped professionally to provide specific data on particular aircraft and particular missions. Yet mission requirement had come to be the most important consideration in the technique of forecasting. AWS studied its organizational structure closely and concluded that no matter how greatly it was strengthened, it still could not give major commands the specialized support they required.

The solution to the difficulty lay in abandoning the old geographic system and substituting for it a functional organization in which Air Weather Service command channels would parallel those of the Air Force. The decision to do just this was made and the changeover was planned in exhaustive detail. When the reorganization had been completed, the historical study of Air Weather Service termed it:

"A major event in the history of Air Weather Service since it enabled the organization, for the first time, to give using agencies in the Zone of Interior a specialized meteorological service specifically tailored to their individual needs."

In its present format, AWS has assigned a group to each command in the United States. Each group has the number of squadrons and detachments it needs to serve the Air Forces and bases of each command. The weather group command is located in the headquarters of each command. Squadrons are located at the numbered Air Force level and detachments at the bases.

As a result, the commander of each weather unit, in descending order of command, can act as staff weather officer for the adjacent major command unit. In a staff position, the weather officer thus has access to all mission planning. He knows what specialized data the command requires to satisfy its mission; and he has clearly defined command channels within his own organization to direct that the required information be provided. The groups are empowered to provide effective weather service to all levels of the major command, to act directly to eliminate operational shortcomings, to guide weather detachments in meeting specific operational requirements and to concentrate their efforts toward solving particular command weather problems.

Nor does this functional design jeopardize the global system concept that always has been associated with Air Weather Service. Indeed, it furthers that concept because it makes AWS capable of shaping its information to the specific needs of the major commands. The world-wide weather network remains under Air Weather Service Headquarters for technical control and personnel assignments. Weather reconnaissance squadrons, which track Atlantic hurricanes and Pacific typhoons and make regular observations in the Arctic, continue to gather information of use by all military and civilian weather facilities. ●

CLEAR AIR TURBULENCE

Next time you get jolts out of the blue Make a report to the weatherman.

By Lt. Col. William H. Wyatt, USAF Air Weather Service

HAVE you ever been flying along in perfectly clear air, with not a cloud for miles around, when suddenly your plane was bounced and jarred as if you were driving down a corrugated road? If so, you have experienced clear-air turbulence and can understand why this unpredictable gustiness is becoming an important problem. I'd like to describe my recent trip in the Air Force's six-jet bomber—the B-47—and tell just how it feels to be shaken up with no apparent reason.

It all began when I was briefing B-47 pilots at Wichita Municipal Airport on the nation-wide program of the National Advisory Committee for Aeronautics for collecting reports of all high-level clear-air turbulence encounters. We took off from Wichita, climbed to approximately 30,000 feet, then leveled off and headed for Oklahoma City and Fort Worth.

The weather was perfect — clear, with good visibility—and the trip to Fort Worth was smooth and uneventful. I had time to look around the plane and marvel at some of the changes that had taken place since the days of the B-17. Having been accustomed to feeling and hearing the rhythmic throb of piston engines driving the propellors, the smooth power of the jets was a new experience to me. We saw our first clouds while passing over Fort Worth, a thin cirrus that looked to be at about 40,000 feet. We turned and headed back for Wichita, now at 37,000 feet indicated altitude. The sky again cleared.

Just after passing Oklahoma City, I felt a series of short, choppy bumps hit the plane. There was an interval of about one second between bumps, giving the sensation of riding in a motor boat across the wake of another boat on a smooth lake. The pilot said the wingtips would flex through an arc of about two feet under these conditions; the plane itself did not seem to move up or down with the gusts. We climbed to 40,000 feet and, as suddenly as it had started, the turbulence disappeared. After about a minute of flight at this altitude, we again descended to 38,000 feet. The bumpiness was again evident during this descent, although it soon ceased and we flew the remainder of the trip back to Wichita in smooth air.

The weather situation at the time of this clear-air turbulence encounter is interesting. Figure 1 shows the location of this turbulent area on the flight cross-section; Figure 2 indicates its relation to the lapse rate and the tropopause. As seen from the Oklahoma City sounding (Fig. 2), the bumpiness occurred just below the tropopause and ended as the plane approached the stratosphere. The main jet stream at this level was far to the north — across southern Nebraska. There was, however, at a lower altitude (30,000-35,000 feet), another jet stream just north of the turbulent area, between Oklahoma City and Wichita.

Much more information of this type is needed to solve the problems of what causes clear-air turbulence and how it can be forecast. At present some rules-of-thumb have been developed. For example, the occurrence of these gusts is associated with the tropopause or with the jet stream, and it has generally been found that a climb or descent will end the bumpiness and put the plane back in smooth air again. Since the loads and stresses that this unexpected form of turbulence can impose must be considered in aircraft design, the importance of this unseen hazard is very evident.

Before World War II, pilots and weathermen associated turbulent air (bumps and jolts in flight) with cumulus clouds, wind blowing over rough terrain and convective currents sun-heated surfaces. During the second World War, however, reports began to come back that pilots were meeting turbulence in clear air at all altitudes and at distances far removed from any type of clouds.

As new designs raised aircraft flight ceilings and speeds, the frequency of such reports increased. Clear air turbulence has now been recognized as a major problem confronting pilots, weathermen and aeronautical engineers. The solution to the problem lies in wholehearted cooperation among the three groups concerned with the turbulence.

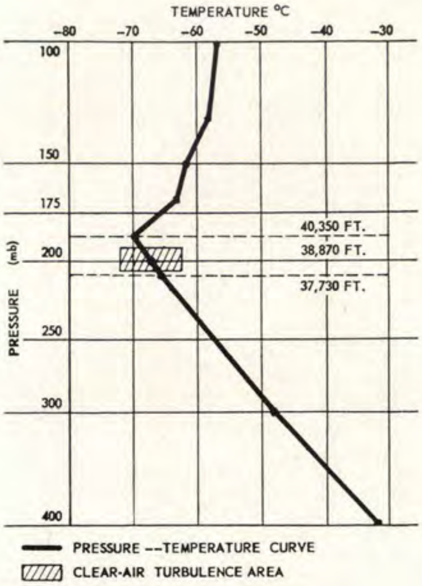
First to recognize and study the problem, the British organized a research project in 1947 to investigate clear air turbulence and came up with some very significant findings. For example, the British study shows that clear air turbulence occurs in isolated patches and at varying altitudes and is of variable depth, length and width.

Reports indicate that the average sample of clear air turbulence is 50 to 100 miles long and only about 3,000 feet thick. Unlike thunderstorm turbulence, clear air turbulence seldom results in a change in the plane's altitude, as is the case when a plane flies through strong vertical currents (updrafts and downdrafts). There is little pitching or rolling and the bumps follow one another faster than in convective clouds, giving the feeling, as one pilot put it, of "being in a fast car and suddenly running over a series of deep, unseen ruts in the road."

