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FLYING SAFETY

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Annual Jet Issue—Part Two

• *Do's and Don'ts for D's* • *The C Around You* • *Spinning the Sabre*

FLYING SAFETY

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Department of the Air Force
The Inspector General USAF
Major General Victor E. Bertrandias,
Deputy Inspector General

Brigadier General Richard J. O'Keefe
Director
Directorate of Flight Safety Research
Norton Air Force Base, California

Maj. Philip A. Watson, Jr.
Acting Supervisor of Flight Safety
Publications

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Circulation Manager
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Next month we'll jump from jets to jumbos. Tips for you reciprocating drivers fill most of the magazine.

CONTENTS

SUBSCRIPTIONS

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Pages 2 to 13, inclusive, are devoted to discussions of flight characteristics of the F-94C, the F-89D, the F-84F and the F-86F, written by veteran test pilots.

Aimed at You . . . .

How many times have you heard this phrase? "Flying is not inherently dangerous, but like the sea it is terribly unforgiving." Even in this age of flight that lies somewhere between the old "seat of the pants" flying and fully automatic flight, this adage still holds true.

The basic principles as applied to reciprocating engines still apply to jets. They are just more critical. From preflight planning through cruise control and landing, jet flying leaves less margin for error.

High speed and fuel consumption are the two basic differences between flying the jet and the reciprocating powered aircraft. With the increased speed, you are required to think faster in order to stay ahead of the plane. With the high rate of fuel consumption, you are required to plan your flight much more carefully. These two basic differences are sometimes forgotten or minimized in coping with the operational problems of jet aircraft, especially by pilots transitioning to jets.

All in all, it can be said that there is no time for day dreaming when you are hustling through the blue in a jet aircraft.

This month FLYING SAFETY is presenting Part II of its annual all jet issue. An effort has been made to include material on specific aircraft and some of their special operational phases, as well as general information on jet flying. The articles contained herein were selected after careful screening and editing and are directed specifically at you, the jet pilot.

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Next month the greater portion of FLYING SAFETY will be devoted to new, up-to-date information on reciprocating powered aircraft. Our lead article should be of great interest to all C-124 pilots, in particular.

Do's and Don'ts for D's

By Lewis A. Nelson, Supervisor of Experimental Test Pilots, Northrop Aircraft Inc.

SOMETIMES engineering test pilots must conduct tests under flight conditions prohibited to the operational pilot for one reason or another. As a result, the test pilot requires certain first hand knowledge that is not always found in flight handbooks. You might call this supplementary flight experience.

As one of the pilots assigned to engineering flight tests of the F-89D airplane, I have been exposed to some supplementary flight experience that has convinced me thoroughly of the structural integrity of the Scorpion for all aircraft loading and flight conditions. I also have been there when this airplane demonstrated its stability and control characteristics. Sometimes I've been privileged to be the first witness of this sort of thing on the Scorpion.

That's why I have a special pride in this big, husky fighter.

Flight characteristics may be best discussed by considering low speed handling qualities, spins, high Mach and high altitude flight.

Low Speed Handling

The Scorpion is an easy airplane to fly. It is completely honest approaching and in the stall. Normal wing heaviness and slight buffet occur prior to stall which is "straight-ahead." This holds at all altitudes, from sea level to 45,000 feet plus. Similarly, accelerated stalls are mild and straight through. Extension of gear, flaps or speed brakes causes no change in stall characteristics, only in stalling speed.

Slow speed flight characteristics make it ideally suited for its role as an all-weather "bomber-knocker-downer." Use of speed brakes during instrument approach provides go-around potential approaching that of prop types since acceleration is immediate as speed brakes close. Trim changes are negligible with use of gear, flaps or speed brakes. Response to aileron deflection is slow at low speeds due to reduction in aileron effectiveness at high angles of attack, and the high tip pod weight of Ds makes this more apparent than on previous models, but control at normal approach speeds is more than adequate. Tests have shown that it is possible to land normally with one tip full and one empty. Little reserve control remains in this condition so it is strongly recommended, as outlined in pilot operating instructions, that tip fuel be dumped prior to landing if one fails to feed.

Spin Test Results

Spin tests on the F-89D have not been completed at this writing. However, spin recovery tests performed on the F-89C have shown it to be unwilling to spin. It is necessary to hold full up elevator and full rudder in the desired direction of rotation to induce and maintain the spin.

The Scorpion is the heaviest airplane ever to go through spin tests.

Spin tests on the F-89C were conducted under a wide variety of flight conditions. Spins and recoveries were made with varying configurations of control surfaces, with engines idling and with power on, with the aircraft in clean flight condition and with landing gear and flaps extended, and with varying fuel loads and center-of-gravity positions.

During these tests it was determined that aileron position had no adverse effect on recovery characteristics. Power-on spins resulted in steeper entry and apparently faster rotation. Power effect produced a steep recovery, but did not adversely affect stopping the rotation. Landing configuration spins were flatter and slower than those when "clean."

Altitude loss during spins was about 3000 feet per turn, with recovery after rotation stopped requiring 1000 to 3000 feet, depending on pitch attitude at start of recovery.

The general conclusion drawn from spin tests was that the Scorpion has no dangerous inherent spinning tendencies and has excellent spin recovery characteristics. Conventional recovery techniques are entirely satisfactory; that is, full rudder opposite to the direction of spin, followed by forward stick will stop the spin quickly. Slight aileron movement opposite to the direction of spin adds appreciably to the speed of recovery.

High Indicated Airspeeds

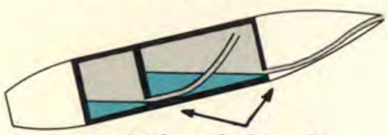
High speed characteristics of the F-89D are quite similar to other high

Tip Tank Dumping

Normal Operation

Normal dumping should be in level flight or climb. Time required to empty full tanks (engines at 100%) is 60 sec. Cycle completed in 75 sec.

Fuel Dumped in Dive



Intake end of transfer and dump lines uncovered.

If tip tanks are dumped in steep dives, fuel outlet ports may be uncovered by fuel shifting in tanks, resulting in incomplete dumping.

Fuel Dumped Decelerating With Speed Brakes

If dumping is initiated during deceleration with speed brakes, a second dumping cycle may be required to empty tanks completely.

Approximately 0.3G back pressure due to deceleration forces.

Legend: Fuel ▇ Compressed Air ▇

WARNING: During takeoff and climbout, don't initiate dumping unless you're sure that you can stay airborne until tanks are empty.

performance airplanes. It is possible to exceed the structural design limits if excessive control deflection is used at the high indicated speeds possible at low altitude. These characteristics are discussed in every Pilots' Handbook so will not be repeated here. However, a phenomenon was observed during low altitude high speed tests that a pilot should have knowledge of to prevent "panic-button pushing." Normal fuel sequencing on early F-89s reduced the fuel weight at the tiptanks early in the flight before it reached high speeds.

The addition of pylon tanks to early models and rocket-fuel pods and pylon tanks to the "Ds" made it possible to reach placard speeds with heavier pod weights; consequently, this configuration was tested to maximum speed at low altitude as part of routine flutter tests. During these tests it was found that the wing had a tendency for bending oscillations often in turbulent air at or above limit indicated airspeeds at low altitude. As a result a thorough investigation and analysis was made which ascertained that this wing damping was definitely damped out at all times. Normally the pilot should not encounter this phenomenon; but if it does occur, all that need be done is to reduce speed slightly by reduction of throttles or by pulling up.

Another important characteristic investigated during early tests was that of elevator power limit or, as it is sometimes called, reduction of elevator effectiveness with increasing Mach above 0.8. This loss due to high Mach compressibility effects is aggravated by high dynamic forces developed at high speed at lower altitudes. All trailing edge controls suffer in this manner, but only the elevator will be discussed here.

The loss of elevator power is most critical during dive recovery because of reduced ability to pull G for pullouts. This data presented in the Pilots' Handbook should be studied carefully, since it graphically illustrates the many factors affecting dive recovery. The data presented has been flight tested, and values are for stabilized conditions. It is suggested that a "cushion" be left for inaccuracies in judging dive angle and lag in instrument readings. This holds for any airplane type but is more critical for aircraft which have elevator power limits which prevent increasing pullout load factor. Study your dive recovery charts and approach their limits cautiously. Power reduction and speed brakes both help in the recovery.

High Mach Characteristics

High performance aircraft commonly exhibit some undesirable characteristics. A whole new language describes the deficiencies found in this flight regime: 1 G buffet, rudder shift or yaw, wing drop, aileron buzz, tucking and pitchup.

At this time it seems appropriate to restate my feelings that the '89 is an "honest" airplane, affected only a little at high Mach numbers. This may be shown best by examining the high Mach characteristics of the Scorpion in the order of their occurrence as speed is increased.

The first indication of transonic characteristics occurs as speed approaches maximum speed in level flight. This is manifest as a mild reversal in static stability gradient or, as often described, "tucking." Actually tuck is not too descriptive in this case since this reversal, while quite abrupt, is not dangerous in any sense. Only slight increase in back pressure is required to maintain level flight as speed increases. This region is also restricted in Mach span and usually goes unnoticed in rapidly changing speed conditions such as might occur in a dive, with the pilot instinctively correcting for the change.

Beyond maximum speed in level flight, 1 G buffet develops. This is not of sufficient intensity to affect the tactical worth of the bird. Shortly after buffet onset, noticeable wing heaviness develops with the airplane "clean." This usually occurs to the left but has been experienced to the right as well. This variation from one aircraft to another is the result of manufacturing tolerances, asymmetrical trim, etc. Ailerons, being trailing edge controls, suffer the same loss in effectiveness as do the elevators, so considerable stick displacement is necessary to maintain wings level attitude. The incorporation of split ailerons for use as speed brakes (decelerons) makes it possible to eliminate this normally troublesome transonic characteristic. Partial opening of decelerons (approximately 5-10 degrees) restores effectiveness of the ailerons almost completely. This may be shown best by diving the Scorpion with decelerons closed and holding wings level with the ailerons. Once approximately two-thirds of stick displacement has been reached, opening speed brakes slightly results in a tendency to roll abruptly in the direction of stick displacement as aileron effectiveness is restored. The best way is to crack brakes prior to roll-off, thus preventing loss of aileron effectiveness.

It is interesting also to note that this small opening of speed brakes at high Mach does not increase drag but actually reduces it as will be discussed under high altitude characteristics. As Mach is increased over that where roll-off would occur the buffet intensity decreases, finally disappearing entirely as flow conditions about the aircraft stabilize and local airflow becomes supersonic and stability increases. No further change in flight characteristics occurs with increase in speed beyond this point, the bird being very solid. Return through the region just described during pullouts poses no problem, simply being the reverse sequence.

High Altitude Flight

The increase in airplane speed and altitude performance made possible by the many improved engine designs has opened a new region of problems.

Not too long ago angels 40 was our goal; now it is 50 with one eye on 60. With each increase in altitude the problem of just keeping the bird flying becomes more acute. Add to this the requirements of maneuvering to close in for a "kill" and you really have a problem.

Tests that I have made have indicated to me that extension of a few degrees flaps improves altitude performance. The reason for this is quite simple; indicated airspeed for a given Mach number is reduced considerably from that of low altitudes, i.e., to fly at 0.90 Mach, one would indicate 410 knots at 20,000 feet, but for the same Mach at 50,000 feet indicated would be only 200 knots. It is upon this indicated speed (dynamic pressure) that the airplane depends for developing lift to sustain flight. As you know, if indicated airspeed is reduced the angle of attack must be increased to maintain altitude.

Also, sad but true, is the fact that in level flight as angle of attack is increased, drag is increased. Thus starts the vicious circle, speed decrease requires increase in angle of attack which results in increased drag and accompanying further decrease in airspeed — and around we go.

Discussion thus far has assumed a constant airfoil section (clean); however, flaps also change the lift developed by the wing. For a given angle of attack and airspeed, lift is increased as flaps are extended. Drag of the airfoil is also increased, so the lift increase isn't for free. While the use of flaps *increases* the drag of the wing at the same time lift is increased, the total drag of the airplane decreases since the fuselage angle of attack reduces this component's drag more rapidly than flap extension increases wing drag. Of course, there is a limit to this, approximately seven and one-half degrees flap seems to be the optimum to date. Don't expect the bird to leap from under you. We are talking about small numbers, a few knots at best.

The gain from use of flaps will be much more noticeable in another way which is just as important, if not more so, than the slight increase in speed. You gain up to 50 per cent in available maneuvering load factor. A solid aircraft above 45,000 feet — no "sinking" feeling in the turns.

The low indicated speed that is the source of our altitude problem has one advantage—flaps may be used at high Mach number without structural beef up. I use caution not to forget I have 'em down and split "S" out. Above 40,000 feet you are okay if you have seven and one-half degrees or less. There is no need for ever using more. I force myself to remember the flap placard speeds published in the Pilots' Handbook.

I also like this flap setting above 40,000 feet to improve the "feel." A few degrees will cause the aircraft to feel much more solid in the climb above this altitude. After you level off, flaps may be increased to seven and one-half degrees as speed increases. Exact angle is not too critical, feel is as good a criterion as any.

Speed brakes aid in much the same manner as landing flaps but to much less a degree.

Emergency Flight Controls

No discussion of airplane handling characteristics would be complete if the control system itself were not defined. This is especially true for full power control systems having artificial feel. F-89 type, that is. The pilot's ability to handle an emergency comes with experience and is aided by his knowledge of his airplane's characteristics and limitations.

Recent tests have shown the Scorpion flight control system to be extremely reliable. Briefly describing the tests seems to be the most obvious way to present this important information. For simplification, only the three major conditions tested will be discussed: full (3000 psi) pressure in only one of the two independent systems; emergency pressure (1500 psi R. H. system) only, and with one windmilling engine supplying pressure. These tests were made on a test aircraft having special shut-off valves for normal systems, so that the configurations mentioned previously and combinations thereof could be thoroughly investigated.

Little difference normally will be noted with only one full pressure hydraulic system available. This holds for flight at maximum speed level flight down to stall-in landing configuration. With only one system operative, the load factor available at limiting elevator power is reduced by approximately 0.3G.

Full basic control is possible with only the 1500 psi emergency system. The emergency pump's capacity is sufficient to maintain pressure during fast actuation of controls such as might be necessary during flight in turbulent air.

If the only pressure available to the control system is that from one windmilling (12-20 per cent rpm) engine pump, a safe landing is still possible. However, it would be necessary for the pilot to exercise caution in the rate of control movement to maintain at least 800 psi in the system. In other words, keep control movements to a minimum and avoid rapid application of either stick or rudder. This pressure is considered the minimum desirable since danger of dumping all remaining system pressure exists if the purge valve actuates (500-600 psi). Once this valve operates, the windmilling engine will be unable to develop sufficient pressure to close the valve, and the system is lost. The hydraulic pump replenishing rate at windmilling speed is low. Obviously this latter case is extreme, but it serves to illustrate the margin of control available if caution is used in control movement.

Excluding battle damage, the most critical condition conceivable would be loss of both engines as a result of fuel starvation. In the event this occurred it would be advisable to use windmilling engines only as hydraulic pressure source during descent to save the electric emergency pump for added safety during landing.

In this article, I have attempted to accomplish one purpose — to discuss the flight and handling characteristics of the Scorpion F-89. The best "selling point" for you is to have a little time in the airplane under operational conditions. It was designed and built for a purpose and is fully able to fulfill its mission. As I mentioned previously, it is an easy, "honest" airplane to fly. ●

the C AROUND YOU

Sammy Mason, Flight Test Pilot
Lockheed Aircraft Corp.

WHEN I was first asked by FLYING SAFETY to do a story on spinning the F-94C, I wondered what there was to tell. After all, I reasoned, the Pilot's Operating Instructions cover the subject adequately, and I was sure the magazine didn't want a rehash of the Dash One. Still, the Directorate of Flight Safety Research had asked that the spin characteristics of the "C" be analyzed, so there must be a reason behind such a request.

You know, it's funny how many angles a man will come up with when thinking seriously on any given subject. The more I thought about spins in the F-94C, and the more I reviewed the Operating Instructions, the more I realized that although the manual is complete insofar as basic principles are concerned, there are still some fine points that are well worth considering.

About the only way I can lead into a piece like this is to discuss some typical spins. After riding through several hundred in any one type of aircraft, they become almost commonplace, but still, I'm of the school that believes every flight and every maneuver will teach something new, so let's run over some typical spins in the F-94C.

I don't care whether you're going to fly a Maytag Messerschmitt or a Starfire, the first thing you must do is to complete a thorough preflight check of the plane and make certain that all loose objects are tied down in the cockpit. This is especially vital when you are planning any acrobatic maneuvers, including spins.

We've all had our share of odds and ends flying around the office unexpectedly, such as bucking bars and wrenches, and it just isn't fun. So—I say again—make that preflight check complete and thorough.

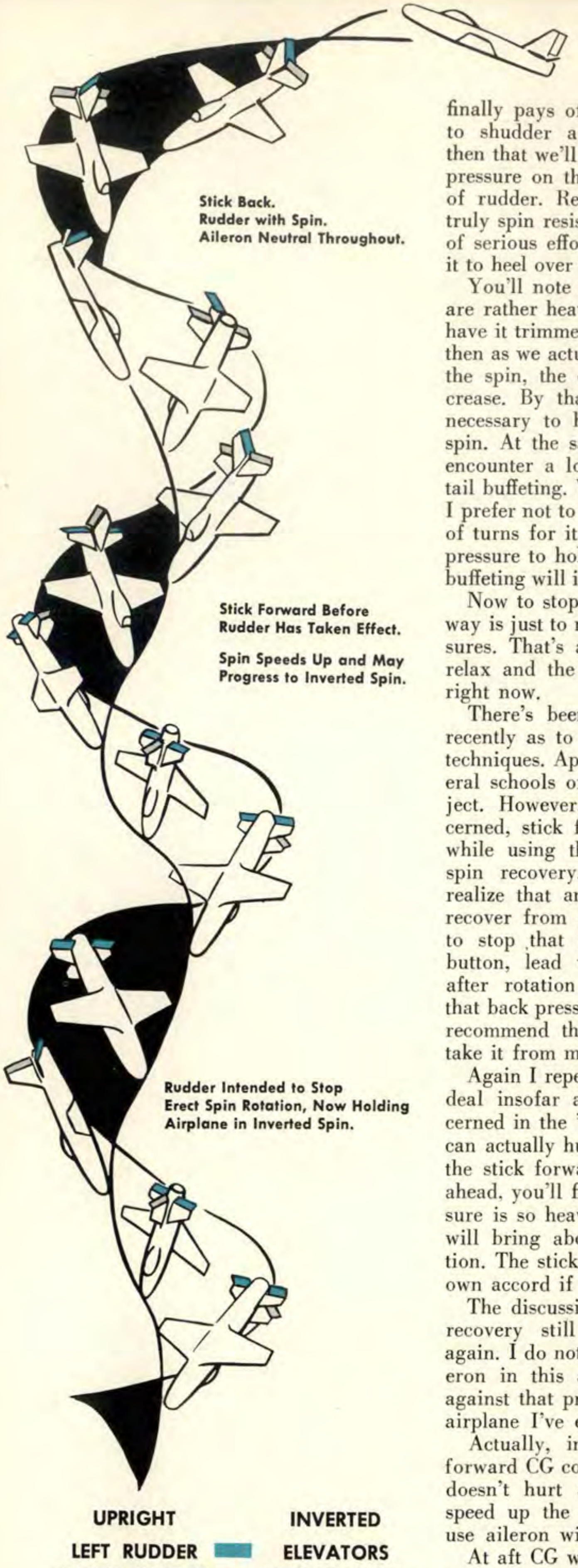
Okay, so we've completed our ground checks, fired up the plane and have climbed upstairs to about 25,000 feet. Everything is going along fine, and we're ready to perform some spins.

First things being first, we clean up the cockpit, trim the plane for level flight and then clear the area carefully. Remember how your instructor taught you to roll that old PT around before you started any acrobatics? You made certain that you had plenty of air around you that was not cluttered up with other airplanes. This is a two-way proposition. You don't want to spin into some poor unsuspecting soul, and by the same token, you could get a bit irritated if someone came clobbering into your cockpit. So, clear the area carefully.

Now, let's put our F-94C into a normal entry, spin it and recover. Believe me, it's a simple maneuver and I feel you're going to enjoy it.

We'll make this first one nice and clean. Let's check. Gear, flaps and dive flaps all tucked in? Okay, now throttle back to IDLE and pull the nose up slightly. Like any jet, the plane seems slow in decelerating but as the speed falls off we start easing the nose up, even more. Nothing extreme, mind you, just a clean stall.

The "C" is a kindly aircraft and gives you a lot of warning before it



finally pays off. You'll feel it begin to shudder a little, and it's right then that we'll feed in plenty of back pressure on the stick and apply lots of rudder. Remember, this baby is truly spin resistant, and it takes a bit of serious effort on your part to get it to heel over and slip into that spin.

You'll note that the rudder forces are rather heavy, especially when we have it trimmed for forward CG, and then as we actually get winding up in the spin, the control forces will increase. By that I mean, the forces necessary to hold the plane in the spin. At the same time we begin to encounter a lot of buffeting, mostly tail buffeting. With that forward CG, I prefer not to wind up over a couple of turns for it takes a lot of control pressure to hold her in the spin, and buffeting will increase.

Now to stop it. One easy and sure way is just to release all control pressures. That's all there is to it. You relax and the plane stops spinning, right now.

There's been a lot of discussion recently as to various spin recovery techniques. Apparently there are several schools of thought on this subject. However, as far as I'm concerned, stick full back is important while using the rudder to effect a spin recovery. Understand now, I realize that any good airplane will recover from a spin unassisted, but to stop that rotation right on the button, lead with the rudder, and after rotation has stopped, release that back pressure. The NACA people recommend this procedure too, and take it from me, it works nicely.

Again I repeat, trim means a great deal insofar as recoveries are concerned in the '94C. With aft CG you can actually hurry things by pushing the stick forward, but with CG trim ahead, you'll find that the back pressure is so heavy, merely releasing it will bring about a responsive reaction. The stick will pop ahead on its own accord if you give it a chance.

The discussion of ailerons in spin recovery still crops up now and again. I do not recommend using aileron in this airplane, in fact, I'm against that practice in almost every airplane I've ever flown.

Actually, in the F-94C, with a forward CG condition, use of aileron doesn't hurt anything, but it may speed up the rotation a bit if you use aileron with the spin.

At aft CG we have a different picture. