AUGUST 1954

FLYING SAFETY

UNITED STATES AIR FORCE

In this issue . . .

Gunnery Patterns — Hot Runways

FLYING SAFETY

VOLUME TEN
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Seconds eat up space. See story on page 16.

SUBSCRIPTIONS

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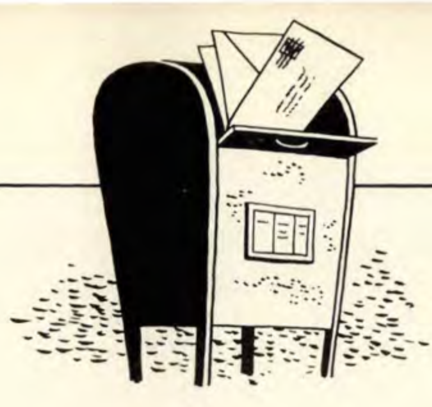

CROSS FEED

LETTERS TO THE EDITOR

Covered Visor

I'd like to mention what I consider a potentially dangerous occurrence which could happen if, prior to takeoff, a pilot failed to remove the protective cover from the visor of the flying helmet. Recently I overheard this being discussed by two pilots. The pilot (talking) was number two man in a formation of F-86s, and just after takeoff, a turn was made to the left, into the sun. This pilot pulled his visor down and with the cover on he could not see. Fortunately, this time there was no collision.

It is suggested that Flying Safety Officers discuss this with pilots at their meetings. The protective cover part number is 51C3808 and the visor part number is 81C3632. Also, you might mention it in *Flying Safety Magazine.*

In closing, I'd like to say that your very informative magazine is thoroughly read and enjoyed here by both air and ground crew personnel.

T/Sgt Harry M. Ferguson
Instr. 108th M&S Gp (ANG)
Newark Airport, N. J.

The Sergeant has a point. Check those visors before leaping off.

★ ★ ★

Fit To Fly

I would like to thank Colonel Moseley for his well presented article on "Fit to Fly," in your May issue of FLYING SAFETY.

How many times have we heard people in our organizations say, "Oh, I'm not sick enough to go on sick call," or "The old man would think I was just goofing off," or even "I just have too much to do this morning to worry with a cold."?

I am a control tower technician for Airways and Air Communications Service and must take a yearly physical examination like the officers and airmen on flying status. It is a risky business to put a sick tower operator on duty with the great responsibility he has, being the eyes and ears of an air base.

It is my firm belief that tower operators, GCA operators, ARTC personnel and all officers and airmen who work directly with various phases of flying should use good common sense at all times and not doctor themselves, but should let the Flight Surgeon decide.

T/Sgt Donald E. Bradford
1944-7 AACS Det, APO 65

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More Safety Records

The First Tactical Reconnaissance Squadron, flying RB-26s, completed 15,000 accident-free flying hours on 21 June 54. The last accident was on 1 May 1951 when a nosewheel collapsed because of materiel failure. The 12th Air Force believes this to be a record for this type aircraft flying similar missions.

10th Tactical Recon Wing
Spangdahlem AB, Germany

●

At the close of June, the 318th Fighter-Interceptor Squadron completed a year of successful operation at Thule Air Base. The squadron, commanded by Major W. O. Belton, and operating F-94B all-weather interceptors and T-33 instrument trainers, accomplished 7 313 hours of flying training. This outfit averaged over 40 hours per month per aircraft, and its aircraft were maintained in commission at a rate of 84.8 per cent.

A single hard landing marred an otherwise perfect flying safety record for the squadron several months ago. Since that time, nine consecutive months of accident-free flying was accomplished, part of which was during the winter period of continuous darkness and sub-zero temperatures.

A yearly aircraft accident rate of 13.7 was achieved by this squadron.

Invaluable experience for the 318th's air crews and maintenance personnel has been derived from the training accomplished during the past year at this Arctic outpost.

PIO, 318th F-I Sq
Thule AB, Greenland

FLYING SAFETY would like to hear more from the field about outstanding safety records.

★ ★ ★

File Prunes Under "P"

Early in January your office advised us that our Library's allotment of FLYING SAFETY would be increased by 20 additional copies each month, starting with the January issue. Up to now, we have not received any of the copies promised, and, moreover, the two copies that we had originally been getting each month were not sent after February. We did receive two copies of the February issue.

You will be interested to know that about ten days ago we did receive from you a one-pound, 14-ounce box of pitted prunes (packaged by the Al Pearce Orchards of California).

Would you kindly check to determine if we have been placed on the mailing list for the additional copies of FLYING SAFETY and if the extra copies for the past three months are to be sent?

Also, what disposition is to be made of the prunes?

Marion Gaffney
Periodicals & Documents Section
National War College Library
Washington, D. C.

Our Circulation Manager advises us from Lower Slobovia that you should eat 'em, gal.

Panel White on Left Site

Here's how the Tigers do it. Gunnery patterns and training SOPs explained by Nellis AFB instructors.

THE RANGES were set up, the air-to-ground targets were clear, the tow targets were ready and team personnel were eager at the crack of dawn on 7 June, the start of the first all-jet U. S. Air Force Fighter Gunnery and Weapons Meet.

Brig. Gen. J. E. Roberts, Commander, Nellis AFB, fittingly summarized the purpose of the meet when he stated, "The first all-jet U. S. Air Force Fighter Gunnery and Weapons Meet is an important occasion, both for the American public and the Air Force, for this meet enables the Air Force to evaluate the combat readiness of competing pilots and support personnel. Tactics and continuing training requirements for an ever-ready and mobile, world-wide Air Force can be determined.

"Some of the U. S. Air Force's best pilots and equipment will take part in the six-day meet. It is friendly but hard-fought competition between far-distant Air Force commands; but more than that, it is a forum for flying and maintenance techniques. Korea veterans will demonstrate the battle abilities which gained complete mastery of the air for the United Nations over the Communist forces in North Korea, while pilots and other personnel not battle-tested in Korea will learn much from those who fought the Reds."

The importance of the meet was highlighted by the important observers from U. S. military services and NATO countries and by the many officials from the aviation industry who attended.

Months of planning by the project officer, Lt. Col. Franklin L. Fisher, and his staff went into preparing for the meet before the 12 teams representing eight USAF major commands arrived. Housing and transportation had to be arranged. A 100-man team of judges had to be assembled. Meet rules had to be set up and agreed upon. Materiel and reserve supplies had to be procured and stocked to allow for any eventuality. And a complete book of SOPs had to be written, covering every phase of the meet.

One of the prime targets in this jet "World Series" was to see that it was accident-free, just as the 1950 meet was. Credit for "hitting this target right in the bull" goes to all participants, from the supervisory personnel and judges, the team pilots and ground support people to the behind-the-lines men who performed every chore from scoring to opening and closing the ranges.

The meet "book" which was issued all team pilots was another important item in establishing the accident-free record. It was of invaluable assistance in briefing the competitors in all procedures to be used while at Nellis.

The SOPs included a policy whereby all competitors were to report all incidents and near-accidents to the Wing FSO who could then take action where necessary to rectify the situation. Location and use of the crash barrier were explained fully. Pilots were briefed on the possibility of crash landings and given maps of local areas depicting dry lakes where forced landings were feasible. Experts explained the use of parachutes in the rough terrain, emphasizing how to land and what to do after landing in mountain country. Survival technique was discussed; all pilots were required to carry survival equipment, including a signal mirror and whistle, and to wear suitable foot gear.

Briefing on emergency procedures included whom to call if an emergency occurred, how to give a position report by using local grid maps, duties of wingmen in the event a team member was forced down, how to proceed after a landing was made (either in the aircraft or by chute) and procedures used by the helicopter rescue teams.

Qualified Nellis AFB instructor pilots served as tower and mobile control officers during the entire meet. Their duties included coordinating all takeoffs and landings, checking gear and flaps down on landings, assuring adherence to the traffic pattern (pilots were briefed on letdowns and patterns for all Nellis runways), assisting pilots having difficulties in landing, helping during possible emergencies and insuring that aircraft returning with less than 100 gallons of fuel made closed patterns.

The "book" also specified tow target aircraft procedures and designated runways for hung targets and cables, spelled out traffic spacing distances and pinpointed rendezvous points on the gunnery ranges.

Pilots assigned firepower and precision flying demonstrations were fully briefed with emphasis on minimum altitudes, general area peculiarities and range procedures.

Besides the usual means of determining fouls on the gunnery ranges, a special radar device was developed to check pull-out altitudes in the air-to-ground phase. The equipment was developed by a General Electric Company representative in conjunction with Nellis range officers. It was designed to replace the existing angle-ometer system in order to warn pilots immediately when they entered the danger zone.

An APG-30 airborne radar unit, normally used in the gunsight system, with an antenna installed in a separate rig, permitted vertical and horizontal aiming of the signal cone to cover rocket, bomb or strafing targets. Radar circuits were fed into an oscilloscope to give visual indications of planes entering the field of control.

Center line of the signal cone was zeroed-in to the center of the target. Elevation of the signal area was set to desired minimum altitude, 500 feet for rocketry, 35 feet for skip bombing and 1000 feet for dive bombing—during the meet. When a pilot passed below the set minimum, the scope operator spotted the error and flashed a report to range control and the pilot was notified immediately. The equipment's reliability enabled accurate measurements to be made within tolerances of plus or minus 25 feet.

Four teams from four major commands competed in the Special Delivery phase: 20th Fighter-Bomber Wing, USAFE; 3600th Flying Training Wing, Air Training Command; 49th Fighter-Bomber Wing, FEAF, 31st Strategic Fighter Wing, SAC.

Eight teams from eight major commands competed in the Day Fighter phase of the gunnery meet; 3595th Flying Training Wing, Air Training Command; 146th Fighter-Bomber Group, ANG; 508th Strategic Fighter Wing, SAC; 64th Fighter-Interceptor Wing, AAC; 64th Air Division, NEAC; 8th Fighter-Bomber Wing, FEAF; 86th Fighter-Bomber Wing, USAFE, and the 366th Fighter-Bomber Wing, TAC.

Each team flew six air-to-air missions; two were free-style at 20,000 feet; two radar at 20,000 feet, and one free-style and one radar at 27,000 feet. Each aircraft carried 400 rounds of .50 caliber ammunition, with each pilot allowed a maximum of six passes at the tow target. For the meet, minimum angle-off allowed was 15 degrees and minimum range 600 feet. Scoring was based on 100 per cent with each round of ammo counting as one-quarter of a point.

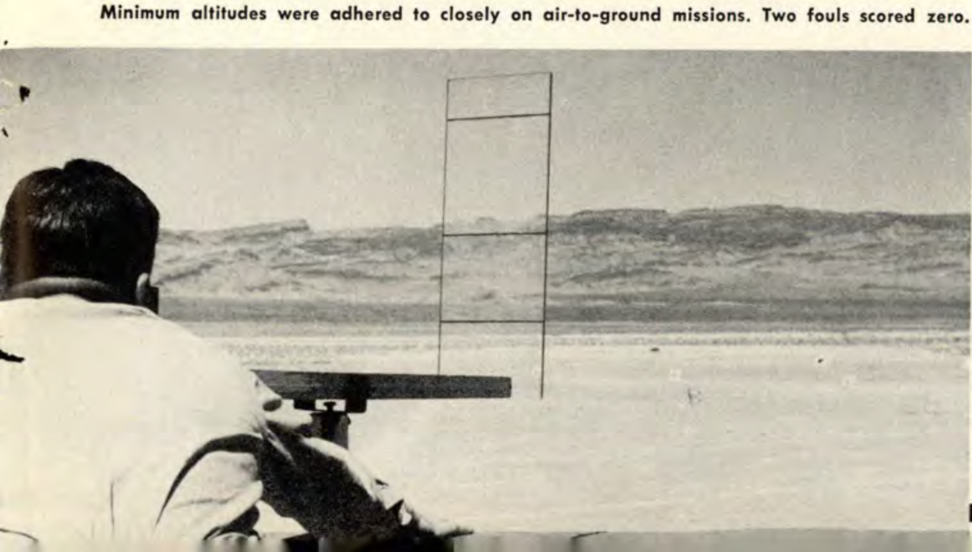
Each team flew two low-angle bomb/low-angle strafe missions during the meet. Each aircraft carried four 3-pound practice bombs per mission and 400 rounds of ammunition. Each pilot was allowed five passes to release his four bombs, and for the strafing phase each pilot was allowed six passes.

Two high-angle bomb/rocket missions were flown by the eight teams. Each aircraft carried four 3-pound practice bombs and four 2.25-inch rockets. The target was a circular grid area on the ground, with an old auto body serving as the bullseye. Five passes were allowed to drop the bombs and five passes for the rocket runs. The best three out of four rocket hits were scored on a footage basis.

Flying Safety Magazine obtained the complete gunnery patterns and procedures, as used by highly qualified Nellis AFB instructor pilots in student teaching, which contributed

Minimum low-angle strafing altitude is 150'.

Minimum altitudes were adhered to closely on air-to-ground missions. Two fouls scored zero.



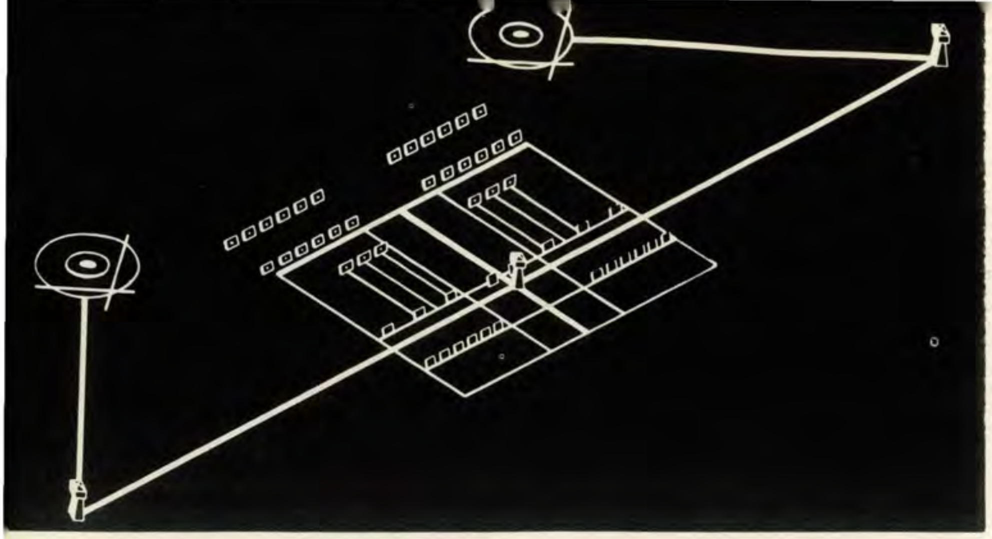


Fig. 1. Air-to-ground patterns are set up to preclude pulling guns through central tower.

Range officer checks on pull-out altitude.

to making this meet accident-free. We believe other organizations in the field can benefit from an account of these patterns and how they are flown. This article is concerned with procedures and general gunnery patterns. It is not intended as instruction in the finer phases of gunnery. No discussion is made concerning types of sights, wind drift, varying speeds for different aircraft, sight errors or depression angle corrections. It is intended to point out techniques which, if used, can help eliminate potential costly errors in procedure.

Each range is divided into two sites, left hand and right hand. A central observation and scoring tower dominates the range, with two sighting towers on the outside of each site. (See Fig. 1.) There are six 10′ x 10′ targets for strafing (two spares) on each site and four 10′ x 20′ targets for skip bombing. Two 150-foot bombing circles are used for the high-angle bombing and rocket firing.

All ranges are under strict radio control of the range officer, a qualified instructor, who is assisted by three spotters (one for each tower) and a recorder. Either the range officer or the flight leader can correct anything that appears incorrect in the pattern. This has been found to be a better all-around check on the flight, as the flight leader can't observe his number two man well in the pattern.

Low-Angle Bombing-Strafing

Aircraft enter area in echelon, pilots check in by radio with the range officer and are instructed which site to use. Right hand traffic is flown on the left site, and left hand traffic is flown on the right site. This arrangement is used to keep pilots from dragging aircraft guns through the central tower area where personnel are stationed.

The flight leader then initiates a spacing pass, with each pilot breaking at three-second intervals. A properly spaced pattern will have one man turning off target, one man turning on target, one man turning on base leg and one man turning on downwind leg, simultaneously. The base leg must be kept constant to maintain proper dive angle. If adjustment of spacing is necessary, it should be made on the downwind leg by moving in or out to respace.

While making the spacing pass, the flight leader should achieve and hold release condition airspeed. This will enable the rest of the flight to trim their aircraft for release condition and to keep them that way around the rest of the pattern. While this method makes pattern control pressures greater, it gives better hits by insuring that the aircraft are trimmed properly at release. It will also prevent a pilot from using forward trim while at minimum altitude, and averts the possibility of runaway nose-down trim condition.

Airspeed in the pattern is contingent upon moderate power settings, on the sight settings, model of the aircraft being flown and conditions at the moment of release, firing or skip bombing.

Downwind and base legs are flown at 2500 feet above the terrain. The attack is initiated by making a steep, nose-low turn of approximately 45 to 60 degrees when the target is approximately 30 degrees, or at the one o'clock position. This will prevent the pilot from making too steep a peel-off on target. The aircraft will start to lose altitude as it rolls off base. The pilot should be lined up on the target, with wings level, at least 300 feet above the ground. He picks up his target (1, 2, 3 or 4) through the canopy (not through the sight), and then reduces altitude gradually down to 35 feet above the ground, maintaining the line-up with the target.

THE WINNERS

U. S. Air Force All-Jet Gunnery and Weapons Meet

DAY FIGHTER PHASE

OVERALL TEAM (VANDENBERG TROPHY)
1st — 3595th Flying Training Wing, ATRC
AIR-TO-AIR TEAM
1st — 3595th Flying Training Wing, ATRC
AIR-TO-GROUND TEAM
1st — 508th Strategic Fighter Wing, SAC
OVERALL INDIVIDUAL
1st — Captain C. C. Carr, ATRC
AIR-TO-AIR INDIVIDUAL
1st — Major W. H. Wescott, ATRC
AIR-TO-GROUND INDIVDUAL
1st — 1st Lt. R. D. Williams, SAC
HIGH ANGLE INDIVIDUAL
1st — Captain C. O. Chennault, TAC
LOW ANGLE INDIVIDUAL
1st — Major R. R. Wright, ANG
HIGH TEAM CAPTAIN
Colonel G. L. Jones, ATRC

SPECIAL DELIVERY PHASE

OVERALL TEAM (McGUIRE TROPHY)
1st — USAFE
LABS HIGH INDIVIDUAL
Major J. J. Kropenick, USAFE
LABS LOW INDIVIDUAL
1st Lt. N. L. Walters, FEAF
DIVE BOMBING
Major J. J. Kropenick, USAFE
HIGH TEAM CAPTAIN
Colonel J. A. Dunning, USAFE

Too low—too slow—too flat on skip-bomb run.

For best results 35 feet must be held; any lower will mean the pilot fouls on his pass while higher can mean incorrect sighting. A pilot should line his aircraft up with the target originally, then maintain the track with the gunsight until the release point.

After releasing the bomb, either the 100-pound or the three-pound practice bomb, initiate pull-up with wings level until the nose is 30 or 40 degrees above the horizon before starting the turn. It is at this point that a student may get in trouble if he starts his turn before bringing the nose above the horizon, particularly if the terrain is uneven and he is just a little too low.

The turn is then steepened, and the plane is rolled out on the downwind leg, again 2500 feet above the terrain, finishing a continuous 180-degree turn that gives the break-off end of the pattern an oblong shape. At this point the pilot should pick up the aircraft ahead to get and maintain proper spacing. Sights are turned on after leaving the home field, but gun switches, circuit breakers and bomb switches are not turned on until after entering downwind leg from spacing pass. On each pass, starting with the initial pass, each pilot calls in to the range officer the range (that is, left or right) and the color of the panel (red or white), which shows whether the range is open or closed.

For example, the flight leader might call, "Reno leader in, left and white."

After the last pass each pilot makes a radio check with the flight leader stating that armament switches are off, the sights caged and the circuit breakers pulled.

On a low-angle bombing mission a foul is committed if the aircraft gets

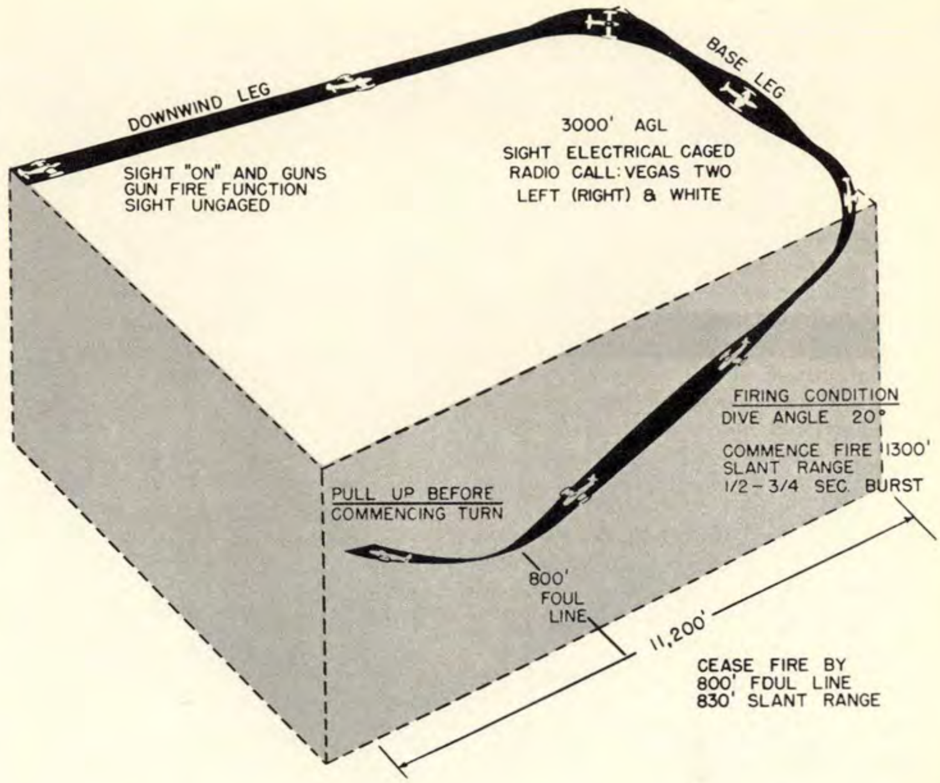
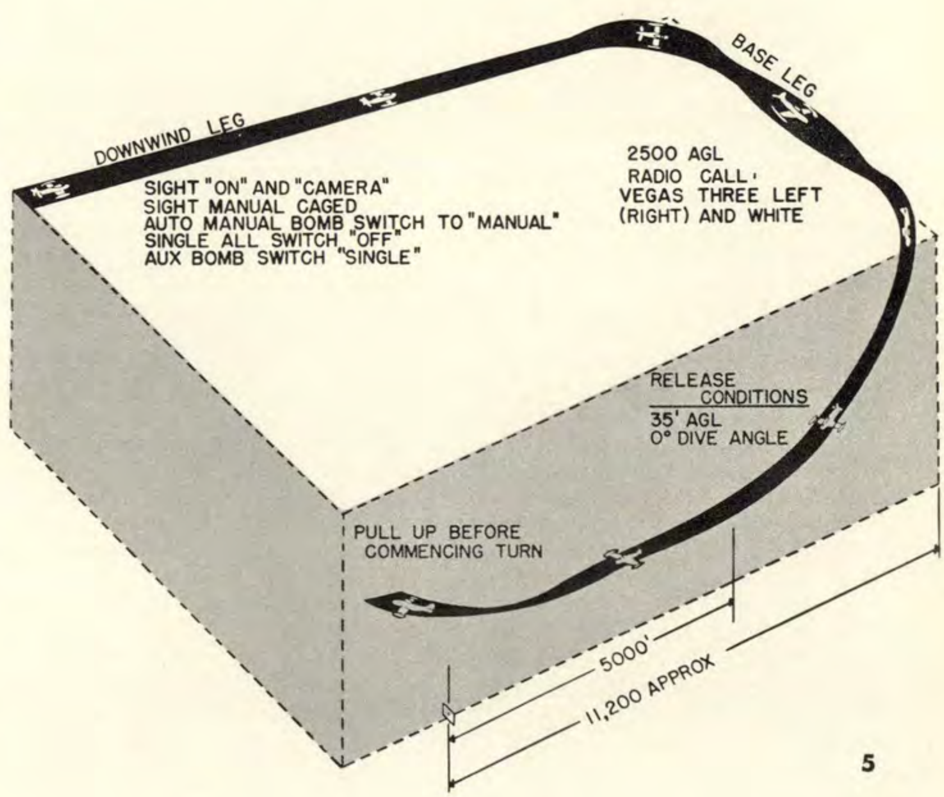


Fig. 2. This Low-Angle Strafing pattern shows degree of dive and minimums used by all aircraft.

Fig. 3. Airspeeds vary but this Low-Angle Bombing pattern is standard for all jet fighters.



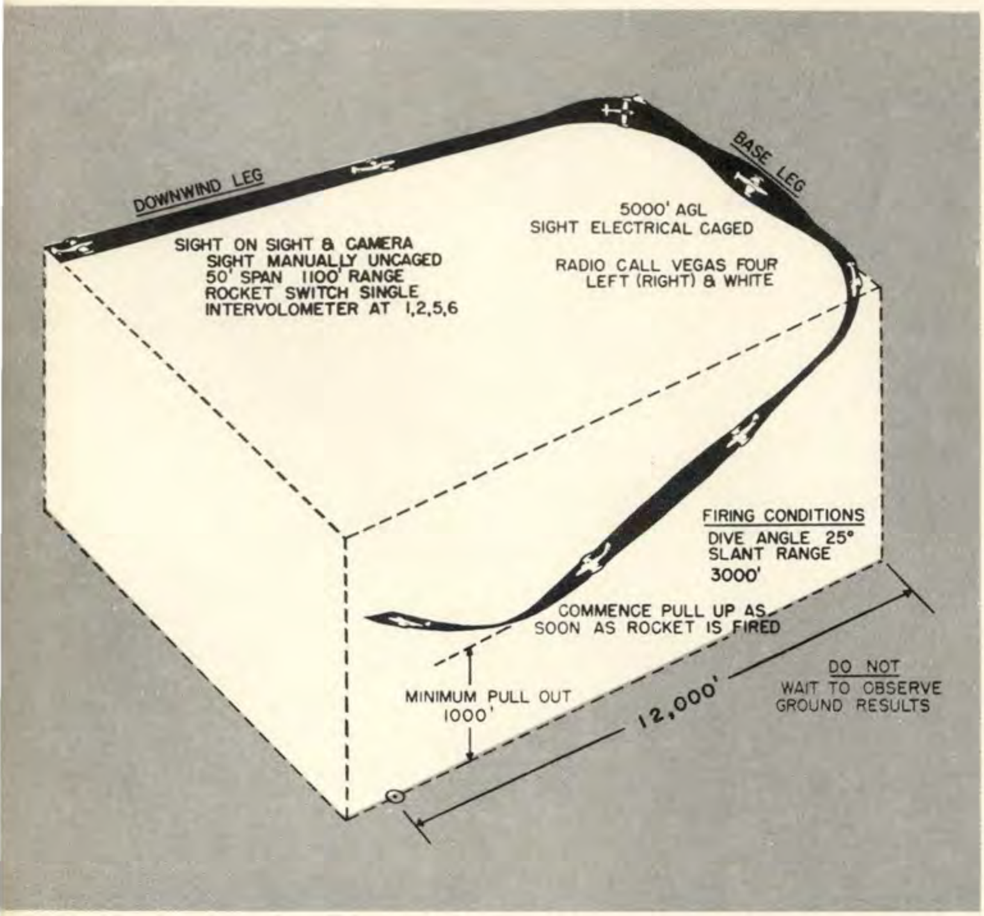


Fig. 4. In all High-Angle Rocket firing sight is put on proper wing span setting on downwind.

below 35 feet. A pilot is warned on his first foul, and if he fouls again, it is a zero mission and he is sent off the range.

After the final low-angle bombing pass, the flight pulls up on downwind leg for strafing runs. During the strafing mission the downwind leg is 500 feet higher than for the bombing runs; that is 3000 feet above the ground. The same relative spacing is maintained, with the base leg in the same position but at 3000 feet.

The turn off the base leg toward the target is not initiated as soon as on the low-angle bomb run and, in further contrast, is made with the least possible altitude loss. To make this turn properly a pilot should bring the sight picture through the horizon in a sweeping turn which will end with the sight in a direct line with the target but not directly on it. At this range the target is too small in relation to the pipper size and is very difficult to track. There is also the possibility of getting target fixation when a target is tracked through the sight too long.

After rolling out on target with the wings level, a pilot should have about a 20-degree dive. He should maintain track until approaching firing range, and at this point ease the pipper on the target. When sight pipper size and target size are in proper relation for the desired firing range, a short burst of no more than one second should be fired. Immediately after firing pull-up is initiated, once again with wings level, until the nose is 30 to 40 degrees above the horizon. After pull-up a steep turn back to the downwind leg is made.

At Nellis AFB the foul line for combat crew students is 1200 feet from target, and 800 feet from target for students in the gunnery instructor's school. Minimum pull-out altitude is 150 feet. The one-foul-warning, two-fouls-leave-the-range procedure is in effect on strafing missions, also.

High-Angle Patterns

On these missions both the central tower and one spotting tower are used for scoring and observation. The same range is used, with the target a 150-foot circle.

The initial spacing pass is made in echelon at a minimum altitude of 2000 feet above the terrain. A minimum altitude is established to preclude wingmen in stacked-down position from flying into the ground.

The pass is made at release condition airspeed to get the proper release trim just as in low-angle work.

The break is every three seconds to establish spacing, and a climb is made to 6000 feet above the terrain on the downwind leg.

While on the downwind, rocket switches are set up for firing, and bomb and gun switches are checked to be sure they are off.

Then the sight is set for proper wing span setting for the desired release condition. Before takeoff, this should be set up and solved as an equation by putting the unknown wing span setting (X) over range drum setting (normal 1000 feet) equal to the diameter of the bombing circle over desired slant range. At Nellis, for example, this would be

$$\frac{X}{1000'} = \frac{150'}{3000' \text{ slant range}}$$

or approximately a 50-foot span on the sight. The important point here is for a pilot to know his span and set it on the sight on downwind. He should never attempt to set it or reset it after turning on final.

A turn onto the base leg is made, maintaining approximately 6000 feet above the terrain. The base leg should be approximately 12,400 feet from the target. A fairly tight turn onto target is initiated with minimum loss of altitude. The sight picture is brought from the horizon into line with the target but not directly on it. If turn onto final is made correctly, the aircraft will be in about a 30-degree dive, with the wings level.

Track is maintained until approaching firing range, which can be determined by the relation of the reticule size in the sight and target size. This reticule size was determined by the span setting and the range setting of sight on downwind leg.

When the reticule size is the same as the major axis of the bombing circle, the aircraft has reached release condition or predetermined slant range. In this case, 3000 feet as set up in the formula.

At release condition a pilot fires his rockets and immediately starts a pullout. DO NOT WAIT TO OBSERVE GROUND RESULTS. If a pilot attempts to observe his hits he can get too low on pull-out and may have to pull excessive G to keep from hitting the ground.

Again, the pull-out must be made with wings level until the nose is 60 degrees above the horizon. A turn back to the downwind leg is then initiated and the aircraft leveled off at 6000 feet.

Fouling minimum is 500 feet above terrain on pull-out. Once again two fouls mean loss of score and an order to get off the range.

After the last rocket pass is made, a pull-up to 8000 feet above the terrain is made, and the same spacing is maintained on the downwind leg. After rolling out on downwind, rocket switches are turned off and bomb switches are set up. Sights are reset to the wing span setting for the slant range to be used on the bomb run. (In this case a 4300-foot slant range, with a 35-foot sight span.)

In high-angle bombing the aircraft is flown somewhat slower on base leg, and approximately 4000 feet closer to the target to increase dive angle. Pattern altitude is 8000 feet above the terrain. The turn onto final is an over-the-top turn, with a reversal onto target. This is used primarily to assure proper dive angle, as a turn underneath or diving turn would result in too much loss of altitude in the turn, causing an improper, shallow dive angle.

The sight is again brought in line with target but not directly on it. A pilot must maintain track until reticule size and target size are the same. Angle of dive is 45 degrees, and the bomb is released at 4300 feet slant range. As stated before: DO NOT WAIT TO OBSERVE GROUND STRIKE.

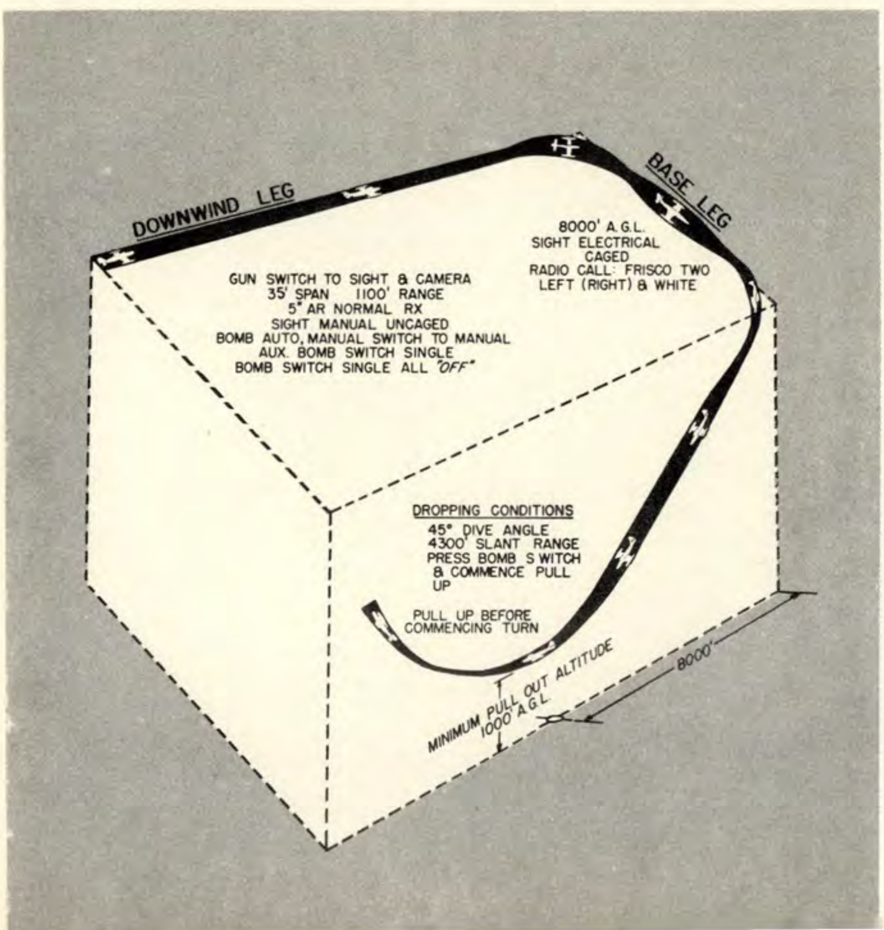
Here also pull-out is made with the wings level, with the nose of the aircraft 60 degrees above the horizon. Minimum fouling altitude for this mission is 1000 feet above the terrain, because of the steep, 45-degree angle of attack.

Care must be observed in all high-angle work to be sure release or firing is accomplished at the proper altitude. Otherwise it is likely that a pilot will pull excessive G, because the pull-out will be initiated too low. Some pilots tend just to release or fire and haul back on the stick (especially bad in rough air) instead of trimming their aircraft on the spacing pass and leaving it alone.

A pilot is required to call in on each pass in both low and high-angle work as mentioned previously, calling left or right range site and the color of the range panel. The instructor calls the end of each phase on all gunnery missions.

At Nellis, range officers are qualified IPs.

Fig. 5. In High-Angle Bombing, turn onto final is over-the-top, with a reversal onto target.



On every air-to-ground mission at Nellis an SOP is set up to cover any foreseeable emergencies.

In the event that a pilot loses his primary radio channel, he is required to go by the tower, on the same side as his gunnery passes, at 300 feet, rocking his wings. He maintains his spacing in the pattern but refrains from firing. He then switches to his secondary channel. If this also is inoperative, he maintains spacing, makes another pass at 300 feet, rocks his wings, breaks in the opposite direction to traffic and goes home.

If a pilot finds something is wrong with the plane and has no radio, he can still request assistance or escort home. He can fly a rectangular pattern, 1000 feet above base leg altitude and the flight leader then will cancel the mission, join up and escort him home.

Air-to-Air

After establishing contact, both visually and by radio, with the tow pilot, the flight leader makes a spacing pass with his flight in trail, approximately five ship lengths separation between planes.

If right hand firing passes are to be made, the pass is made level with and to the left of the tow aircraft. If left hand firing passes are to be made, the pass is made level with and to the right of the tow plane. The leader breaks up and over at an angle of 60 degrees to the tow aircraft flight path and in a steep climb. The rest of the flight follows suit and establishes proper spacing.

After breaking at a 60-degree angle, the turn is reversed, and the tow ship is picked up visually again from the other side of the canopy. The climb is continued at an angle to the flight path of the tow aircraft that will place the fighter 6000-8000 feet out and 4500 feet above it. This position will be line-abreast of the tow aircraft, and commonly is called the *perch* position.

Attack is initiated from the perch, with proper airspeed and power setting, by a nose-low diving turn into the target. At this time the target is observed through the top of the canopy, while the majority of altitude is lost in the turn. The diving turn has a two-fold purpose: it increases airspeed and precludes the possibility of collision with another aircraft in the pattern positioning on the perch.

At the gunnery meet, radar was used to detect altitude errors. This helped minimize fouling.

During this diving turn the aircraft is physically forward of the tow target (not the tow aircraft), but the sight is pointed slightly behind the target. At an altitude approximately 1000-1500 feet above the target and approximately 4000 feet out from the target, turn reversal is initiated so that the fighter is 90 degrees to the target. Now the sight moves from a position slightly behind target to one slightly forward of the safety webbing. At this point a pilot should begin tracking the target, correcting his line of flight and checking airspeed.

When the line of flight is established, he allows the pipper to slowly drift back onto the target bull and maintains this position until firing range is reached. Firing range is normally recognized by the comparison of pipper size in relation to target size or bullseye.

In the final stage of the pursuit curve, an aircraft normally will be approximately 1500 feet from the target, 500 feet above target altitude, varying from a minimum of 15 degrees angle-off to a maximum of 45 degrees angle-off. Firing position is 1000 feet from the target, 250-300 feet above target altitude. Firing minimums are 600 feet and 15 degrees angle-off.

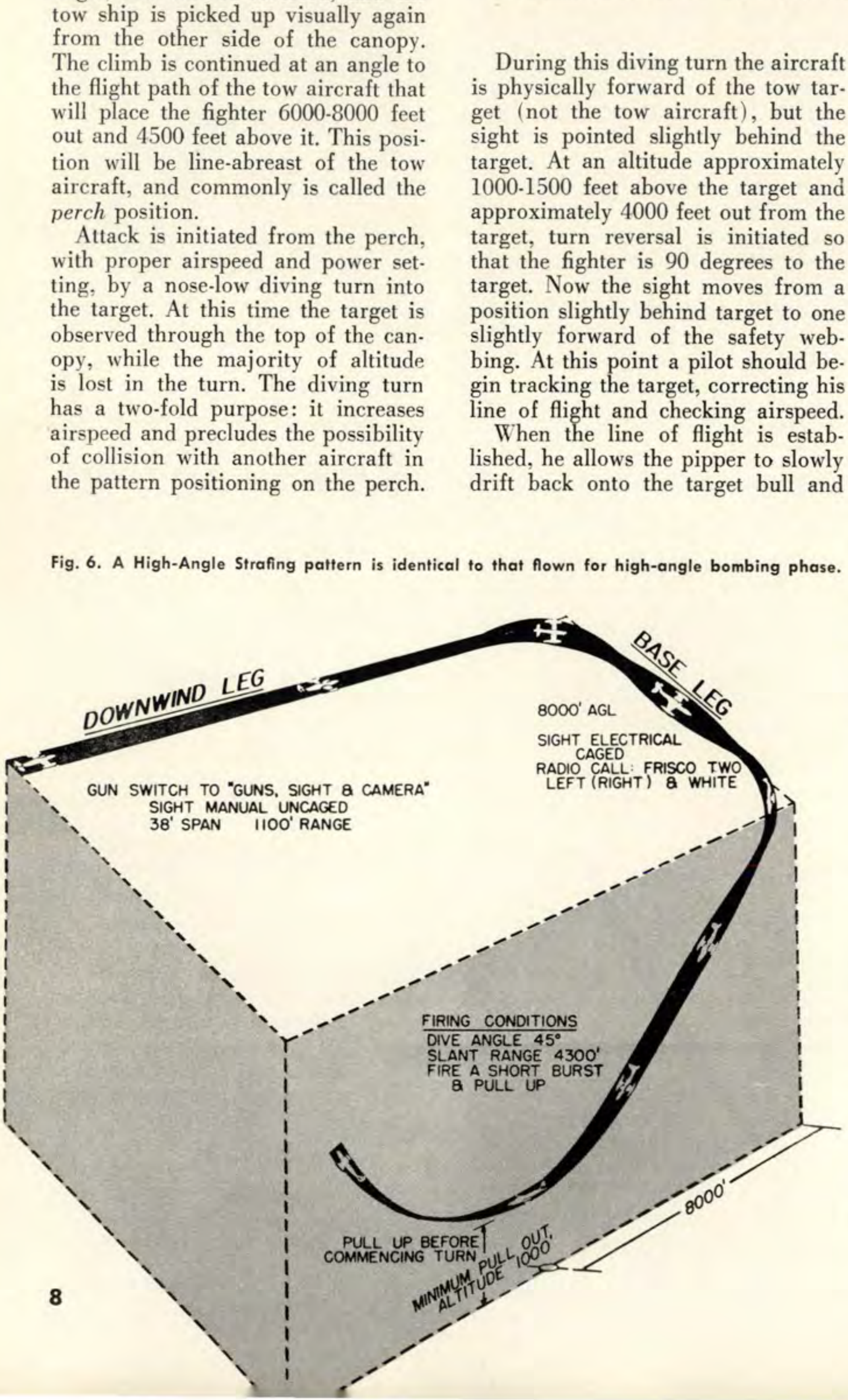
Breakaway is made behind and above flight level of the target. This enables the fighter to parallel the tow aircraft flight path at the same altitude, until passing the tow ship. A pilot, after passing the tow aircraft, should again initiate a steep climbing turn, 60 degrees to the tow ship flight path, and reposition himself on the perch.

The two most common errors in air-to-air gunnery are attempting passes at too low an angle-off and at too great an angle-off.

A pass made at too low an angle-off should be noticeable immediately to a pilot. His aircraft will close on the target very slowly, and he will pull only 1 or 2G maximum. This pass usually ends up with the fighter in trail of the target, which, as the angle decreases, will tend to appear wider than it is long. At no time should a pilot fire from this position because of the danger of hitting the tow target aircraft and the poor depth perception caused by the small target area.

A pass at too great an angle-off can be recognized by the high G forces (5 to 6G) required to track the target. This error should be corrected by repositioning the fighter in

Fig. 6. A High-Angle Strafing pattern is identical to that flown for high-angle bombing phase.



This joker scored the wrong kind of hit!

relation to the target in reversal turns on subsequent passes.

If at any time a pilot finds himself in a tail chase position, he should immediately break off the pass and call, "Making spacer." This is extremely important, as the next man in the pattern, if positioned correctly, will be in firing range at about the time the first aircraft passes the tow target and may not observe it because of his attack position. After making the spacer call a pilot should immediately start a climb, and cut to the inside of the gunnery pattern only after he has the attacking aircraft in sight.

All aircraft call "in" before turning into the target and call "off" when passing the tow ship. Before a pilot initiates an attack, he must have all aircraft in flight and the tow plane in sight. At no time will a pilot start an attack before the preceding aircraft has started his turn reversal. Care should be taken when repositioning on the perch, as the pilot in front will be initiating his attack just slightly below and behind.

The flight leader calls his flight immediately prior to making the last pass in the mission, warning that this is the last pass. After the last pass all pilots call the flight leader to state that gun switches are off, sight is caged and circuit breakers pulled, if applicable.

Before each mission, regardless of type, all aircraft are armed at a position adjacent to the takeoff runway, with armament pointing toward an uninhabited area. As a pilot pulls into position for arming, he rechecks

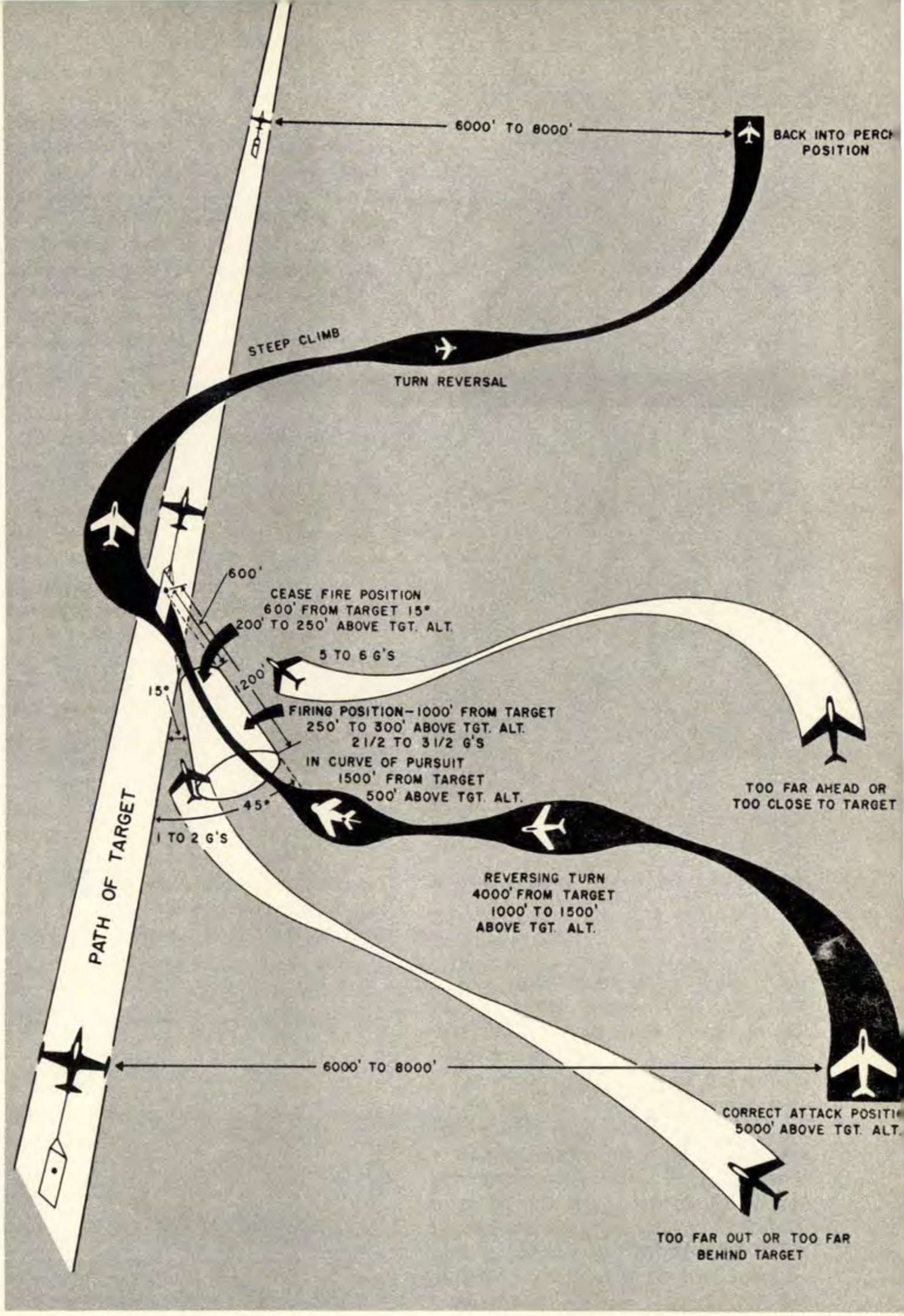


Fig. 7. Correct angle-off of 15 to 45 degrees is a must when flying an Air-to-Air mission.

to be sure the armament switches are off and places his arms outside cockpit to indicate that all is clear.

De-arming procedure is the same but at the opposite end of the runway. Any aircraft with automatic chargers are de-armed while still at the end of the runway.

At Nellis AFB each phase of a mission is briefed by the flight commander, with further individual briefing by the instructor immediately prior to the mission. After the flight a de-briefing is held, and the instructor pilot points out mistakes and improper techniques to his students. Cameras are used on each flight, and the film is assessed to further analyze each phase of instruction.

The people at Nellis believe they produce the finest fighter pilots in the world. That they have succeeded in the past is evidenced by the record of the Nellis graduates in Korea. They also believe that the procedures and patterns they have set up are reducing accident potentials, and from here it looks as if they are right. ●

SLANT RANGE ANGLES

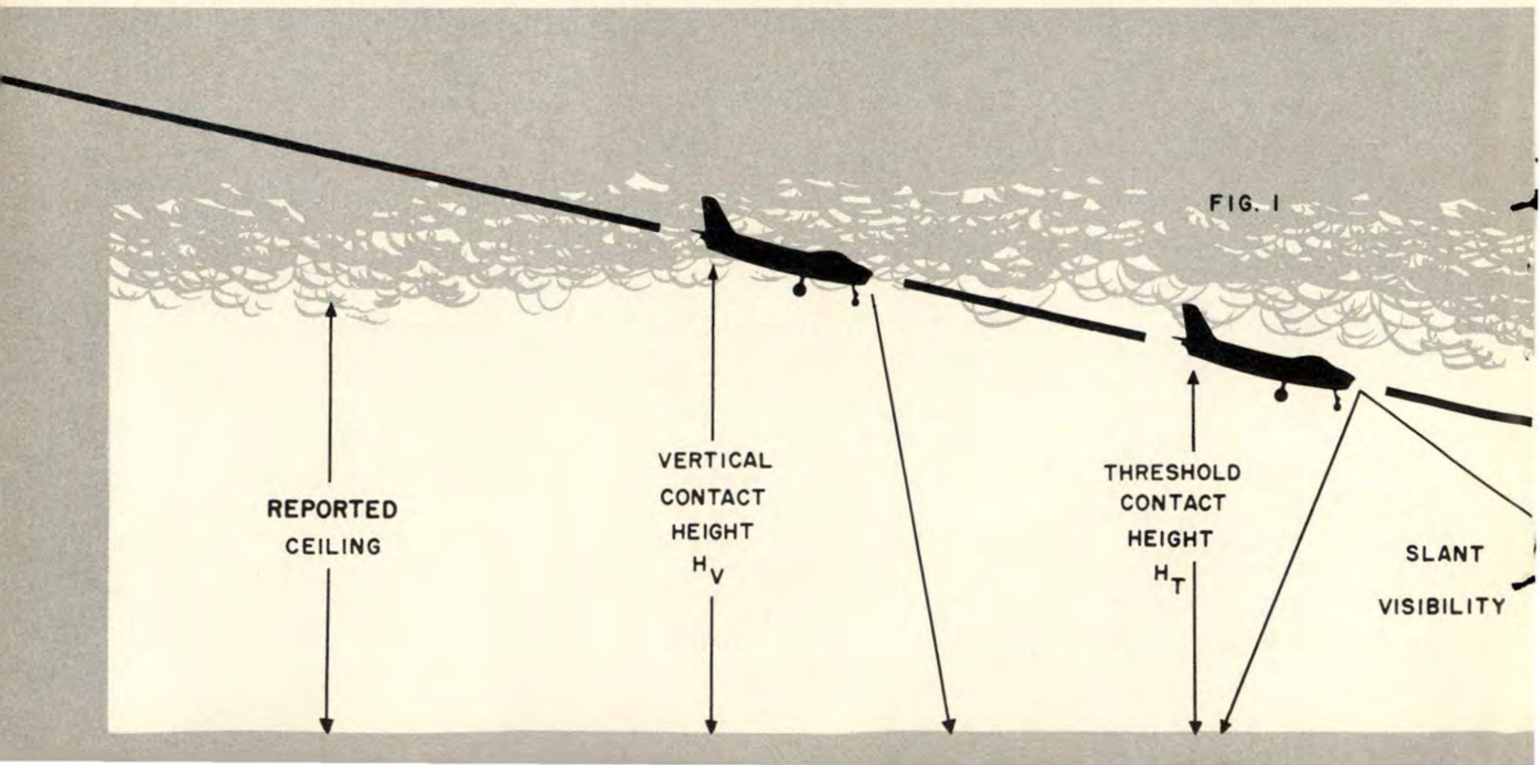
The problem of visibility and cloud height in the approach zone has been investigated during the past few years by eighteen separate countries, including the United States. The specific problem of pilot's slant range visibility or "effective pilot ceiling" was recognized as early as 1949. Two articles appearing in Flying Safety Magazine (May and September, 1953) shed additional light on this problem.

The following information was supplied by Air Weather Service. Although no firm cure-all has been developed, pilots will be interested in the thinking and planning currently being employed to solve the slant range problem.

JUST what is the definition of a meteorological obscuration?

It is any element which obscures or partially obscures the sky. The problem to be discussed in this article, however, is limited to those obscurations which are touching the earth's surface. These are commonly called "surface based obscurations" and are reported as "partial obscurations" (−X) and "obscuration" (X).

During the early years of aviation, when meteorological practices were being developed to satisfy aviation requirements, the concept of "ceiling" height was developed. This concept involved measuring or estimating the vertical visibility from the surface. With obscurations (clouds) based aloft, this vertical visibility was the distance (height) of the base of the obscuration above the surface. But when the cloud base was on the ground, the ceiling was not reported as zero. The vertical visibility distance was reported (as some multiple of a reportable ceiling increment). The practice of reporting vertical visibility was applied to all ceiling conditions, whether cloud ceilings, or fog, rain, snow, haze, smoke, dust or any other type of obscuration which could obscure the sky. This method



of reporting proved fairly satisfactory in the past for several reasons.

Aircraft operations were not normally conducted under very low weather conditions, and possible reporting errors were not therefore of great significance.

The method developed was a logical approach to determining the ceiling. No refinement appeared necessary because ceiling reports coincided with pilot reports of broken or overcast cloud bases, which are the types of ceilings usually encountered.

Why, then, has the obscuration problem developed? First is the constant lowering of weather minimums required for aircraft operations (a 500-foot error in a reported 1500-foot ceiling is of small importance when compared to this same error in a reported 500-foot ceiling.). When we report conditions approaching VFR minimums, the pilot is highly indignant when he finds conditions existing which are too low to allow a safe landing. The difference between what we report and what the pilot reports often exceeds the pilot's margin of safety, especially when we report (X) or (—X).

This apparent discrepancy is not usually of vital importance to the pilot of a conventional aircraft. If he finds conditions too low for safe landing, he can make a go-around and proceed to his alternate. However, the advent of jet aircraft has changed all this. It is now of vital importance that we report what the jet pilot will find when he approaches. This is of prime importance because, in many instances, if not in most instances, the jet pilot must commit himself to a landing from altitude, not from his approach. He can't approach, go around, and then go to his alternate. He must know if he can land . . . or proceed to alternate before he begins his descent.

We all have learned that there are discrepancies between the official observation and the pilot's report. Why? Simply because we can't observe what the pilot will see, and because we can not observe, measure or determine slant range visibility when a surface obscuration is present. The net result is that we report vertical visibility as the ceiling. This is the pilot's vertical contact height, if his visibility down is equal to our reported visibility up. (See Fig. 1.) However, this is not the ceiling height which the pilot will see or report because:

- The pilot is not peering between the rudders for the ground. He can't, even if he wants to. Instead, he is flying by means of instruments down the descent path.
- Even if he made vertical contact, he has visibility *only* in this straight down direction. He can't go VFR and complete, from that altitude, a visual approach.

The ceiling height which he will report is the altitude at which he is first able to see a sufficient ground distance ahead of the aircraft such that he can go VFR and remain so through his landing roll. (Ht. in Fig. 1.) This is variously called "threshold contact height" or "Effective Pilot Ceiling." It is the "ceiling" as far as the pilot is concerned, because he has slant visibility sufficient to "go VFR." (If no obscuration is reported, the cloud ceiling height is also the pilot's ceiling height, since he does have slant visibility. In this case, vertical visibility will give the pilot the correct ceiling, but *only in this case*. See Fig. 2.).

So you see, the discrepancy arises when we report one element while the pilot reports another. The danger is obvious. We report one element which the pilot interprets to be another element. The significance of obscurations now also becomes apparent. These are the conditions under which it is impossible to report the "effective pilot ceiling," and the thing we do report is misinterpreted by the pilot to be the "Effective Pilot Ceiling."

Recently we have begun to report in Sequence Remarks the amount of sky obscured by a partial obscuration. This is the first step taken to clarify reported conditions. This does not solve our problem, however, since a partial obscuration (defined as a surface based obscuration through which vertical visibility is unlimited) can also create an "Effective Pilot Ceiling." This is so because "Effective Pilot Ceiling" is tied to slant range visibility, not vertical visibility. The Directorate of Flight Safety Research has suggested that we cease reporting obscuration "ceilings" altogether in order to stop confusing the pilot.

Actually, the entire obscuration problem can be stated simply to be the problem of "slant range visibility" in the approach zone. Measurement of

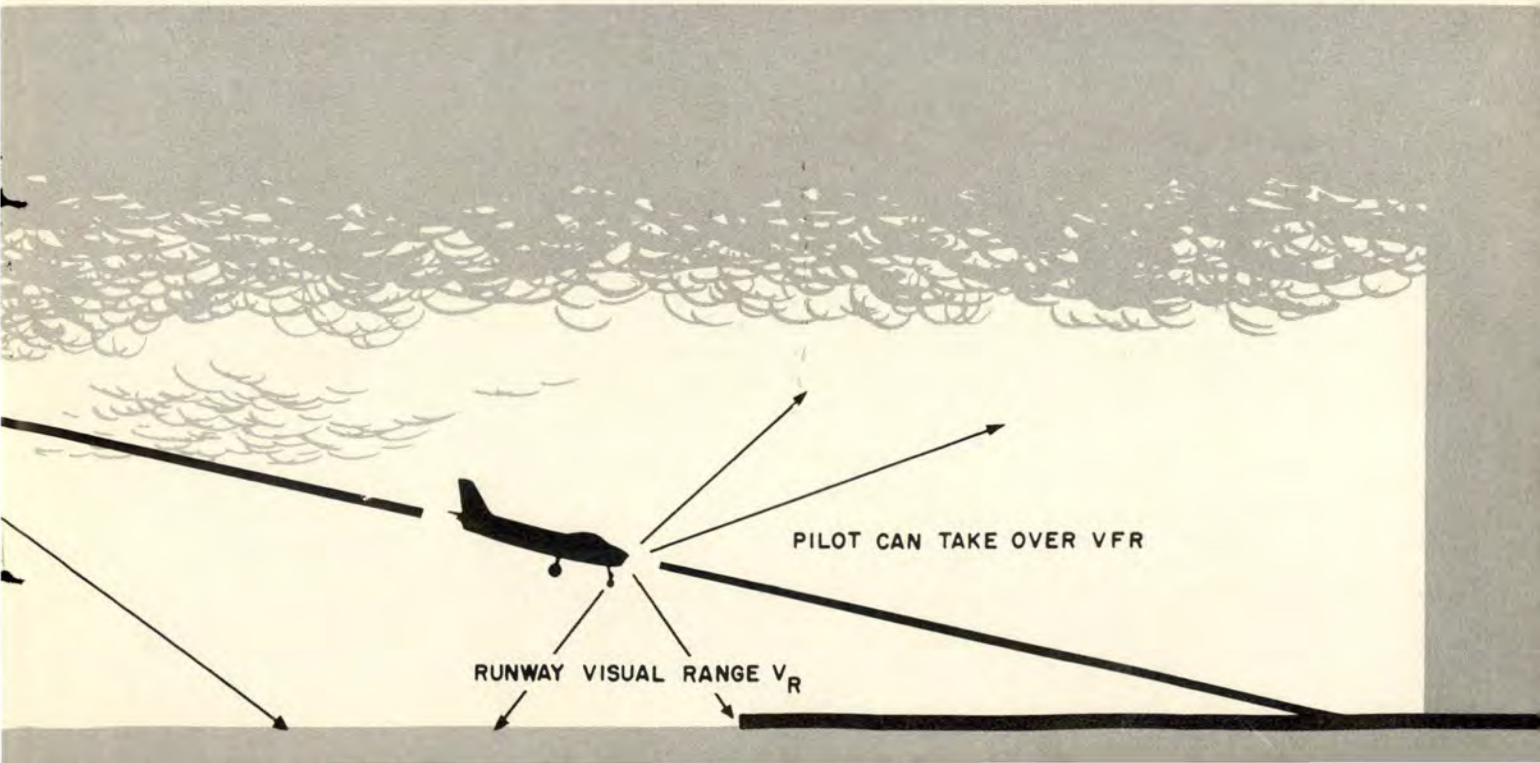
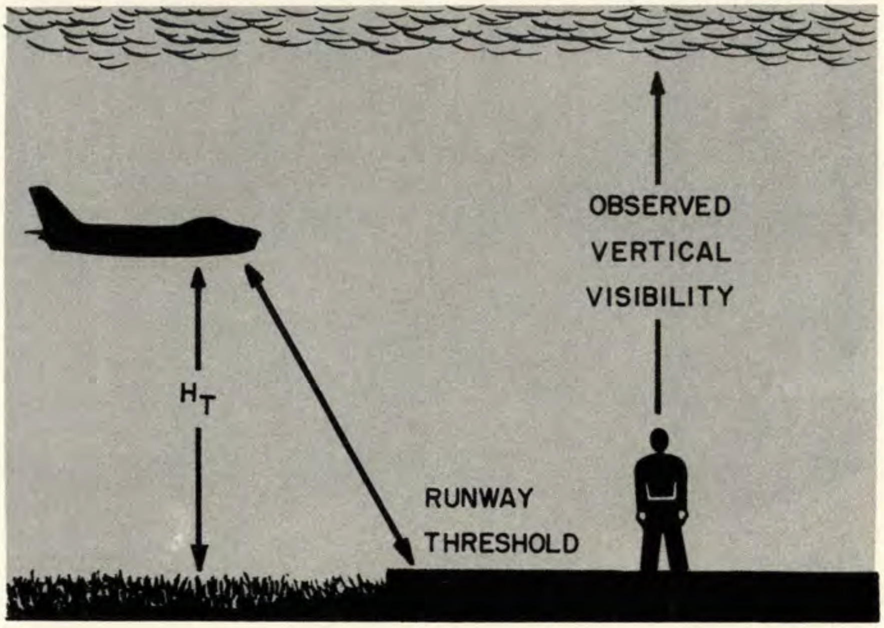


Fig. 2. With no obscuration present, the ceiling, as reported by the weather observer, is the same as the pilot's threshold height.

Fig. 3. With obscuration present, the weather observer's reported vertical visibility is greater than the pilot's threshold height.



this element has been, and is presently being investigated by several agencies both within and out of the United States. The International Civil Aviation Organization included this item as the first on its agenda at last year's Air Navigation Conference at Montreal. The ICAO is presently collecting all available information on the problem as is the Subcommittee on Meteorology of the President's Air Coordinating Committee. The British, French and Dutch have all investigated the problem, and Sperry Gyroscope Company is presently engaged in a research project under contract from the Air Navigation Development Board.

The Sperry project involves collecting and evaluating data from:

- A standard Weather Bureau Station.
- Transmissometers and rotating beam ceilometers (installed on the field and in the approach zone).
- Flights during about 500 low ceiling-low visibility approaches made at MacArthur and other fields on Long Island and in the New York area.

This data, when evaluated, may enable us to adopt the suggestion of Flight Safety Research, or to come up with other changes in our reporting procedures so as to report the actual flying conditions which pilots will find. The Sperry report on this project is scheduled for publication about 1 September of this year.

This process of educating the pilot should be of some help until we get the real solution: a revision of reporting practices which will eliminate the built-in confusion of our present reporting methods.

At the present time, and from information presently available, we have two possible approaches to our obscuration-slant visibility problem.

- The first and most desirable approach is to find a method of computing and reporting the "Effective Pilot Ceiling" or "Threshold Contact Height" from elements which we can presently observe and measure. This computation should lend itself to application at any aerodrome where trained observers take the observations. This method should report a "ceiling" height, since one of the MET elements which determine aircraft operating minima is the "ceiling," and because this element lends itself best to use by the pilot, who flies heading, airspeed, rate of descent, and ALTITUDE when making his instrument approach. To substitute a *time* or a *distance* element for the "ceiling" would only increase the pilot's workload. We expect to be able to determine if it is acceptable to report an "Effective Pilot Ceiling" corresponding to the "vertical visibility" ceiling by correlating presently reported elements and pilot's slant range obtained from the Sperry data.
- If we can not find a suitable method for determining "effective aircraft ceilings" and "pilot's slant range," we may be forced to cease reporting "obscuration ceilings." This will force the operators to completely revise the present system of determining operating minima, and may also involve other problems not presently anticipated. ●

Flak Is Outlawed—"Irate farmers who have been shooting at low-flying aircraft that allegedly disturbed their stock had better hang up their shotguns after 1 July in N.Y.

"On that day, under a bill approved recently by Governor Dewey, the willful discharge of a firearm at an airplane, whether in the air or on the ground, becomes a felony.

"The law authorizes a jail sentence of up to twenty years if 'the safety of any person is endangered' by the shooting.

"The first draft of the bill provided the same penalties for throwing 'stones or other missiles' at airplanes. It was amended late in the session to cover only the firing of guns."

(But shotguns are still *de rigueur* for disturbing a farmer's daughter!)

Flight Safety Foundation

It's the Way It Bounces—After banging around the world for lo these many years and suffering numerous bruises, I'm partial to those flights where a stewardess says, "May I help you fasten that safety belt?" You never know when the sweet gusts will sprawl her in your lap. But, with this Passenger Basic AFSC that I hold, I find most of my orders specify military air; hence, usually, no lovelies to get sprawled with.

Even though I can't toss with a stewardess in a thunderstorm or enjoy some intimacy in clear air turbulence, I WANT TO BE STRAPPED IN REAL TIGHT. Further, I want some warning from the pilot, crew chief or radio operator . . . anybody. I once rode the mountain wave in the lavatory. It was bruising and — to say the least, embarrassing.

The following excerpt from an airline vice president in charge of operations to his pilots is appropriate to the military:

"The increase in speed in modern aircraft has been accompanied by an increase in the number and severity of passenger and attendant injuries resulting from turbulence. Some of these occur in clear air turbulence. Others occur in frontal or thunderstorm areas where turbulence is known to exist.

"In practically all cases the seat belt was not fastened. Generally, this was because the sign was not on, or had not been on long enough for the attendant to check the belts . . ."

Give the boys in the back room a break. When you *expect* turbulence, allow time for them to break up the card game, drain the coffee cups and secure their belts. After all, it gets real old in a hurry when a man finds himself spread-eagled five feet in the air, about to stall in on a bucket seat.

"Quac"—A new, high-performance computer, capable of accurately programming over 20 separate flight operations simultaneously, has been developed and built by Northrop Aircraft, Inc., under contract to the U. S. Air Force.

The computer accomplishes this task by simultaneously picking up flight data, performing mathematical computations, timing and recording navigation directions, remembering and sending out flight instructions over a long period of time.

This machine, called a Quadratic Arc Computer and nicknamed "Quac" by the engineers who designed it, is an extremely compact device when its ability is considered. The computer measures five feet long, 40 inches wide and 33 inches high.

"Quac" is made up of over 6,000 electronic parts. It can "think" at the rate of 5,000 calculations per second and store up 2,600 digits in its memory system.

The "Gee Whizzer"—Ten months ago the U. S. Air Force, in a succinct 52 words, one of the briefest new-aircraft announcements on record, disclosed a contract with Lockheed for prototypes of the XF-104 jet fighter, called the "Gee Whizzer" by test pilots who have flown this new aircraft.

Recently, the USAF announced that this new member of the team is flying successfully — that Lockheed put the sleek sliver of aluminum in the air only a year after it was ordered. The XF-104 made its first flight in February, 1954, at Edwards AFB, Calif. "Designed to establish local superiority in a given area by sweeping the skies of enemy planes," as USAF announced, the XF-104 has been unofficiallly reported to be a light-weight fighter plane, which is unusually fast.

"This contract with Lockheed represents one part of the U. S. Air Force's continuing program to press aggressively the development of superior weapons," according to the Secretary of the Air Force, Harold E. Talbott.

The contract with Lockheed Aircraft Corporation was signed in March, 1953, and the XF-104 rolled out of Lockheed's Burbank, Calif., plant in February, 1954.

Following roll-out, it was trucked to the Mojave Desert test facility, where it is still undergoing airworthiness tests.

A Curtiss-Wright J65 jet engine powers the new fighter.

Glare—The glare of the runway lights appears to be a strong contributing factor in some accidents. Depth perception and orientation in space are impaired by glare. If sudden changes in the intensity of the most prominent feature in the visual field (the runway lights in this case) are made, false impressions of distance are induced. This effect might be considered an illusion. Decreasing the intensity of a light makes it appear to be farther away when there are no other clues to distant judgment. For this reason changes of the intensity of the runway lights during the last seconds before landing should be discouraged. Tower personnel should be instructed about this phenomenon. Pilots should be similarly instructed so that they request the necessary changes early in their approach. Pilots must be aware of the above mentioned effects so that they mistrust distance judgments affected by light intensity changes and in so doing can help avoid accidents. ●

KNOWLEDGE

WELL DONE

TRAINING

Lt. Jack R. Lovell
97th Fighter-Interceptor Sq.
Wright-Patterson AFB, Ohio

While shooting a GCA in an F-86D, Lt. Jack R. Lovell was told to take his plane around from an altitude of 700 feet on final approach. Lt. Lovell added full power and raised gear and flaps, clearing to the right of the runway.

Immediately the F-86's engine lost power, then surged again. The RPM fluctuated between 60 and 90 per cent. Lovell turned back to the runway, retarded the throttle to idle and switched to the emergency fuel system. After switching, the engine remained in idle RPM and he declared an emergency. At this time Lovell was on a downwind heading at 800 feet. After planning his base leg carefully, he was able to lower gear and flaps on final and make a downwind landing.

Well Done!

Captain Harry A. Brown, Jr.
331st Fighter-Interceptor Sq.
Suffolk Co. AFB, New York

While climbing an F-86D to altitude on a local test flight, Capt. H. A. Brown, Jr. noticed that the airspeed indicator and rate of climb indicator were fluctuating. Capt. Brown leveled off at 17,000 feet and turned back toward his base just as the instruments became inoperative.

At this time, the aircraft developed electronic fuel control problems which finally resulted in a flameout at 14,000 feet over the field. After two unsuccessful airstarts were attempted, Brown set up a flameout pattern and made a successful deadstick landing on a 7000-foot runway, with no airspeed or rate of descent indicators. This was Capt. Brown's third successful deadstick landing in six months!

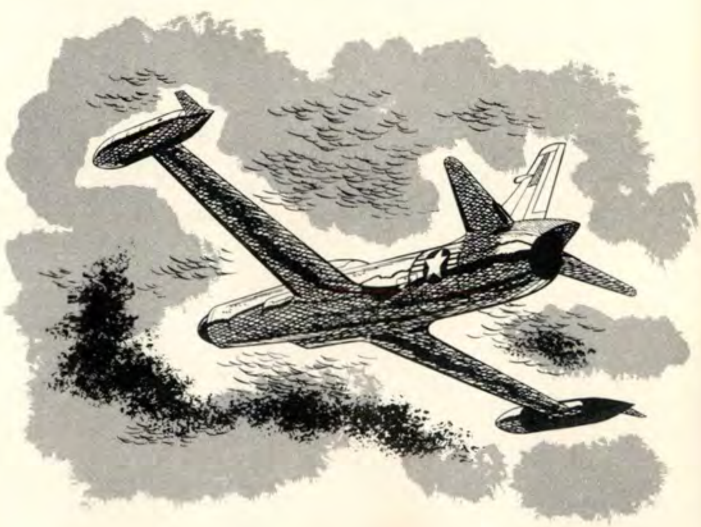
Well Done!

Lt. John A. Sickel, USN
84th Fighter-Interceptor Sq.
Hamilton AFB, Calif.

While flying at over 40,000 feet, Lt. John A. Sickel, USN exchange pilot, had his F-94C's engine flameout. Base weather was 3000 feet overcast, 1500 feet broken. Lt. Sickel started a glide toward the field, homing on the local beacon.

Sickel arrived over the beacon at 20,000 feet and started a spiral descent while employing all airstart procedures without success. He entered a solid cloud layer at 9000 feet and caught his first glimpse of the ground at 3000 feet. Orienting himself, he lined up with the landing runway, slightly upwind of the high key point. He established a tight 360-degree turn while lowering the gear, using the emergency system and made a normal landing on the runway.

Well Done!



In high performance aircraft, on a collision course, you have only . . .

Short Seconds!

Colonel H. G. Moseley, USAF (MC) Chief, Medical Safety Div. D/FSR

RECENTLY a pilot who was undergoing training in a jet fighter aircraft returned from a skip-bombing mission and was somewhat concerned when his crew chief pointed out several dents in the leading edge of the wing, scratches on the bottom of the aircraft and pieces of Yucca cactus firmly embedded in the air scoop.

In this foliage-gathering mission, the pilot's wingman, who was flying behind him, was impressed with the low level of the pass, so low indeed that jet wash raised considerable dust in the passing.

All of which might be placed in the "Tut-tut, don't-do-it-again" category except for the fact that a number of other pilots have had similar experiences but leveled off a few feet lower, with rather dramatic results. If the pilot had stopped to calculate his dive angle and closing speed toward the ground, he would have realized that at the time he began his pull-out he was angling toward the ground at the speed of some 500 feet a second, and if he had delayed his pull-out as much as 1/50th of a second more, well . . . ? ? ?

There is little doubt but that the pilot was sincerely attempting to fulfill his mission of bouncing a bomb through a target and that he did not wilfully intend to give his wingman a case of near-nervous collapse by the maneuver. His near-miss was inadvertent as he would never have had this mishap had he realized the vital importance of two factors, both of which every jet jockey needs to know and respect. These factors are, first, the terrific, almost unreal rate of closing speed in high performance aircraft and, second, the built-in limitations of man whose reactions are appallingly slow when pitted against the rapidity of events which may be encountered in high speed flight.

Closing speed of high performance aircraft is something rather new to the human race. To grandfather it never meant much more than an occasional collision between a buggy wheel and the front porch step during the haste of getting grandmother to church. Even to father in the day of the Model T it seldom meant more than a crumpled fender and a ruffled disposition which could be straightened out by means of a pair of pliers and a bottle of beer, respectively. The driver of the modern car, however, has begun to learn more about closing speed and why to respect it. The

relative ease with which man has encompassed this new challenge is somewhat of a tribute to his ingenuity. Within a very few years he has learned to glance at on-coming traffic and decide with a certain degree of accuracy his ability to safely pass the truck in front of him. Subconsciously he has developed a third dimensional gage of a new phenomenon. And, one might add, Monday morning's papers contain some interesting observations on those who were unable to learn.

Yet, in spite of his experience on the highway, when man pilots a jet aircraft he encounters closing speed which has no earthly comparison and whose significance he has not yet learned to interpret at a glance. Therefore, it may be appropriate to take a more or less typical fighter mission, dissect it and look at the anatomy of this strange new force.

Inasmuch as high-angle strafing and bombing attacks are common maneuvers we can take a high-angle strafing mission in an F-86 with roll-in at 10,000 feet and pull-out at 1000 feet above terrain. Fortunately, it takes no Einstein to understand the time-space anatomy of this situation. There are just three factors in it: *direction, speed and recovery.*

In this mission direction is simple; once the nose of the aircraft is pointed 45 degrees below horizontal, it is established. There is only one nasty little complication. This will become apparent later.

The next factor is speed. This also sounds simple; once a velocity of approximately 450 knots is established we have the speed. Any questions?

At this point all who have no questions might reconsult their insurance agents, because just as two and two equal four there are two factors built into the problem which, if unaltered, may add up to an untimely end.

These factors are vital because the direction is down, and, to state it mildly, the aircraft is moving. As a result, a collision with the earth is sooner or later inevitable. Therefore, in any mission where speed toward the earth is established there must be an accompanying and equally important consideration of time. Not knowing the minimum length of time that the speed and direction may be maintained before change is essential can be placed in the same category as not knowing the gun was loaded.

There are many charts showing how long it takes to lose altitude in various degrees of dives at various

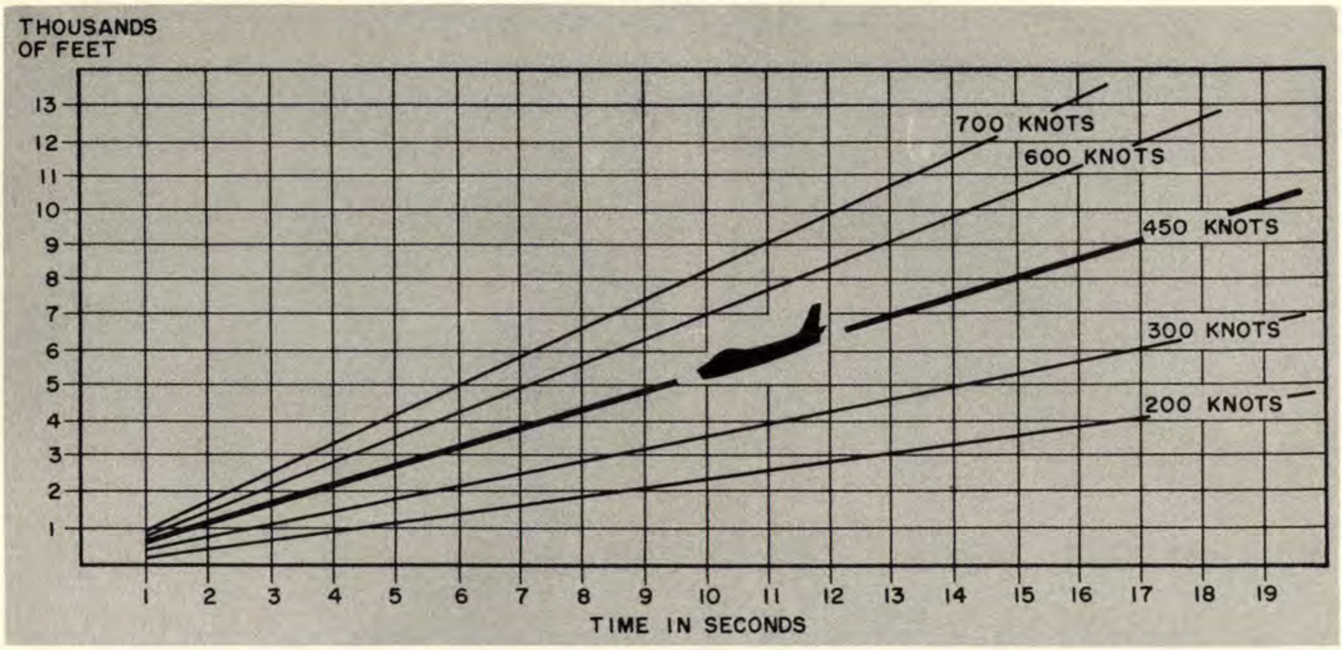


Chart A. As shown by the chart, at 450 knots in a 45-degree dive, 9000 feet will be lost in about 17 seconds.

speeds. An example is Chart A. In this mission we start at 10,000 feet and pull out at 1000, indicating that we have 9000 feet of altitude to lose. As can be seen by the chart, at 450 knots 9000 feet in a 45-degree dive will be lost in approximately 17 seconds. However, if we hold the dive for 17 seconds we will commit one more unpardonable error—that is the error of allowing insufficient time for recovery. Recovery is the last major factor in the relatively simple anatomy of a dive. However, we should take a long, careful look at this item, for recovery from a high-angle strafing mission brings into sharp focus some of the most critical hazards of rapid closing speed.

Flight surgeons and scientists have gone into long dissertations and have written reams concerning acceleration, G force and other physical laws of time, motion and space which are involved in changing the speed and direction of flight.

Momentum and Inertia

However, the factors which most directly confront us in recovering from this dive are the forces of momentum and inertia. One of the peculiarities of nature is that when something is moving, it keeps right on moving in a straight line until it meets some form of resistance. And the heavier the object and the faster the speed, the more resistance it takes to slow it, turn it or stop it.

This tendency to keep on going is due to the object's momentum and inertia, and for the sake of simplicity we can think of these forces together as momentum. A baseball, after being pitched, continues in the direction it is thrown due to its momentum, and it is stopped by the resistance of the batter, the catcher, the solid earth or the friction of air. If a rock the size of a basketball is thrown with any force, neither the batter nor the catcher can stop it effectively and it will take considerable friction to overcome its momentum.

In the F-86 high-angle strafing mission we have committed several streamlined tons of aircraft to a speed approximately that of a .45 caliber bullet. Here we have momentum in truly awe-inspiring proportions, and it is momentum which will require tremendous resistance to change. Unlike the baseball, the only acceptable form of resistance we can use is the friction of air. With this friction we must both slow down the dive and change the direction of the aircraft by at least 45 degrees.

A speed of 450 knots is considerable, and a jet aircraft, even with dive brakes extended, does not offer much surface for effective atmospheric friction. Therefore, we need both time and distance to overcome speed. In fact we need so much time and distance to slow a nose-down dive that reduction of speed is only of minor importance in our problem of recovery. What is of paramount importance is change of direction.

It is the item of change in direction which is the toughest problem of all. It is something that every pilot is constantly confronted with, and it is so closely tied to fundamental laws of nature that it must be given monumental respect if human flight is to be successful. As we mentioned above, momentum tends to keep an object going at the same speed and in the same direction until it meets resistance. Thus, when an aircraft's nose is pulled up, the pilot tends to go on in the original direction, and G forces are created. These same G forces work on the aircraft structure and wings, and the more rapidly the direction is changed the greater become the physical laws pushing the aircraft and the pilot straight ahead. After a point neither the pilot nor the plane can any longer resist this force, and unconsciousness or disintegration occurs.

Required Pull-out Time

It is appropriate here to look at Charts B and C to see the length of time which will be required to pull out of a 45-degree dive at 450 knots, at both 4 and 6G. At slower speeds less altitude is needed than is shown on the charts. However, the amount of G that can be used effectively on the aircraft and the time required to recover at this speed, must be computed well in advance. If insufficient time is allotted and the aircraft is committed to too low an altitude before recovery is begun, momentum and inertia, following the inexorable laws of nature, will take over and commit the aircraft to disintegration in the air or collision with the earth, no matter what efforts, threats or appeals the pilot may use.

The amount of altitude needed for recovery must be carefully computed, because it is least subject to compromise, and this altitude must be added to the distance above the ground wherein level flight is desired. Above that can be found the time allowed for aligning, sighting and firing. The successful pilot will know full well this time factor, because the seconds computed will be far more exact than his altimeter, and frequently more reliable than his vision.

For those who wonder why the altimeter is not reliable, it is relevant to note that a target and an altimeter cannot be simultaneously watched, and it is even more relevant to note that in high-speed dives the altimeter lag places the aircraft many hundreds of feet nearer the earth than is shown by the instrument. For those who wonder why vision alone is not a good substitute for timing a dive, it is well to consider the limitations of man and his reactions.

In considering man and his reactions, we can briefly review another accident. It is also true. It is chosen because it is typical rather than bizarre. The factors which caused it are still present. These causes are unchangeable. Only by knowing them can we prevent repetition.

This accident had its inception when a pilot, flying a jet interceptor found it rather monotonous making the usual camera gunnery passes at a bomber and requested permission from the bomber pilot to make a head-on pass. Permission was granted, and the interceptor pilot moved out ahead, oriented himself and waited for the bomber to appear. Eventually he sighted it approximately three miles distant and coming toward him. He swung in for his pass and then pulled up over the left wing of the bomber and away. He immediately noticed a severe yaw accompanied by buffeting and found

Chart B. This chart shows altitude lost in pull-outs from 30, 45, 60 and 90-degree dives from 10,000 feet at 6G.

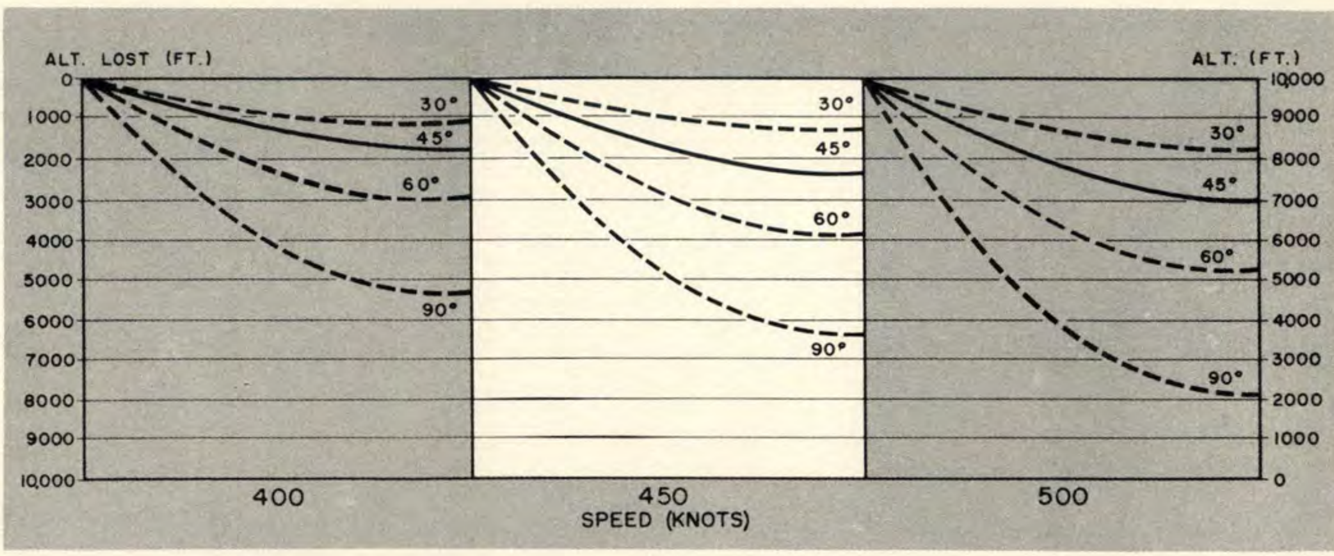
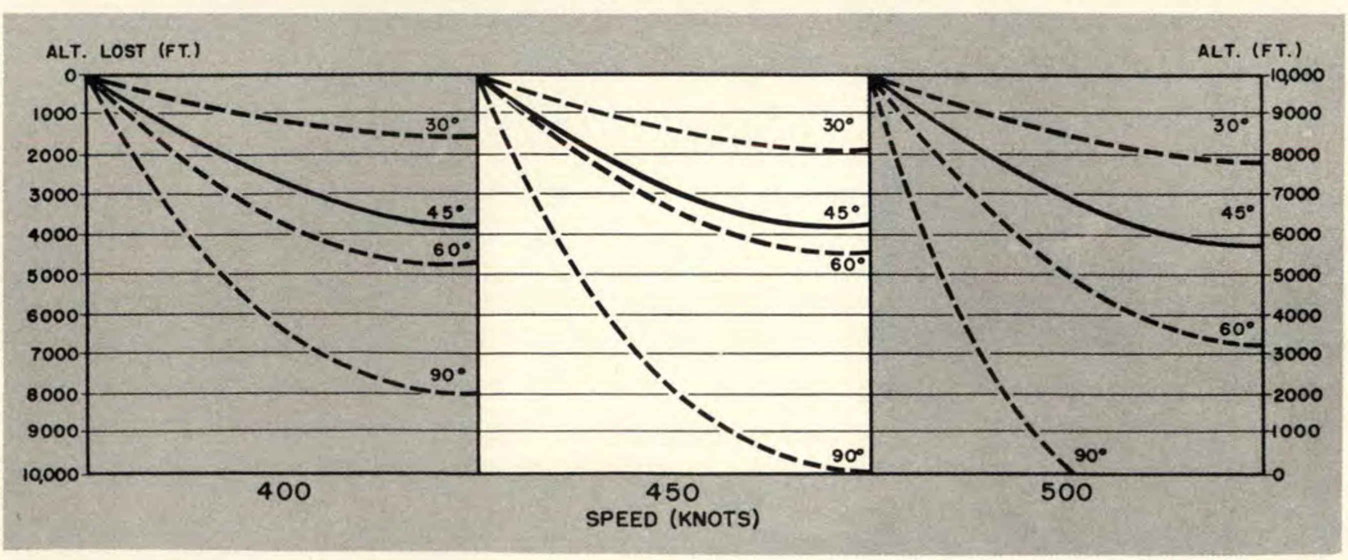


Chart C. Note increased loss of altitude when a pilot pulls 4G instead of 6G at 30, 45, 60 and 90-degree dive angles.



that he had a ruptured right tiptank. He determined that his aircraft was controllable and returned to his home station and landed successfully.

The fate of the bomber was different. With a piece of the wing sheared off by the interceptor tiptank, it went out of control, partially disintegrated in the air and crashed. There were no survivors.

Neither the bomber nor the interceptor pilot realized the odds against them when they set up this simulated attack. It is certain that had they realized it, they would never have tried the maneuver. Let us review the cause factors in this accident, because, as mentioned before, they are still present.

Primarily this simulated attack, like all head-on attacks, created a formidable closing speed. The bomber was traveling at 170 knots indicated, and the interceptor was coming toward it at 350 knots indicated. Thus, at their altitude they had established a closing speed of approximately 1100 feet a second. The rest is a story of human reactions.

Reaction Problems

In considering man's reactions when confronted with such closing speed one finds that the first problem is one of visibility. Even on perfectly clear days it is difficult to see an approaching aircraft until it is quite close. The greatest distance at which a bomber can be seen is a little over seven miles, and a fighter a little over five miles. However, the probability of seeing an aircraft at such distances is about as great as seeing a grain of sand somewhere on a rug. It is not until an object is near enough to be relatively large that it is usually seen, even when searched for. So, as might be expected, the interceptor pilot first recognized the bomber when it was about three miles away. In some respects he was lucky, he might have been much closer before recognition dawned. If he had not been searching he might not have seen it at all.

However, the interceptor pilot did locate the bomber at a distance of approximately three miles. Here is where the plot really thickened, because while closing at a rate of 1100 feet a second a stubborn, uncompromising factor called time lag stepped into the picture.

What does time lag mean? It means it takes approximately 1/10th of a second for the nerves to carry what the eye sees to the brain and it takes approximately one second for the brain to recognize what it sees.

In turn, it takes approximately five seconds for the brain to make a decision when there are several choices. For instance, to decide whether to turn the plane up or down, right or left.

It takes approximately 4/10ths of a second for the nerves to carry that decision to the muscles and make them move.

What did this time lag mean to the interceptor pilot? It meant 110 feet in the 1/10th of a second for sight to reach the brain. It meant 1100 feet in the one second for recognition to take place. It meant 5500 feet in the five seconds spent in deciding how to line up. It meant 440 feet in the 4/10th of a second to react. All in all, it meant 7000 feet from the time the bomber was seen until it was lined up.

The die had been cast. Now the end was inevitable. Considering that the bomber was first seen at about three miles, or approximately 16,000 feet, and considering that 7000 feet were lost in the line-up, we now have 9000 feet separating the two aircraft, and it's time to fire away.

Here, again, time factors are encountered. We hold the course and squeeze the trigger. Four seconds and 4400 feet. We recognize we are getting close. One second and 1100 feet. We decide to break away. Luckily, the decision was made in advance of the attack to break up and to the right. No complicated choice here. Only one second for a decision. Only 1100 feet. And now only 4/10ths of a second to react to that decision; only 440 feet. However, we have precipitously obliterated another 7000 feet.

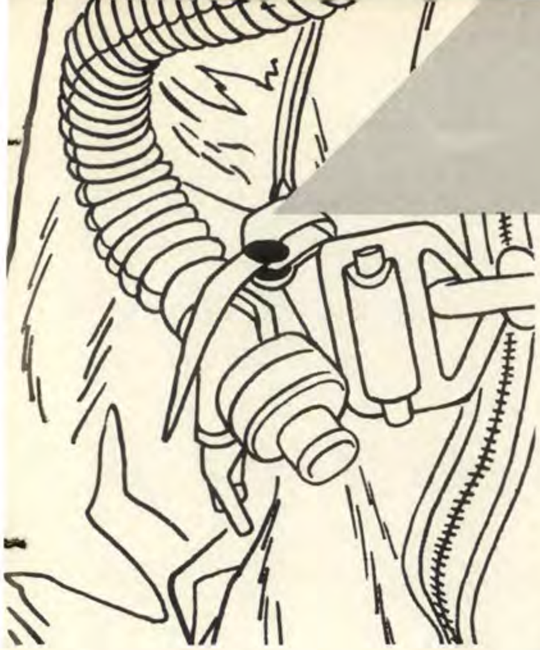
How much space remains? Approximately 2000 feet now separate the aircraft, and evasion has begun. Only it is started too late. Here, again, time lag steps in. This time it is not the lag inherent in the reaction of the pilot, but the time lag in the aircraft itself. It takes time to stretch the cables. It takes time to move the rudders. It takes time to change the airflow over the controls. Especially, it takes time to change the tons of momentum from their near-irresistible course. How much time elapses between pressing the controls and significantly changing the course of an aircraft? That isn't known exactly. Certainly more than a second. Probably more than two seconds. Some observers say five seconds.

In this case there were two thousand feet between the two aircraft; 1100 feet a second. Time ran out. This pilot learned the hard way.

Yet, those who cannot remember the past are condemned to repeat it. Recently two experienced pilots in jet fighters, disregarding instructions, decided to fly a head-on pass. It was the same story. The pattern was similar. Not much distance when they first saw each other. A fraction of a second for sight to reach the brain. A second for recognition. A few seconds for decision. A fraction of a second for reaction; another few seconds to decide upon the breakaway. It was their last earthly decision. Little else could be expected. Their closing speed was approximately 1700 feet a second.

However, the true significance of closing speed and human reaction does not lie in making head-on passes. It lies rather in the fact that in spite of high velocity and man's slow chemistry, flight can be eminently successful. Although the laws of nature appear to stand rigid and immutable in the paths of aerial conquest, they can be circumvented. To this end man has established the codes and rules of flying. Thus, the warnings of minimum altitude are designed to neutralize the momentum encountered in a strafing mission, and the rules of air traffic are established to avoid the awesome closing speed of on-rushing aircraft.

It is a wise pilot who will know well and abide by these rules of the game. He cannot change the laws which make them necessary. Nor can he alter the penalty of disregard. ●



LOOK to HOOK

THERE have been many reports of the separation of the oxygen-to-regulator disconnect during flight. If this happens at altitude the results are obvious. That thin air won't be doing the pilot much good, that's for sure. If he's lucky, he'll notice the condition before it's too late.

Another problem that crops up from time to time is the loss of the helmet and oxygen mask during ejection. By that we mean losses have occurred even though the visor was properly positioned prior to bailout, but the oxygen tubing was not secured correctly.

Investigation of these incidents has indicated that there are many different methods by which flight personnel are attaching the mask-to-regulator-tubing disconnect. And this improper securing of the equipment is causing many of the helmet and mask losses.

We've observed pilots and crew members attaching the disconnect to flight clothing, shoulder harnesses and parachute harnesses in many different positions. And applicable Technical Orders do not provide definite optimum arrangements for attaching the connector—yet.

Here are a couple of hints that should be of benefit to every man who goes charging off into the blue, and needs to use his oxygen mask.

When connecting the mask hose male connector to the mask-to-regulator tubing female connector, make certain that the connector is positively locked. This can be ascertained by listening for the connector to click when it locks.

In noisy areas, such as the usual flight line, it may not be possible to hear the connector click. In this case, look at the connector at the point of connection. When the connector is completely closed, the sealing gasket is compressed so that one-half of the gasket shows.

We suggest that flight personnel get better acquainted with the function of the disconnect by getting in a quiet area, listening for the click as a proper union is made and then looking at the gasket to see that only a half of the gasket shows after the connector is locked.

So much for making a positive connection for the mask. Now let's consider means of properly securing the oxygen hose to preclude loss of the mask in the event of a bailout.

The disconnect should be attached to the parachute harness chest strap as close to the center as possible. If you'll look at the accompanying photo and drawing on this page, you'll see what we mean.

The attachment strap on the male mask connector should be attached to the parachute chest strap by routing the connector strap under the chest strap, then around the strap twice and then finally snapping it to the connector.

Next, the female connector of the mask-to-regulator tubing should be connected to the mask male connector. Finally, the alligator clip should be attached to the mask male connector strap, as shown in the photo.

The alligator clip should be turned so that it is positioned next to the parachute chest strap. The free end of the mask connector strap should be put through the teeth of the alligator clip.

Push the alligator clip as close as possible to the snap fastener to take up any looseness. Any movement of the head that creates a pull on the mask hose fitting will be absorbed by the strap wrapped around the chest strap, thus preventing tension on the connector which possibly could cause separation.

Any pull on the mask-to-regulator tubing connector will be absorbed by the alligator clip, thus preventing tension on the connector which could cause separation.

If it should become necessary to eject from the aircraft, the following sequence of events will take place:

After ejection and during separation from the seat, the mask-to-regulator tubing which is attached to the seat will pull on the mask male connector before separation. This pull in turn will be absorbed by the mask male connector strap and then the parachute chest strap. The alligator clip will easily separate from the mask connector and strap. Thus, during ejection, the mask-to-regulator tubing will not tend to pull off the oxygen mask and helmet.

In general, WADC recommends the following simplified checklist:

- Attach mask male connector strap to parachute harness chest strap.
- Connect mask-to-regulator tubing female disconnect to mask male connector, listen for click and look to see that sealing gasket is only half exposed.
- Attach alligator clip to mask male connector strap.

As a rule we try to avoid quoting Technical Orders; however, in this case we suggest that pilots familiarize themselves with T.O. 13-1-37 and 13-1-38. These TO's cover proper fitting of helmets and masks. Sure, we know that personal equipment people have to follow the directions, but for your own sake, read 'em.

Just a couple of final do items:

Insure that your helmet chin strap is attached at all times and if a bailout becomes necessary, insure that the helmet visor is placed in the locked position before you squeeze that go-handle. ●

the HOTTER the SHORTER

THIS month we are getting away from tornadoes and thunderstorms and other allied ills and concentrating on another type of problem. As you should be well aware, the length of a takeoff roll of any aircraft, particularly jets, is dependent upon air density among other things. This, then, means that DENSITY ALTITUDE enters the picture.

Failure of pilots to understand and consider the possible effects of density altitude variations on aircraft performance can and has resulted in some serious accidents.

A typical example occurred recently in a jet training aircraft at an air base located about a mile high. When the aircraft failed to become airborne after a ground roll of approximately 6500 feet on an 8000-foot runway, the pilot aborted the takeoff. The plane slid off the end of the runway and was destroyed. The pilot received major injuries.

Although the elevation of the field was only a bit over 5000 feet above sea level, the density altitude at the time of the accident was 8700 feet. The takeoff distance charts in the Flight Handbook show that a ground roll of 6600 feet was required for takeoff at the temperature, pressure and aircraft weight involved in this instance. In other words, the pilot aborted his takeoff attempt one hundred feet short of the point where the aircraft would have become airborne. It is apparent that the pilot was not aware of the longer takeoff roll required under the atmospheric conditions existing at the time that this accident occurred.

During the past year other similar accidents involving jet fighter aircraft occurred. In each instance no evidence of material failure or malfunction could be found.

In almost every case the density altitude was greater than the field elevation. The outstanding feature of these accidents is the fact that all involved aborted takeoffs, made before reaching a properly computed unstick point, when no apparent difficulty existed.

There is, then, only one logical explanation. The pilots were not thoroughly familiar with the operating characteristics of the aircraft under the existing atmospheric conditions.

Most pilots have had occasion at one time or another to take off from high altitude airfields such as Denver, Cheyenne or Albuquerque. It is fairly certain that they have observed the difference in takeoff performance as compared to that at airfields of lower altitudes. Most pilots realize that these differences are related in some way to the density of the air, but few understand the underlying principles in detail.

In the past the relatively good takeoff performance of reciprocating engine aircraft overcame the air density problem, and runway lengths were adequate under all but the most extreme conditions. With the advent of jet aircraft, however, the picture has changed considerably.

No longer can the pilot leap into his aircraft and take off with complete disregard for field atmospheric conditions. He must understand the effects of air density on the performance of his plane and consider these conditions when planning his mission.

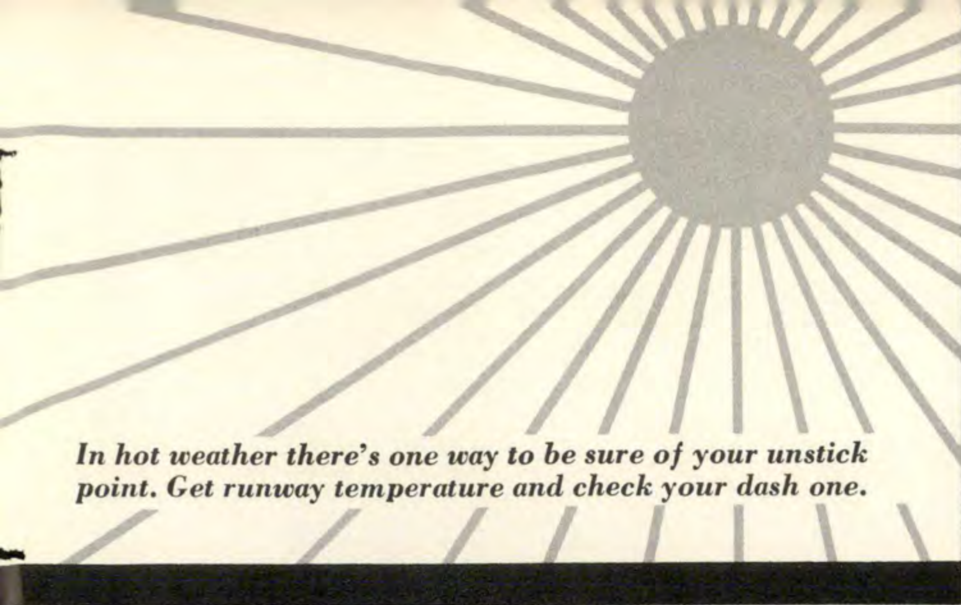
Although this problem is relatively new to the pilot, aircraft and engine designers have always considered air density in their calculations. The performance of both aircraft and engines is dependent upon the density of the air in which they are operating. That's just common sense.

Since the density of the air varies with atmospheric conditions, the performance of aircraft and engines can be analyzed objectively only if preliminary and test data are reduced to certain standard conditions. Basically, these standards as established by the NACA are:

- The pressure at mean sea level is 29.92 in. hg.
- The temperature at mean sea level is 59 degrees F. (15 degrees C.).
- The temperature drops at a constant rate of 3.56 degrees F. per 1000 feet throughout the lower atmosphere.

These standard conditions rarely exist however, and the density of the air varies with the temperature and barometric pressure. But these varying conditions can be corrected to standard and expressed as density altitude.

Density altitude is the altitude at which air of a given density exists in the standard atmosphere. If for example, the temperature at Denver, Colo., elevation 5500 feet, was 110 degrees and the altimeter setting (barometric pressure reduced to sea level) was 29.55, the air would be rarified to the extent that the density altitude would be approximately 10,000 feet. Under these conditions, an aircraft taking off would respond



In hot weather there's one way to be sure of your unstick point. Get runway temperature and check your dash one.

the same as if the actual runway was 10,000 feet above sea level under standard conditions.

Since the airspeed indicator operates on pitot pressure, which in turn is dependent on air density, the indicated takeoff and stalling speeds will remain the same for all density altitudes in the lower atmospheres. However, since the lift of an airfoil varies with the density of the air, the true speed or groundspeed required to produce sufficient lift for takeoff will increase as the density altitude becomes higher.

As an example, check this table:

DENSITY ALTITUDE	STALLING AIRSPEED Indicated	True
Sea Level	90 mph	90 mph
10,000 feet	90 mph	105 mph

The most noticeable effect of density altitude on aircraft performance is the ground roll required for takeoff. The thrust produced by a jet engine, like the lift of an airfoil, varies directly with the density of the air. Here, we must consider the mass flow of air through the engine. The mass decreases as the density decreases resulting in corresponding loss of thrust. Elementary, you say? Okay, so it is. But, apparently a few pilots have overlooked or forgotten some of the basic principles of jet propulsion.

Now, here is where we begin to get into a bind. This reduction of takeoff thrust coupled with the higher required true airspeed (takeoff groundspeed) results in sharply increased takeoff ground rolls for jet aircraft at high density altitudes. Let's examine the takeoff roll distance required for a jet fighter currently employed by the Air Force:

DENSITY ALTITUDE	TAKEOFF GROUND ROLL
Sea Level	3900 feet
2000 feet	4200 "
4000 "	4700 "
6000 "	5500 "
8000 "	6700 "
10,000 "	8100 "

Aircraft performance under varying atmospheric conditions has been calculated and tabulated in the Flight Handbooks for convenient use. The problem is primarily that of insuring that a pilot considers these conditions during mission planning.

Although we didn't specifically mention it earlier, jet bomber aircraft were not involved in any of the accidents cited. This was not because the bomber is any less vulnerable to the exacting demands of density altitude problems, but rather that jet bomber pilots are required to calculate the takeoff performance for each flight as a part of their preflight planning. We feel this proves a point, too.

Since density altitude is a comparison of existing atmospheric conditions to standard conditions of pressure and temperature, density altitude can be computed by correcting the atmospheric pressure adjusted to standard pressure (29.92 in. hg.) for the existing temperature.

Humidity must be considered for exact calculations, but the effects are negligible from the pilot's standpoint, and this factor therefore is not included in this discussion.

A knowledge of density altitude is necessary in understanding the effectiveness of any given aircraft or power plant. However, the performance charts in the Flight Handbooks are based on pressure altitude plus temperature which determines air density but are read in terms of operating data instead of density altitude.

Now here's a little wrinkle that may stand you in good stead one of these fine, hot days. Pressure altitude may be determined by setting an altimeter to the NACA standard, 29.92 in. hg. and reading the altitude shown by the instrument. The temperature is available in any weather office, but here is a word of caution. Secure the runway temperature if possible rather than ambient. The difference is likely to be several degrees, at least.

With these two factors available, plus the known weight of the aircraft, the pilot can determine aircraft performance from the charts in the Handbook. When he wants to know where the old blowtorch will become unstuck, the pilot can go to the dash one for that answer.

By rule of thumb, an increase in temperature of 15 degrees F. or a decrease of 1 in. hg. in barometric pressure will raise the density altitude 1000 feet. A 1000-foot increase in density altitude can result in over 10 per cent increase in takeoff roll requirements.

Pressure variations of 1 in. hg. are rare; however, it is not uncommon for the temperature of the air near the surface of the runway to be as much as 10 degrees F. above the air temperature recorded at the station.

Since aircraft performance is dependent upon actual density of the air in which it operates, the runway air temperature must be provided for the pilot so takeoff performance can be determined accurately.

The Air Weather Service has recognized the importance of this condition and published a letter (No. 55-33, dated 6 Aug 52), directing weather personnel to offer runway temperature observations to base commanders for the pilots' benefit.

So, in the final analysis, it all boils down to this: Accidents resulting from ignorance of aircraft performance under varying atmospheric conditions are inexcusable. All necessary information and data are available to pilots and operating personnel. Just crack a dash one. You'll find the info you need there.

Don't let old Sol catch you with your guard down. Remember, the hotter the temperature the shorter the runway! ●

A preview of things to come in navigation. Automatic devices will relieve pilots from the ever-increasing burden of traffic control.

the Automatic way

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IN this age of flight which lies somewhat beyond the half-way mark between "seat of the pants" flying and fully automatic flight, the trend is toward high speed, high performance aircraft, increased complexity in the cockpit and growing congestion of the airways. These factors are placing an ever increasing burden on the pilot as well as the traffic controller. However, there is much evidence that automatic navigation devices can bring some relief to both.

At this point we should define both "automatic navigation" and the "common system." A search reveals no appropriate definition for "automatic navigation," so the following will be used for the purposes of this article. "Automatic navigation is the automatic process of obtaining position information and converting it to steering information." The principal difference between this and automatic flight is that the pilot retains manual control of the aircraft and actuates the controls in accordance with the steering information.

The "common system" is a national system of air navigation and traffic control which serves the common needs of civilian and non-tactical military aviation, but which is capable of useful integration with any air defense system set up by the national military establishment. The responsibility for the development of the common system is vested in The Air Navigation Development Board (ANDB), which was created by charter agreement between the Secretaries of Defense and Commerce in 1948. This charter agreement has recently been revised and reaffirmed to accelerate the program and increase its effectiveness. The principal navigation facilities of the present common system are the omni-directional range (VOR), the distance measuring equipment (DME), the instrument landing system (ILS) and the precision approach radar (PAR). For traffic control, these facilities are supplemented by airport surveillance radar (ASR), VHF/DF and various communication facilities.

Until 1929, air navigation was accomplished primarily by visual reference to the ground, including the use of beacon lights, and by dead reckoning.

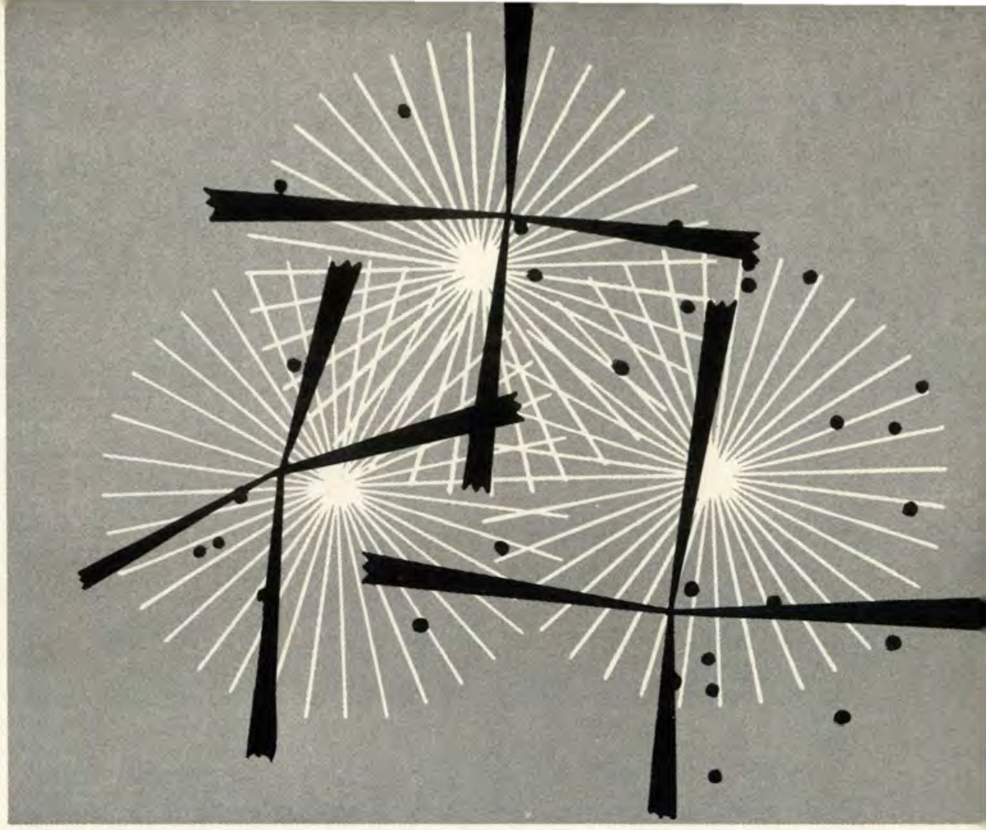
Development and implementation of the low-frequency navigation aids such as the low-frequency/medium-frequency four-course range, and the non-directional radio beacon provided the first well-defined radio navigation routes and introduced a new era in the age of flight. Most of this system is still with us today and is being actively used for navigation and traffic control. However, this system with its limitations of heavy static, course swinging, limitation on the number of courses and lack of distance information is already inadequate and is gradually being phased out. It is being replaced by a polar coordinate system, often referred to as the RHO-THETA system. In this system RHO is the distance from the station obtained from the distance measuring equipment, and THETA is the magnetic bearing obtained from the omni-directional range. In contrast to the four separate courses provided by the low-frequency range, such a system provides continuous fixing information and lends itself to the use of automatic navigation devices.

The common system program is still young and much navigation is still done on low-frequency facilities. There is little question that, within a very few years, azimuth and distance position information, supplied by VOR/DME and TACAN, or some other system, will be available in virtually all of the airspace above the United States.

The use of such a system, especially with automatic navigation devices and aided by radar and the common system ILS, will ease traffic control. It will provide more precise navigation, greater flexibility of routes, and will improve possible hazardous situations by taking much of the burden of navigation from the pilot.

Figure 1 illustrates the increase in utility which can be achieved by replacing three low-frequency range

Fig. 1. RHO-THETA facilities provide a means of establishing multi-lane airways.



facilities with three RHO-THETA facilities when users are equipped to take advantage of the continuous fixing information. It will be noted that there are 35 airports within a coverage area of these facilities. However, as the four-course range provides a position fix only when the aircraft is directly over the station, at the intersection of two range legs or where a VHF marker is located on a range leg, it readily can be seen that the low-frequency ranges in this area serve only a few airports (at best about four each). However, the RHO-THETA facilities properly sited will permit position fixes at any point within the area, thereby serving all airports. They also provide a means of establishing multi-lane airways rather than the single lanes provided by the four-course range.

There are at least three different degrees of flexibility which can be achieved in flying the present common system depending upon the manner in which the aircraft is equipped.

Referring to Figure 2, let us consider various means of going from point *A*, which is in the coverage of VOR *B*, to point *C*, which is in the coverage of VOR *B″*, via *A* course which passes through the coverage of VOR *B′*. An aircraft equipped with a single VOR receiver can proceed from *A* to *C* by tuning his VOR receiver successively to VORs *B*, *B′* and *B″*, and flying radials *AB*, *BD*, *DB′*, *B′D′*, *DB″* and *B″C*.

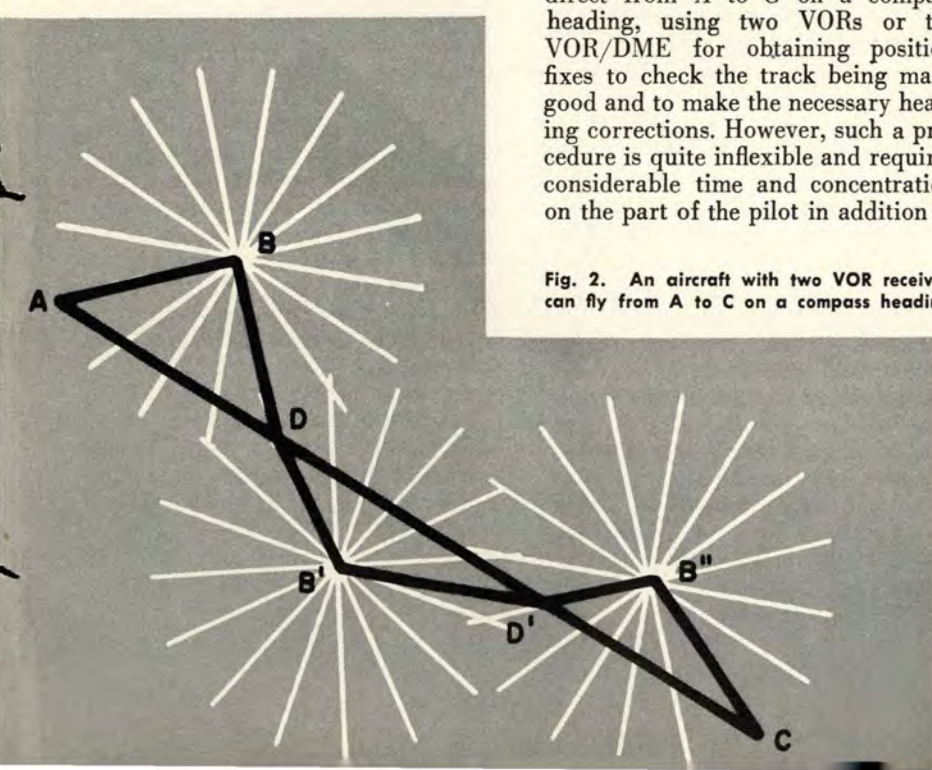


Fig. 2. An aircraft with two VOR receivers can fly from A to C on a compass heading.

Having selected the VOR station and the radial which he desires to fly, the pilot then has only to fly in accordance with the right-left steering indications provided by the cross-pointer instrument. If, however, his aircraft is equipped with two VOR receivers, the second receiver can be tuned to station *B′* while he is flying radial *BD* and provide a smoother execution of the transition from radial *BD* to *DB′*.

As a matter of fact with two VOR receivers or one VOR and one DME receiver, it would be possible to fly direct from *A* to *C* on a compass heading, using two VORs or the VOR/DME for obtaining position fixes to check the track being made good and to make the necessary heading corrections. However, such a procedure is quite inflexible and requires considerable time and concentration on the part of the pilot in addition to considerable preflight planning. The so-called course line computer automatically solves this problem. In effect, it enables a pilot to establish a VOR/DME combination at his point of destination, and thus fly directly to it as though it were actually the location of the VOR/DME.

Thus in flying from *A* to *C* he would first establish the station at *D*, then *D′*, and then at *C*. He would then fly this course manually by reference to the cross-pointer instrument which would provide right-left steering information with regard to his desired course plus distance information to the destination. He could also fly this automatically by the use of the autopilot couplers which are gradually becoming available. There are two types of course line computers: one of which computes the desired course from the outputs of two VOR receivers, and another type which computes the desired course from the combined VOR/DME information. This development represents a definite step forward in extending the usefulness of the RHO-THETA system. But its use still requires the pilot to make reference to a map to translate his coordinates into his position, relative to natural and man-made obstructions.

Flying a complicated flight pattern with this equipment requires the pilot frequently to change input settings to the computer, and in addition re-

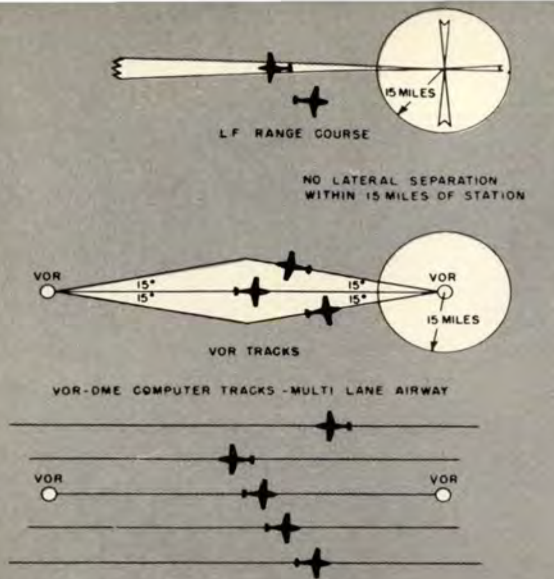


Fig. 3. Pictorial computer, VOR/DME add airways capacity.

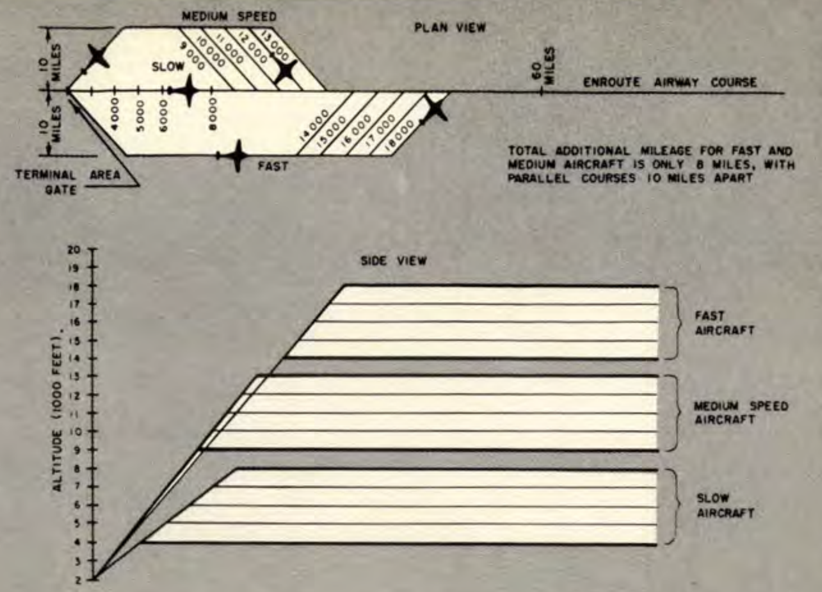


Fig. 4. Multiple tracks used for different speed aircraft to climb to cruising altitude.

quires considerable detailed preflight planning. Furthermore, the addition of the course line computer adds cockpit complexity and increases rather than decreases the number of things the pilot has to do and watch. Hence, in order to overcome these shortcomings, to simplify the cockpit instrumentation and to present the pilot with a picture of his aircraft moving across a map of the terrain, the Air Navigation Development Board sponsored the development of the pictorial computer. At the risk of seeming to belabor the obvious, it should be emphasized that psychologists and human engineering experts agree that this type of display provides navigation information in the form from which it can be assimilated most readily by the pilot.

The pictorial computer presents the pilot with a map of the area over which he is flying and an indication of where he is on this map at all times. This gives him a pictorial view of his progress along any path he selects, as well as his relation to obstructions or danger areas. In addition, it provides an almost unlimited number of flight configurations and routes. This device takes much of the burden of navigation from the pilot and, it is believed, achieves a greater degree of security by constantly showing him his position with respect to obstructions and by relieving some of the tension which usually accompanies instrument flight.

Three different pictorial computers were developed for ANDB by Aero Electronics, Sperry Gyroscope Corporation, and The Arma Corporation, respectively. The scope of this article will not permit a detailed discussion of the characteristics and evaluation results of the three types of pictorial computers. However, *Flying Safety* proposes to go into these systems in considerable detail at a later date.

Having pointed up some of the advantages to the pilot, let us look at what these devices have to offer for solving some of the air traffic control problems in the en route portion of a flight. For the purposes of this discussion, the en route area will be that portion of the airway system which lies outside of the immediate vicinity of the air terminal. Nevertheless, it includes many of the problems generated by the existence of the terminal area such as those associated with climbing and descending aircraft to and from cruising altitudes for departure from or entry to an airport. In the en route traffic control area there are three particularly troublesome problems which are closely related to the precision and flexibility of the navigation system in use.

The first is the overtake problem or those problems associated with aircraft going in the same direction and along the same airway. Obviously, if all aircraft going in the same direction were of the same speed and climb performance, it would only be necessary to start them out at given intervals. However, differences in performance create problems.

The second is the altitude change problem. This type of problem has several phases. One is the opposite direction phase wherein it is desired for an aircraft to climb or descend on an airway where there is traffic coming from the opposite direction. Normally, opposite direction traffic is assigned to alternate cruising altitude levels. However, the problem develops in transition areas where an aircraft is climbing out of a terminal area to a cruising altitude or descending to a terminal area from a cruising altitude. Sometimes it becomes necessary to make an altitude change due to weather conditions, terrain features or operating considerations for best fuel economy.

This problem is becoming more troublesome with modern pressurized high-altitude aircraft which frequently traverse as much as 75 miles in climbing out to cruising altitude. Similarly, descent from cruising altitudes may be started more than 100 miles from destination. These distances will be extended even further when jet aircraft enter the commercial air carrier field. Present information indicates that jet transport aircraft may traverse more than 200 miles during climbs and descents.

The third problem has to do with crossing courses. This problem is associated with aircraft on different airways that are crossing or converging at the same cruising altitude. When either or both aircraft are changing altitude through levels already in use at the intersection in-

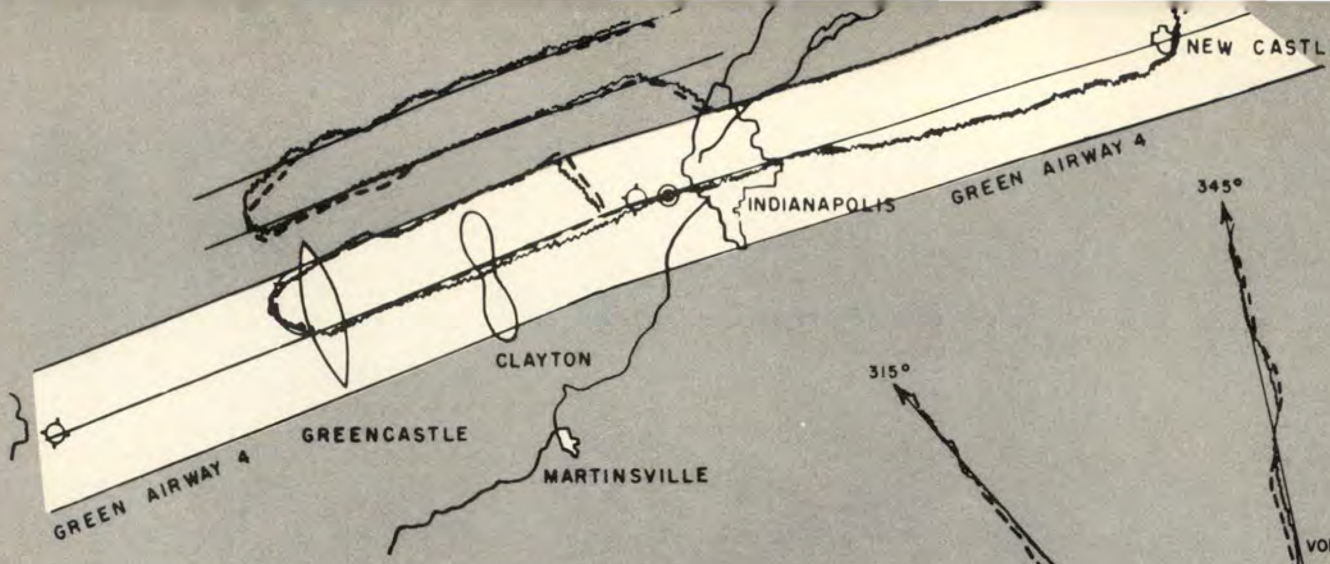


Fig. 5. A pictorial computer flight made on a multi-lane airway with five mile separation.

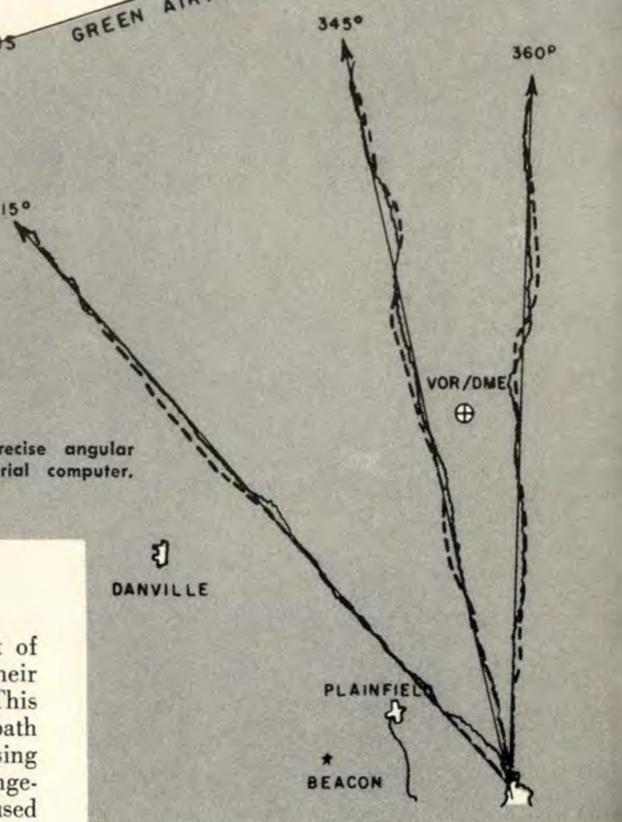


Fig. 6. Aircraft can fly precise angular departure tracks using pictorial computer.

volved, the problem becomes acute.

The solution to all these problems lies in providing additional parallel lanes at the same altitude so that aircraft can climb through or descend with sufficient lateral separation through an altitude which is already occupied. For want of this capability in the present system, aircraft must be delayed in climbing and descending, or vectored off on detour courses in order to bypass such situations.

Figure 3 illustrates how the pictorial computer and VOR/DME can increase the capacity of an airway. On the low-frequency range courses, it is possible on certain ranges, where courses are good, to use what is known as "right side separation" at distances beyond 15 miles from the station. This means that in the case of an airplane ascending to or descending from a cruising altitude, separation would be obtained by having the pilot fly well to the right of the course. This can only be used where courses are good, and at sufficient distances from the station to insure a course width adequate to provide the necessary separation. Figure 3 also shows the use of the VOR with 15 degrees separation to provide right side separation in both directions. With VOR/DME and pictorial computers, it should eventually be possible to use high-capacity airways having a number of parallel lanes, and separated perhaps by as little as 10 miles.

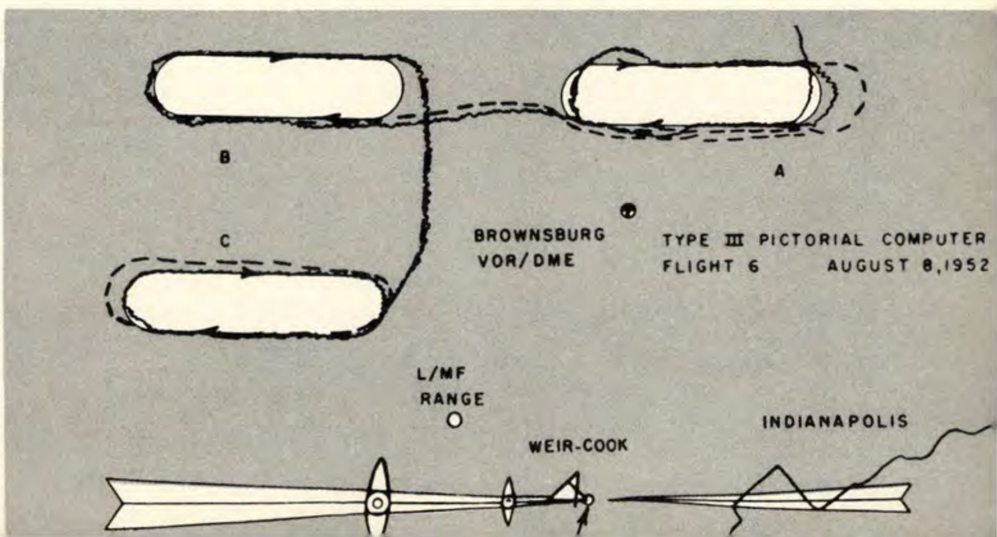
Figure 4 shows how the capabilities of the pictorial display and computer might be used to permit aircraft of different speeds to climb out to their cruising altitudes without delay. This is accomplished by providing path segregation according to the cruising altitude desired. A similar arrangement of multiple lanes could be used to expedite descent of aircraft of different characteristics from cruising altitude to the terminal area. With this arrangement, high-altitude, high-performance aircraft overtaking slower aircraft operating at the lower altitudes would not be penalized and forced to wait until a slower aircraft landed.

Similarly, at en route or cruising altitudes, pictorial displays would permit the use of multiple lanes for change of altitude or for a passing course around another aircraft at the same altitude.

Let us look at some results of flight evaluations of pictorial computers showing the precision with which a desired path may be realized in actual operation.

Figure 5 is a record of a pictorial computer flight demonstrating a multiple lane airway with approximately five miles separation at distances out to 50 miles from the station. These tracks were flown with the type III pictorial computer, which is a lap computer. But they are representative of the results achievable with any of

Fig. 7. Continuous position information and the pictorial display help simplify holding patterns.



the development models. Solid lines show the desired track, dashed lines the actual track and the jagged line the computer track. Precise departure tracks which will help the terminal area controller segregate outgoing traffic can also be achieved with a pictorial computer.

Figure 6 records a demonstration of how precise such courses can be flown with the pictorial computer. The flight recorded in Figure 7 shows the proficiency with which holding patterns may be executed with continuous position information and the pictorial display.

Laboratory tests have shown that the maximum average errors (the greatest error occurring in the average results of repeated tests for a given point of the display) in bearing and distance do not exceed .2 of a degree or a half mile, respectively. Controlled flight tests conducted as a part of the technical evaluation revealed a maximum system error in position of 1.3 nautical miles when a display was used within 15 nautical miles of an omni-bearing station.

The major portion of the system error lies in the bearing information derived from the omni-directional range. Because this error is in azimuth, it introduces position errors which are proportional to the distance from the station; hence, parallel airways separated 10 miles are not now feasible much more than 30 miles from the omni-bearing station. However, recent improvements in antenna design have reduced ground station error substantially, and it is expected that development will further improve the accuracy of the bearing information available and thus increase the utility of the system.

The neck of the bottle in this problem of getting aircraft from the airway to the unloading ramp, is the final approach and landing phase. It is very important to achieve the maximum approach success. An aircraft emerging from the overcast may find itself in an attitude from which it cannot make a successful landing. This not only introduces delays in the system, but involves considerable increase in pilot problems due to the required changes in aircraft trim and power settings, as well as causing the low altitude maneuvering which must accompany the missed approach procedure.

It has been demonstrated conclusively that automatization of this phase of the navigation problem yields a large return in increased probability of a successful approach. Equipment called a flight director system shows great promise of improving the probability of a successful approach on the common system ILS. It can be defined as an analog computer that assimilates information relating to aircraft heading, attitude and displacement from a specific flight path, and computes those attitude changes necessary for the aircraft to attain and remain on that specific flight path.

The required attitude changes are presented to the pilot by meter movements indicating right or left bank, or up and down pitch changes. In this manner, a flight director system allows for a separation of the plan of flight from the mechanics of flight. The pilot sets the plan of flight into the equipment by setting in his desired heading and by tuning in the appropriate radio facility, in this case the ILS. The computing equipment measures how far the aircraft is from where the pilot wants it to be. It does not indicate what the error is but provides an indication of how the controls should be set in order to neutralize the error at a precalculated rate. This minimizes the requirement for the pilot to piece together bits of rate and displacement information from several instruments in order to accomplish an instrument maneuver. It makes it possible for a less experienced pilot to fly an ILS approach as accurately and precisely as more experienced pilots by providing a source of guidance or steering information that does not require a high order of proficiency to follow. The pilot simply has to perform the mechanics of flight by acting as a servo in banking the aircraft to center a steering needle. Errors in pitch are eliminated in a similar manner to those in yaw. Two examples of this type of equipment are the Sperry Zero Reader and the Collins Integrated Flight System.

Flight evaluation data were taken at Wright Field to compare the approach success of the flight director system with that of the E-6 automatic pilot and standard cross-pointer approaches. Data on approximately 23 approaches for each system show practically no difference in approach success between the flight director system and the automatic pilot.

However, both of these systems show approach successes which are very much better than those achieved with the standard cross-pointer instrumentation. These differences become more significant when it is pointed out that the manual approaches were flown by pilots who were very experienced in ILS flying, whereas the flight director approaches were flown by pilots with very little experience in making ILS approaches.

In 1947, the Air Force demonstrated fully automatic flight by equipping an airplane, taking it off from the United States, flying it to England and landing it, all automatically. However, fully automatic flight, especially for commercial passenger-carrying aircraft, is not just around the corner. On the other hand, there is every indication that automatic navigation devices such as flight director systems and pictorial computers will play an increasingly important role in helping to achieve a more effective and efficient air traffic control system, as well as lifting a lot of the burden of navigation from the pilot. Both the flight director system and the pictorial computer are natural waypoints in the development of fully automatic flight.

Furthermore, it appears that the accepted philosophy of having automatic devices in aircraft monitored by humans will perpetuate the pictorial display well into the age of fully automatic flight. Although the pictorial computer development is still in its infancy, one manufacturer of these devices is already considering a production run, and at least two major aircraft manufacturers are making provisions for the inclusion of this type equipment in their new designs.

The principal criticism leveled at the pictorial computer is the space requirement in the instrument panel for a 10-inch display. However, a properly designed pictorial computer should lead to cockpit simplification by eliminating the necessity for some other instruments presently included.

It seems reasonable to suppose that further developments and the inclusion of transistor techniques will permit some reduction in size. The Air Navigation Development Board in its broad program for research and development in the field of air navigation and traffic control will continue to take advantage of these new techniques. The Board will develop and evaluate improved devices such as the pictorial computer for improving the ease, flexibility and precision of instrument flight. ●

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