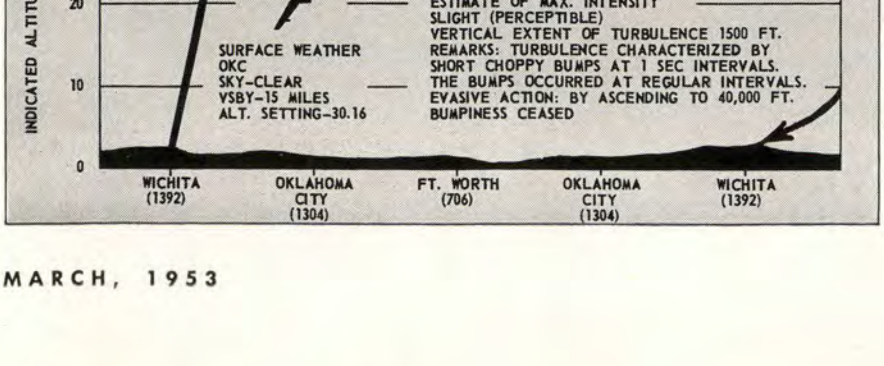
British analysis of the possible causes of clear air turbulence indicates that it is associated with a marked increase or decrease in the vertical wind velocity and that the worst turbulence is associated with jet streams, which are wandering rivers of fast-flowing air at high altitudes. Clear air turbulence appears to occur often near the tropopause, the layer of air at altitudes varying from five to eleven miles above the earth at which the lower atmosphere becomes the stratosphere.

Since the British beginnings five years ago, joint efforts of the National Advisory Committee for Aeronautics, the United States Air Force, the U. S. Navy, the U. S. Weather Bureau and the civil airlines have launched a clear air turbulence program in the United States. Some 400 reports have been received and analyzed under this program, providing valuable information on the subject.

Sufficient data has been collected to give design engineers a basis for computing stress on aircraft structure caused by clear air turbulence. The program has not, however, provided adequate data for comparing clear air turbulence with other weather conditions for the purpose of forecasting the turbulence. Value of the program to pilots has so far confined itself to the long-range benefits they receive from aircraft designed to withstand clear air turbulence more adequately.



The curve in Fig. 2 (above) shows the relation of barometric pressure to temperature in degrees Centigrade for Oklahoma City, February 5, 1952, at 0900 CST. The clear air turbulence area is close to the height of lowest temperature. Below (Fig. 1) is the round trip cross-section of the flight.



It is here that pilots may help themselves by helping the weatherman. Pilot reports received under the present program have been scattered and submitted only when clear air turbulence was encountered. Reports have been taken from all altitudes over a long period of time, making them largely inadequate for accurate analysis from the forecasting standpoint. Under the present program, lack of a report in any particular area may indicate either no clear air turbulence or no aircraft operating in the area.

What is needed is a program to provide for a short-term concentrated effort on the part of pilots to collect data by submitting reports of the occurrence or non-occurrence of clear air turbulence at specific altitudes.

With the assistance of as many as possible of the military and civilian pilots in the United States, such a program has been established this year by the U. S. Air Coordinating Committee. The new program calls for an all-out effort to collect data specifically at 30,000 and 39,000 feet altitudes at specific times during a three-day period sometime during this month.

Units of the USAF, the Navy and the various civil airlines with aircraft capable of reaching these altitudes are being asked to have as many planes as possible participate in the program. Wherever it can be done without adversely affecting normal operations, pilots will report on forms similar to postcards both the occurrence and non-occurrence of clear air turbulence. Pilot report cards will be distributed by AWS forecasters at the base weather stations, who will also brief pilots on the procedures to be followed and the type of data desired.

A successful reporting program may go a long way toward taking the mystery out of clear air turbulence, and its success depends upon the wholehearted efforts of all participating pilots. ●

Jet STREAM

When in a hurry take advantage of a jet stream — but you had better be sure it's going your way.

Much of the information used by weather stations for winds aloft briefing on over water flights is compiled by weather recon crews who report jet streams.

JET streams are narrow currents of very strong winds which meander between 20° and 70° latitude and flow in an easterly direction. They are usually found from 20,000 to 40,000 feet above sea level. This is the region which became important as a flying level during World War II when the first high-altitude bombing missions were flown. With the advent of jet aircraft, it has become a well traveled air lane for military planes, and commercial airlines are now considering this level for regularly scheduled passenger flights since jet engines thrive on thin air.

Jet Stream Discovery

The strong winds were christened "jet streams" by the weather experts at the University of Chicago early in 1947. Jet streams have nothing in common with jet aircraft. The name was chosen because of the similarity that exists between jet streams in the upper atmosphere and those already studied for many years in hydraulics. Some authors have also pointed out the similarity of jet streams to strong ocean currents, such as the Gulf Stream.

As has been the case with many important scientific findings, the facts of the case were known in bits and parts by many students of the upper atmosphere for a long time. It remained for the Chicago group to organize the facts, give them a suitable name, and present a theory to explain what others had observed. The most famous cases of jet stream winds, before they were named, were encountered during wartime bombing missions over Tokyo and Berlin.

USAF bomber crews sometimes reported that they encountered such strong headwinds over Japan that in flying inland from the ocean, ground speed was reduced to practically zero; but when heading back out to sea, ground speed was nearly double the indicated airspeed. We know now that jet streams of strong velocities are common over Japan at the levels and seasons at which the first B-29 raids were flown.

The RAF encountered a similar situation during the famous Berlin raid of 24-25 March 1944. The group of bombers was caught in a violent wind and carried far south of the target. One aircraft found itself over Leipzig and had to fly north to Berlin. Its bombs were dropped half an hour late. Another plane, which missed Berlin completely, was flying over Paris on the way home when it should have been over southern England. After the war a study of German upper air charts showed a definite jet stream over Berlin at the time of the raid.

Jet streams must be taken seriously in planning long-distance flights. If an air crew is on a bombing mission, it doesn't want to be slowed down to less than 100 miles an hour over the target. An airline company can't afford to have its scheduled flight between New York and San Francisco, for example, delayed for several hours because of an unexpected 150 mph headwind over Omaha. A pilot or navigator planning a long distance, high level flight must take advantage of the strong winds of the jet stream to shorten the actual flight time. If a jet stream is identified off course while in flight, it is wise to deviate from the normal great circle course and join the jet stream to pick up a tail wind. If a jet stream is

Best tools for locating jet stream are the 200-300 millibar charts.

encountered on-course as a headwind, it would be perhaps best to deviate from course to fly in an area of weaker winds.

The only trouble with all this planning is that it's a lot easier to say afterwards that you were in a jet stream than it is to predict the place where the strong winds will be. In the last four years a great deal has been learned about jet streams, but the fact remains that wind data at high levels is still very sparse. Since the jet stream is a very narrow current (when measured transversely from half max speed on one side to half max speed on the other) and since observations are reported relatively far apart, the weather officer has a hard time pinpointing the jet stream on his weather chart.

Narrowness of the current and high speed of the winds are two major characteristics of the jet stream. The maximum speed is generally found near the 250 millibar surface (approximately 35,000 feet above sea level), although streams have been reported at all levels from 15,000 feet up to 50,000 feet. The maximum speed is well in excess of 100 mph in winter and speeds of 200 mph are not unheard of. Jet streams are believed to be a key part of the prevailing westerlies. Consequently, they are not found in the northern hemisphere north of the 70th parallel or much south of the 20th.

There may be one jet stream indicated on a northern hemisphere weather map or there may be several. They are sometimes continuous with an axis which appears to circle the globe. Although theoretically the axis of the jet can be drawn around the world, the stream widens and weakens to such an extent that it really can no longer be considered a jet in certain portions. It is more appropriately considered a broad band of westerly winds. More often, jet streams break up and move around the earth in large waves. Thus, although the jet stream occurs in the westerlies, it cannot always be relied upon to furnish a strong westerly current at the required time and place.

A jet stream may take weeks to complete its cycle or it may disappear in a few days. The high winds originate between 60° and 70° N., but in summer the source may be farther north than in winter. They then drift southward in mean latitude with an average speed of one-half to two degrees per day and reach their maximum strength at about 50° N. in summer and 40° N. in winter. The actual movement is difficult to determine because the jets separate like an ocean current into smaller streams or fan out and get lost in the local circulation. One branch may shoot north while another branch goes south and as a jet stream deviates from straight zonal flow, it passes south of cold lows and north of warm highs. A jet stream also can change altitude as it moves. Jets are usually found at higher levels in the south than they are in the north. Usually two jet streams are identifiable at the same time, but there may be only one clearly defined current when an old jet is dying.

The experts say that the best tools for locating the jet stream are the 300 and 200 millibar weather charts which show a packing of contour lines and strong winds reaching their maximum in the core of the jet stream. If these very high level charts are not available, jet streams can sometimes be found by locating a region of rapid temperature change across the wind flow on the 500 millibar chart. The jet stream core often occurs 10,000 to 15,000 feet above this packing of isotherms.

Effect on Tropopause

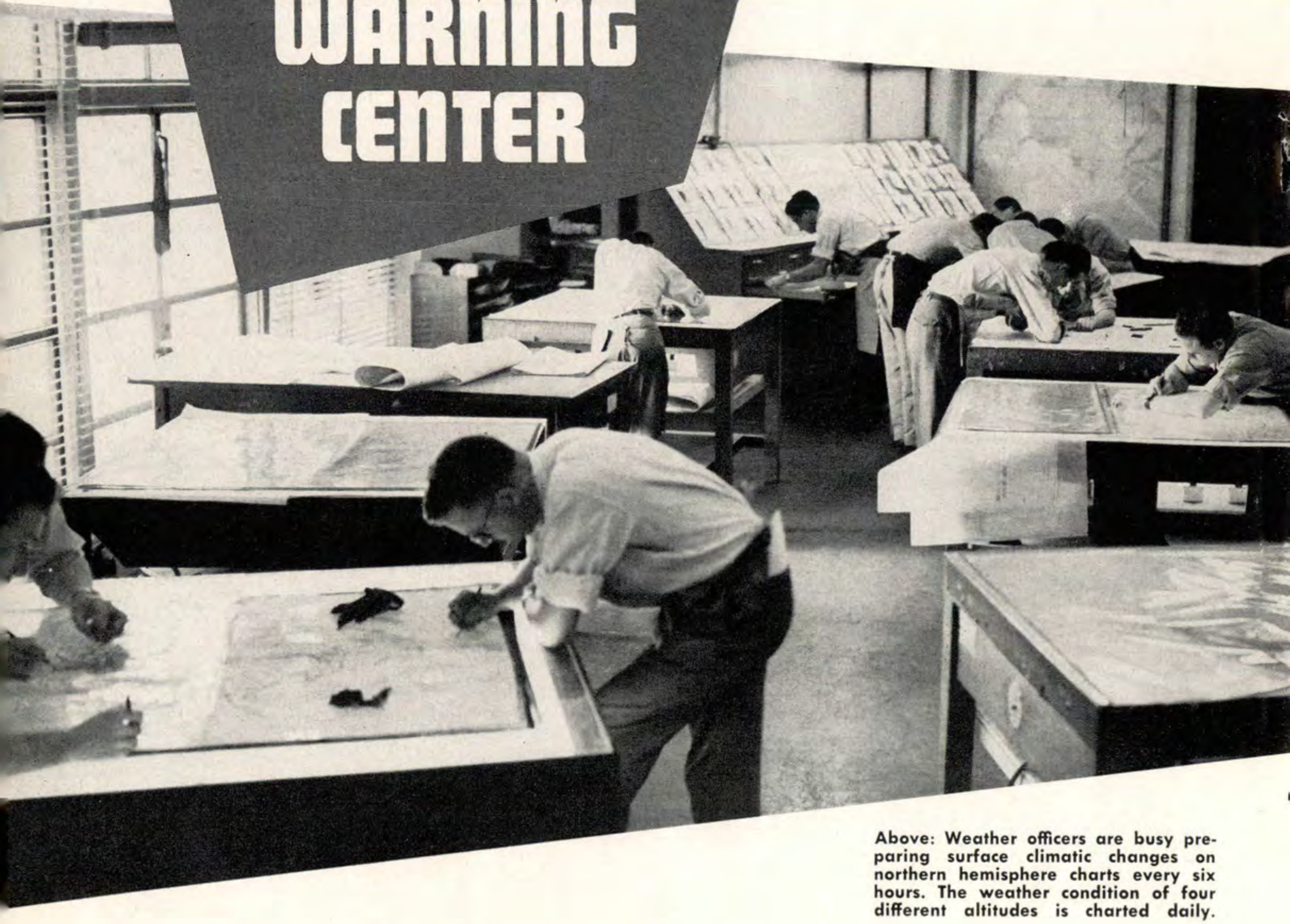
In the vicinity of the jet stream the tropopause is usually broken. The tropopause over the cold air is several thousand feet lower than that over the warm air. In individual cases, the tropopause over the cold air appears fairly level while that over the warm air is sloping. The strongest winds occur in the warm air above and to the north of the surface position of the front and almost directly over the main polar front at 500 millibars.

The winds build up slowly across the peripheral regions to reach a maximum at the center of the jet stream. Where the lines of equal wind speed (isotachs) are close together, the rate of change of wind speed, generally called wind shear, is much stronger. The wind shear is fairly severe on both sides of the jet. In extreme cases a decrease in wind speed of 100 knots in 100 miles has been reported north of the jet stream and 100 knots in 300 miles on the south side. Vertically the isotachs are relatively close together. A decrease of 100 knots in 12,000 feet above or below the center of the jet is by no means uncommon.

Light to moderate clear air turbulence has been found in the jet stream in the vicinity of the tropopause. Severe clear air turbulence has also been encountered there on rare occasions. Clear air turbulence occurs in small unpredictable patches, hence it is unlike the sustained roughness felt when flying in convective clouds or at low levels.

At present, USAF experts on the jet stream are looking forward to the time when they will be able to analyze the jet stream directly. An analysis of the jet stream is now a time consuming task which requires the construction of pressure-contour charts using extrapolated data where soundings do not reach high enough. New equipment recently put into operation at some Air Force bases provides reliable wind data to higher levels than previously. If and when this equipment or a similar type comes into general use throughout the world, not only the jet stream, but the entire wind field will be much more clearly defined. ●

STORM WARNING CENTER



Above: Weather officers are busy preparing surface climatic changes on northern hemisphere charts every six hours. The weather condition of four different altitudes is charted daily.

By Lt. Col. E. J. Fawbush, Severe Weather Warning Center, AWS

IN its current operational status the Air Weather Service's "Severe Weather Warning Center" is charged with the responsibility of issuing forecasts of the weather phenomenon, accompanying the thunderstorm, which presents a hazard to aircraft in flight or to military ground installations within the zone of the interior. These phenomenon are the tornado, damaging straight live winds, hail at the surface and aloft, and severe turbulence aloft. Forecasts are issued as required in abbreviated plain language and are disseminated over the USAF weather teletype network. The Severe Weather Warning Center is staffed by four forecasters and eleven observers.

The envolvement of the Severe Weather Warning Center into a specialized forecasting unit in its present form covers a period of four and one-half years, that had its inception in March, 1948. During that month, two particularly damaging tornadoes struck Tinker AFB, Oklahoma City, Oklahoma, within a span of five days causing several millions of dollars damage. After the first tornado hit the base on the 20th of March, we began to correlate the surface and upper air synoptic patterns in existence prior to the Tinker storm and in several other past tornadic occurrences. Working in conjunction with Major Robert C. Miller, we noted certain similarities in these synoptic patterns and evolved a simple set of rules which we felt might be a step toward the possible forecasting of tornadoes.

On the morning of the 25th of March, 1948, we were confronted with a set of surface and upper air charts which contained, in preliminary form, all the synoptic ingredients necessary to tornadic development. Using the rules we had set up we came to the decision that the Tinker AFB area itself was again the most critical area for a possible severe

Information received from military weather stations all over the world being charted and prepared for relay.

weather occurrence. A base storm warning was issued for excessive winds and all precautions were taken by base officials.

It became increasingly apparent to us that, according to our empirical rules, tornadic development in the central Oklahoma area was very likely. At 1810 Central Standard Time on the 25th of March the second tornado in five days formed southwest of the base and passed through the field moving northeastward.

With this apparent confirmation of our beliefs, we made several more practical forecasts during the year in Oklahoma and Texas with good success.

In 1949, in addition to our regular weather station duties, utilizing our forecast procedure we made fourteen tornado forecasts for the Kansas-Texas-Oklahoma area and in all but one instance tornadoes occurred within the forecast area. These forecasts were not disseminated over the teletype during this period but were given to the weather bureau office in Oklahoma City for informational purposes. In 1950 the forecast area was enlarged somewhat to include most of the middle west and the gulf coastal states. During this year thirty-three tornado forecasts were issued of which twenty-nine verified. In August of 1950 arrangements were completed whereby these tornado forecasts and also forecasts of high winds and hail, accompanying thunderstorms, would be transmitted via USAF teletype to the Global Weather Central of the Air Weather Service at Omaha, Nebraska. During the remainder of 1950, one hundred nineteen severe weather forecasts were issued in this manner and one hundred fourteen of these forecasts verified.

During the early months of 1951, the Air Weather Service decided to relieve Major Miller and me of the routine weather station responsibilities and set up the Severe Weather Central in its present form. The area of responsibility was increased to include the entire zone of the interior on a 24-hour basis. All severe weather phenomenon accompanying thunderstorms were to be forecast as accurately as possible and disseminated to all Air Force weather installations via teletype. During this year from February to December the Severe Weather Central issued eight hundred sixty forecasts of high winds and/or hail and eighty seven tornado forecasts. Of these forecasts eight hundred forty three wind and hail forecasts and seventy eight of the tornado forecasts were verified.

During the four and one-half years, of course, considerable refinement of the original empirical rules has taken place, although basically the procedure remains about the same. The production of severe weather has, as its first requirement, potential instability of the air mass. In other words, the vertical structure of the air must be such that a disturbance of the air column, like a front or heating, will cause violent overturning of the column. This overturning then produces thunderstorms and violent weather. As has been pointed out by meteorologists over a period of years the air structure most favorable for tornadoes requires a concentration of moisture in the lower levels of the atmosphere, capped at intermediate levels by a temeprature inversion or "lid" above which conditionally unstable dry air exists. This type of vertical air structure is especially required for tornadic development and also is productive of violent straight live winds and hail. The cap or temperature inversion, however, is not necessary in the production of violent straight live winds, although the dryer air aloft is desirable.

With the basic requirement of potential instability satisfied, we must then subject this portion of the air mass to forced lifting or triggering. This can be accomplished by an intrusion of a front into the air mass, formation of a squall line, an upper front or, in the case of strong straight live winds and hail, simple convection. If this triggering action is, or will become available, during the forecast period in the instability area, violent weather will result in the area of greatest instability. To further isolate this area, an effort is made to locate the axis of strongest wind flow aloft at elevations from 10,000 to 20,000 feet MSL. It has been found that the maximum intensity of thunderstorm weather phenomenon will occur along either side of these maximum wind surges. This is a particular requirement for tornadic development and in most cases, with other factors being equal, the difference between the production of tornadoes as against straight live winds.

In the absence of this "jet" flow aloft, isolation of the most severe activity is more difficult and recourse must be made to such local influences as terrain and strong surface winds.

A continuing research program is in progress at the Severe Weather Central, and concurrently, past data for numerous cases is being systematically gathered and logged. Upper air soundings taken near the time and place of severe hailstorms, windstorms and tornadoes have been collected over a period of two years and will aid in further refinement of severe weather forecast techniques. The goals of the Severe Weather Center are to continue issuance of accurate and useful severe weather forecasts and to refine techniques resulting in as much isolation as possible by severe weather areas. ●

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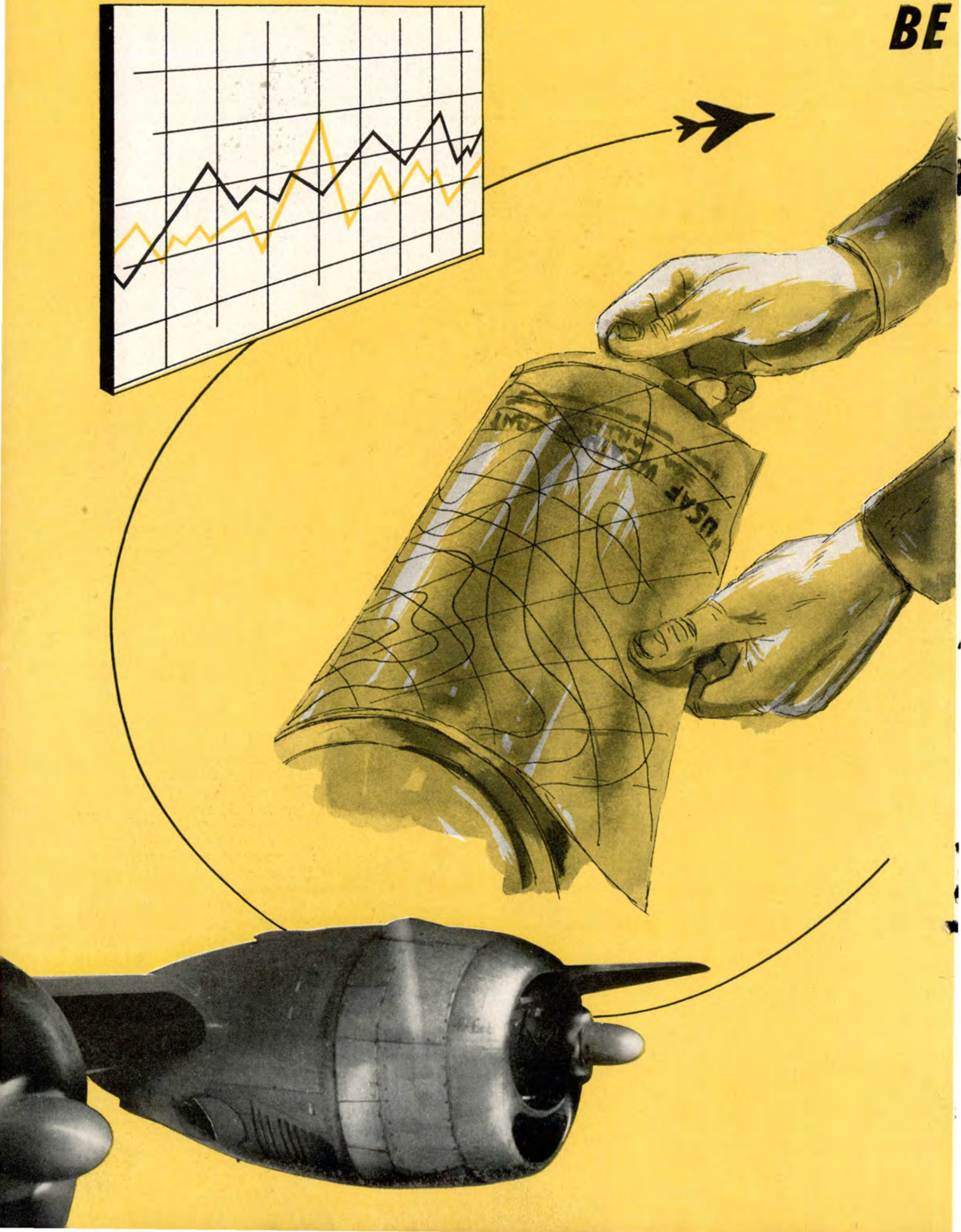


WISE . . . . . WEATHERWISE!

By Lt. Col. Harold L. Powell, Facilities Branch, D/FSR

THE aeronautical age has disclosed three things you can say about weather, with or without the use of profanity:

- It comes and it goes.
- It will continue to come and go.
- People will continue to talk about its coming and going.

In addition, studies—and statistics—show that pilots have come out second best in frequent tussles with the elements. As a matter of fact, a recent study, conducted by the Directorate of Flight Safety Research, shows that over a five year period close to several thousand accidents have occurred, in which weather was a factor.

In the majority of these accidents, pilot error was considered the primary cause factor. Close to 20 per cent of the accidents were attributed to other crew members, ground control and supervisory personnel, materiel failure, and weather phenomena—hail, turbulence, and lightning. *The weatherman himself was the primary cause in only one-half of one per cent.*

All in all, the total impact on the Air Force from these losses, dollar-wise and personnel-wise, was considerable. What makes these losses so hard to take is that many of the accidents hinged on such simple causes as reading an altimeter too high, trying to maintain VFR during bad weather over unfamiliar terrain, taking a chance on landing at intended destination when weather dictated use of an alternate, and failing to out-maneuver gusts and cross-winds.

The accidents were segregated by phase of operation: Runup and Taxi, Takeoff, In Flight, and Landing.

It was found, not unexpectedly, that most of the accidents occurred during landing. An analysis of the landing accidents produced the following facts:

- Surface wind was the weather element involved in a major portion (67%) of the landing accidents. Cross-winds were predominant, while gusts figured prominently in about half of the accidents attributed to winds.
- Pilot error was the primary cause factor in more than 90 per cent of the landing accidents. Most of the pilot errors involved manipulation of the aircraft. One major item in this category was loss of directional control of the aircraft after touchdown in crosswinds and gusts.
- Ceiling and visibility were above VFR minimums in more than 900 of the landing accidents.
- Weather personnel were charged with discrepancies in four per cent of the accidents. Most of these discrepancies concerned ceiling and visibility forecasts.
- Experience level was not necessarily a major factor, in that more than 80 per cent of the pilots had more than 300 hours of total flying time; and 65 per cent had more than five hours of actual "weather" instrument time.

The weather element second to wind in frequency of contributing to the causes of landing accidents was cloud condition.

It generally was the contributing factor in accidents involving instrument letdowns, which, from the standpoint of fatalities per accident, is one of the most deadly accident types. The main cause factors in this category were lack of adequate pilot instrument proficiency, poor pilot judgment, and insufficient ground control personnel proficiency.

In-Flight Accidents

A goodly percentage of the weather factor accidents occurred while aircraft were between departure point and destination. An analysis of these accidents showed the following facts:

- More than one-half of the in-flight accidents were attributed to pilot error; errors of other crew members or supervisory personnel were major factors in 10 per cent; weather phenomena, such as turbulence, lightning and hail were responsible for 30 per cent, and materiel failure was a factor in five per cent.
- The major weather elements contributing to the accidents were, in the order of frequency, clouds, turbulence, hail, thunderstorms and rain.
- The major pilot errors concerned preflight preparation, which

High-speed teletype machines keep Fifth Air Force combat wings and other FEAF flying organizations abreast of latest weather.

covers a multitude of sins—failure to check equipment, weather, adequately plan route, fuel, terrain, and alternates—all errors of omissions. Navigation techniques, instrument proficiency, and voluntarily flying into thunderstorm areas also fell into this category.

- Weather personnel were charged with discrepancies in seven per cent of the in-flight accidents. Most of these errors concerned VFR ceiling and visibility forecasts when actual weather encountered was below VFR minimums.

- Seventy per cent of the pilots had more than 1,000 hours total flying time, and 78 per cent had more than five hours of actual "weather" instrument time.

It was noted that many pilots, after becoming airborne, apparently neglected to keep current on the weather, and especially weather forecasts for points ahead of their position. This neglect often forced them to make hasty, unsound decisions after they were on top of their destination, or plunged them into unexpected, hazardous weather at other points along the flight path.

As for weather personnel, apart from forecasting errors, it is apparent that some weather briefers haven't learned that being too precise about some weather values, (cloud tops, for example) can often do more harm than good. Exactness beyond the capabilities of forecasting methods can promote poor flight planning on the part of the pilot.

Taxiing and Takeoffs

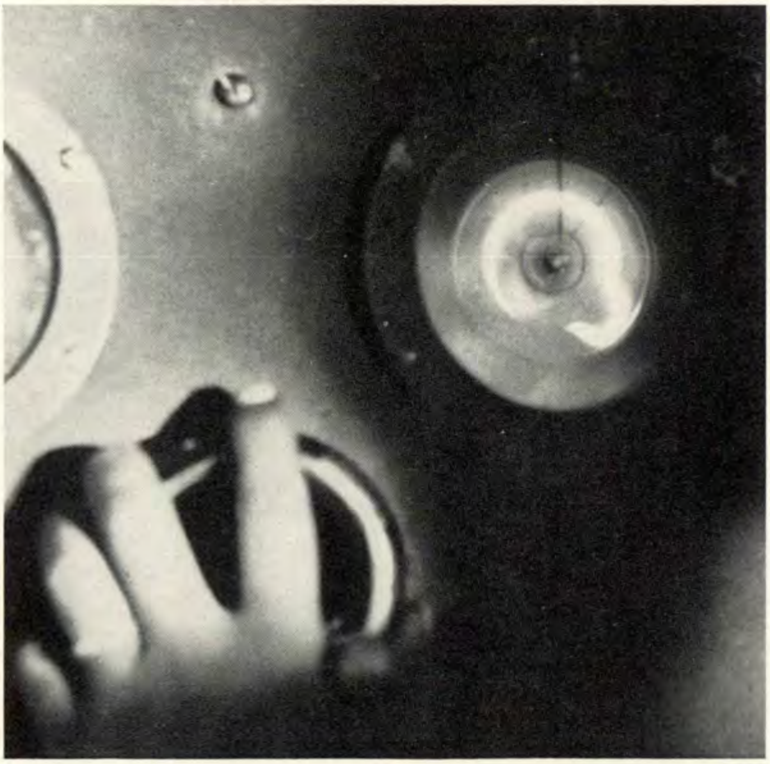
Taxi accidents in which weather was a factor numbered 195, with 179 of those involving wind. The remainder had factors of snow and rain reducing visibility, and snow and ice on taxiways and runways.

In reviewing accidents where weather was a prime factor, wind was considered the prominent weather element, contributing in about 51 per cent of the cases. Rain, fog, other obstructions to visibility, and snow, in that order, were blamed for the remainder of the accidents.

The primary cause factors in these accidents concerned pilot control of the aircraft just before and just after becoming airborne, resulting in groundloops, collisions with other objects, and crashes into the ground.

Not to be taken lightly, regardless of its speed, is the weather element of surface wind. It contributed to 53 per cent of the total number of weather accidents. In all but a few cases, the wind that gave trouble was either a crosswind, gust, or both, and was more than 10 knots.

In getting winds aloft data, ballons are tracked by radar.



This points to the necessity of a pilot always checking surface winds thoroughly for every flight, even for local ones, and getting the forecaster's idea of what is expected at ETA. Cooperation between the weather station, control tower and pilot is the big "MUST."

The weatherman can always help by providing all the information he has on surface winds, not only for takeoff, but for every point at which the aircraft plans to land.

As far as weather in general is concerned, the pilot's consideration should not be hurried. The weather forecaster's middle name is service and he will discuss as capably as he can every weather element along the intended route. The pilot should always take advantage of this.

Even for flights during which VFR weather is expected all the way, the pilot should play it safe by having an alternate planned in accordance with fuel requirements. Then, if an IFR flight plan becomes necessary, it can be approached with a greater fund of knowledge.

Finally, constant weather vigilance by pilots in the air is necessary because of the limitations of weather forecasting methods. These methods, as every sincere weather forecaster will admit, do not always give the accuracy desired. For this reason weather forecasters get their share of criticism. On the other hand, it would be wise for pilots to become acquainted with these limitations, in order that safe allowances can be made during pre-flight planning. In the same vein, it behooves the weather forecaster to be frank with the pilot as to the accuracy limitations of forecasting, so that the pilot may fully consider his personal capabilities and the capabilities of his aircraft and equipment.

It's a let-down-the-hair affair on both sides, but there'll always be problems and limitations. There'll be days when a jet jockey can't get over that hump of cumulus at 45,000, when tops were forecast at 30,000. Those are the days when pilots yearn for the revenge of seeing the weatherman drown in mercury from his own barometer.

But—go easy, boys, the records show that generally, the weather data is a reliable ingredient of flight planning. ●

this is

FLYING SAFETY

The Office of The Inspector General at Norton AFB, Calif., is an organization that has been born of time, place and teamwork. Of missions assigned, one of the more important has been the formation of an effective flight safety research program with the concept of maximum aircraft accident prevention in the United States Air Force.

Through an aggressive approach to the accident problem, The Inspector General has already done much to bring about one of the lowest accident rates in USAF history. The accident facts and flying lessons uncovered today by highly-trained flight safety research teams are turned into knowledge which may be used to eliminate the accident of tomorrow. . . .

VICTOR E. BERTRANDIAS
Major General, U. S. Air Force
Deputy Inspector General

By 1st Lt. Wm. A. Johnston, Directorate Flight Safety Research

The Directorate of Flight Safety Research, Office of The Inspector General, USAF, is charged with the responsibility of achieving maximum accident prevention. Through the application of scientific, investigative, educational, operational and engineering techniques, conservation of personnel and aircraft is possible. These techniques are applied in the correction of design and maintenance deficiencies in materiel, the critical evaluation of Air Force systems and procedures, and the proper selection and education of personnel. These problems are approached through the development of research into engineering, accident investigative and analysis techniques, the psychological and physiological research into human factors involved in accidents, the analysis of aircraft accident histories, and a close observation of all Air Force operations.

The Directorate, therefore, is composed of many segments, subdivided into crews of specialists whose main job is accident prevention and analysis. When a crash occurs, some important questions arise: What happened? Why did it happen? What can be done to keep it from happening again? Here's how it works.

A C-47 crashed into a mountain while en route from Roger AFB to Wilco AFB. The crash site was 30 miles off course. There are fatalities, but rescue personnel report that there are some survivors. Wilco sends a report to the Directorate of Flight Safety Research, and the staff duty officer receives the TWX around 2300.

Immediately, all interested personnel are notified by telephone, and preparations are begun for the daily staff meeting which takes place in the office of the Director of Flight Safety Research at 0900. Various divisions and branch chiefs are alerted and briefed on the accident. By this method, all key personnel have prior knowledge of the mishap, and valuable time is saved.

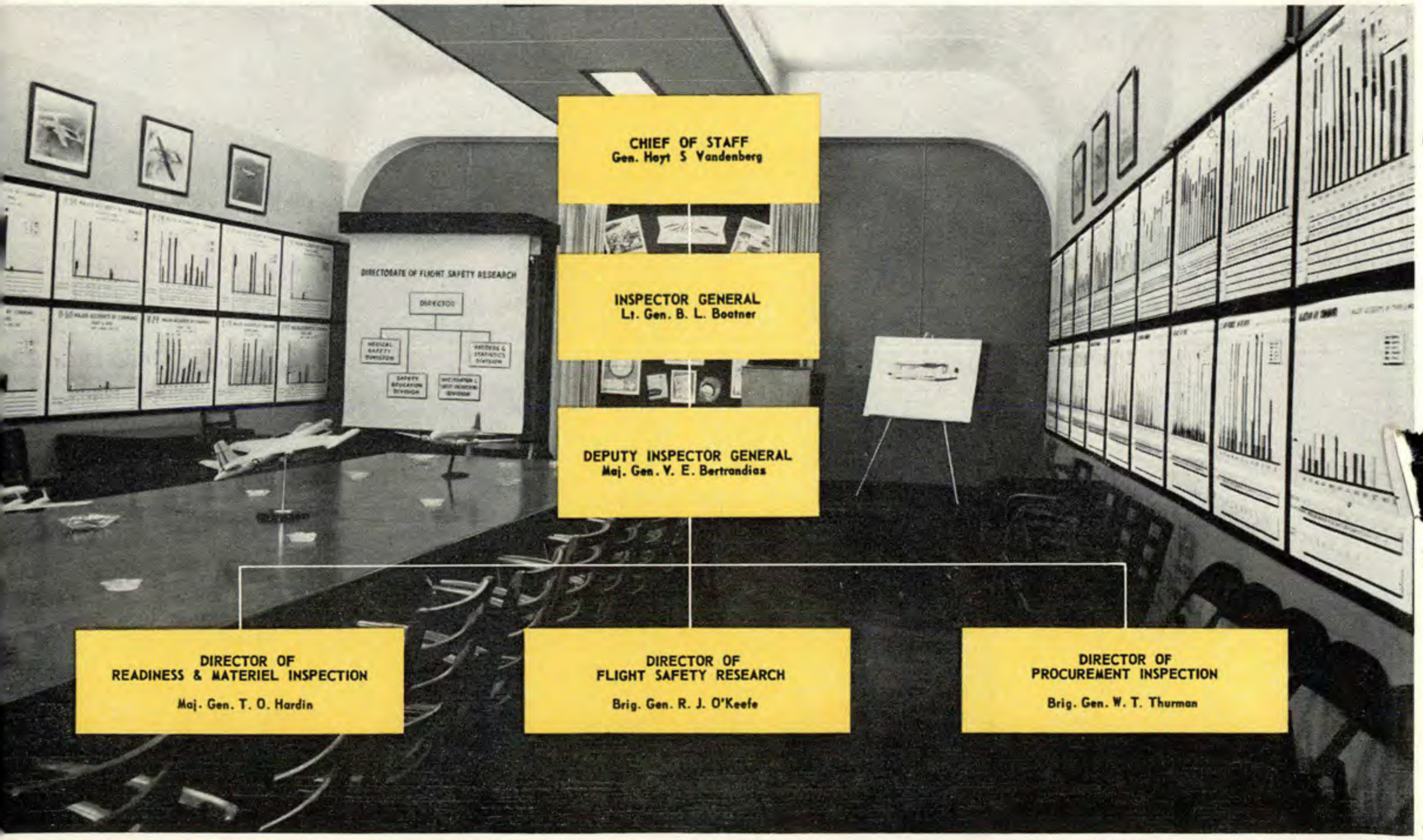
By the time the staff meeting is called to order, all information pertaining to similar accidents, or accidents in the same general locale, has been gathered in order that proper investigative plans may be formulated. Brig. Gen. Richard J. O'Keefe, Director of Flight Safety Research, after conducting a comprehensive discussion with his staff, decides that a team will investigate the accident.

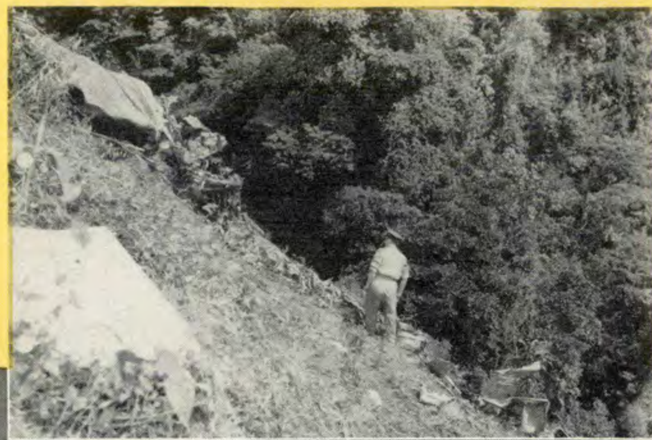
The team would include representatives of the Medical Safety Division, Operations & Facilities Branch, the Cargo Branch, and the liaison officer from Air Weather Service, since there appeared to be a weather factor involved in the accident.

Chronologically, things happened about like this:

The Chief of the Records and Statistics Division brought to the meeting a complete rundown of recent

The Office of The Inspector General, through its three directorates, is concerned with the concept of USAF accident prevention.





When a major accident occurs, it is discussed in the daily staff meeting conducted by Brig. Gen. Richard J. O'Keefe, where determination is made as to whether an investigation team will be sent to the scene of the mishap.

accidents involving the same type of aircraft, accidents occuring along the same route, and other pertinent information of value in determining what happened. In addition, all flying biographical data concerning the rated members of the crew is made available to General O'Keefe. This came from the more than 75,000 Form 5's on file in the Directorate.

Since the R&S Division also maintains a complete file of accident reports (Forms 14), any additional information desired about similar accidents may be obtained within a few hours by making a series of IBM "runs." In this manner, all cause factors of past accidents may be summarized in an attempt to discover certain trends involving the specific airplane or route in question.

Further significant details about the accident were furnished by representatives of the Cargo Branch, which maintains an action log of all cargo accidents, and particularly by the project officer for the airplane. It was then determined that the project officer would be on the investigating team.

Since the airplane crashed approximately 30 miles off course, navigational error, and possibly weather, were assumed to be probable cause factors. As a result, a specialist on navigational aids, the liaison officer from Air Weather Service, and the Chief of the Operations & Facilities Branch, attended the meeting. The aeronautical charts of the area, Radio Facility Chart, and pertinent NOTAMS were furnished for further discussion. In addition, the airplane's route was plotted and compared with existing weather maps to learn where the possible navigational error took place.

In the case of the C-47, it was decided to send the navigational aids specialist and the AWS liaison officer along as members of the special investigating team. As an additional aid to the team, a resumé was prepared which summed up recent navigational error accidents in the same general area, involving C-47's and other aircraft.

Prior to the meeting, the Medical Safety Division sent a message to the Flight Surgeon at Wilco AFB, requesting all pertinent information involving any possible medical factors, or personal equipment malfunctions. Medical Safety, in this case, was also particularly interested in survival activities, in order that further research could be conducted as to existing and future clothing, and food and shelter provisions.

In addition, the base Flight Surgeon was queried as to any factors in the crew's background which would have a psychological or physiological bearing on the accident.

As soon as all interested division and branch chiefs presented their opinions, further discussion was held to add as many facts as possible, to be taken to the accident scene by the investigating team. Complete instructions were then issued and within a few hours the team was on its way.

Upon arrival at the scene, each

Individual Flight Records (Form 5's) are microfilmed for permanent retention in Flight Safety Research files.

team member was directed to perform his phase of the investigation according to his specialty. Then all the data and testimony were pieced together to form the most logical conclusions upon which to base sound recommendations.

In the C-47 accident, the Flight Safety Research team made the following findings:

• The most probable cause of the accident was navigational error.

• A contributing cause of the accident was that the winds were incorrectly forecast.

• A probable contributing cause was precipitation static which made radio reception impossible.

The team also made the following recommendations:

• That the minimum altitude over the route be raised to afford ample terrain clearance in the event aircraft were off-course.

• That continued study be made to develop radio receivers that eliminate precipitation static.

• That a procedure be established with the CAA to provide northbound aircraft calling Blank Radio with the latest en route weather to Wilco AFB.

• That additional radio aids to navigation be installed along the route.

The Directorate of Flight Safety Research was established at Norton AFB, California, as a staff directorate under The Inspector General, USAF, in February, 1950. Military pilot engineers and investigator-analysts were assigned to perform accident investigation and evaluation duties.

Officers, airmen, and civilians talented in editorial and graphic arts were procured to produce educational media and accident prevention presentations, under the direction of the Chief, Safety Education Division. FLYING SAFETY magazine. *The Aircraft Accident* and *Maintenance Review*, and Flight Safety posters such as Rex Riley, Crash and Consequences, and special publications are all produced in this division.

Highly qualified civilian specialists were obtained from such agencies as the Civil Aeronautics Board, other governmental agencies, and civilian educational institutions to perform duties requiring professional talent in the fields of physiological and psychological research, and engineering and statistical analysis.

From this nucleus of specialized talent, the Directorate of Flight Safety Research developed the organization to provide for its exhaustive engineering investigations of accidents, the scientific evaluation of aircraft accidents reported from Air Force units, specialized research into human factors involved in accidents, the production of improved educational media, and the development of records and statistical systems designed to produce realistic cause factor information.

In order to accomplish its mission, the Directorate of Flight Safety Research frequently calls upon the other directorates which comprise the Office of The Inspector General at Norton AFB—The Directorate of Readiness and Materiel Inspection and the Directorate of Procurement Inspection.

The Directorate of Readiness and Materiel Inspection was activated in 1950, charged with the responsibility to "conduct inspections to determine maintenance capabilities for aircraft and related equipment; inspect and evaluate maintenance techniques to eliminate adverse conditions and recommend improvements in maintenance practices and systems, and to evaluate command maintenance inspection systems."

The role of this directorate was particularly important in the overall accident prevention program, which enabled the Air Force to attain a new record low in accidents during 1952. The Directorate supported the program of the Directorate of Flight Safety Research by conducting studies which isolated areas of maintenance deficiences that were potential accident producing factors. The two directorates complement each other.

The Directorate of Procurement Inspection has as its mission the exercising of inspection surveillance over the administration of the Air Force Industrial procurement and local purchase programs. The mission is accomplished through inspection of contractor facilities and procurement functions of Air Force organizations, and by surveys of specialized Air Force programs.

The three Directorates work in close cooperation, with a primary objective being a constant reduction of aircraft accidents. Actually, it boils down to a few simple facts. Procurement monitors the acquisition of all Air Force equipment, with safety a primary requisite. Readiness inspection monitors all maintenance activities to assure that operational equipment is maintained in a safe manner. Flight Safety is primarily concerned with the personnel and equipment utilized in operational organizations.

The all-time low 1952 aircraft accident rate obviously reflects the combined efforts of all members of the Air Force in the field, and that means *YOU!* Personnel of the Office of The Inspector General (and that means *US!* like to feel that we have also rendered a valuable assist.

We're well into the third month of 1953—a year that could become another milestone on the accident prevention road. We've all joked about the recruiting posters—the pointing finger—and the statement that Uncle Sam needs *you*. Well, he does need you, and your cooperation, to eliminate accidents. The *time* is now, and the *place* is any place you happen to be. Only by working together—as a team—can the ultimate accident prevention goal be reached. ●

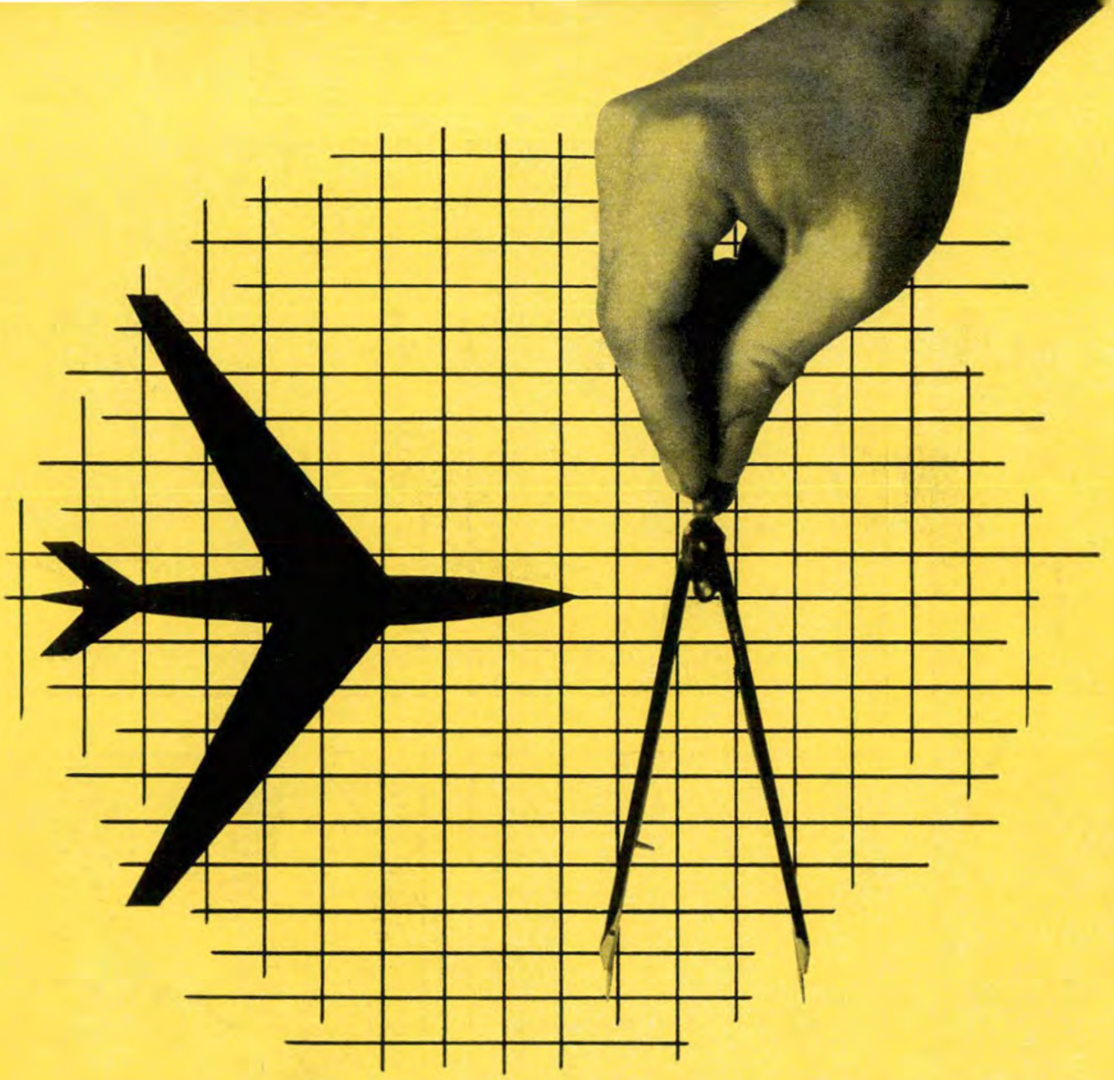
Industry Cooperation

Assisting in reaching this overall objective are approximately 15 full and part-time representatives of major airframe, engine, and other component manufacturers. These specialists work in close cooperation with investigators and research personnel in determining cause factors of accidents and gathering design factor information to transmit back to factory engineering groups, and also work with investigators in the field as part of DFSR teams.

The Medical Safety Division, left, deals with all human factors of aircraft accidents, plus survival and other personal equipment. Technical representatives work in cooperation with rated military specialists in investigations.

The Engineering Branch, left, is part of the Investigation and Safety Engineering Division. The Records and Statistics Division, right, maintains a complete record of all accidents, cause factors, geographical locations, and other important factual data.

T./Sgt. Steve Hotch, left, who draws "Rex Riley," gets technical help from one of the many manufacturer's representatives, who work with the Directorate of Flight Safety Research. The Safety Education Division, right, is responsible for all publications.



Time Equals Distance Over Speed

This is the navigator's formula for Time . . . the conception of flight reduced to a simple equation. But Time cannot be all things to all men. As the tempo of our living increases its beat, Time makes up a new set of values, and our day's existence resolves itself into more and complex pigeonholes.

To those of us who live by the control column and the rudder pedal, Time has taken gigantic strides, and faster ones. Today we must find time to cram into our minds every last ounce of knowledge that will tend to make us better, and safer flying men.

Flying Safety Magazine is one medium through which we can accomplish this task, for in Flying Safety the principles and the trends of safety in flight are condensed each month so those who fly may read.

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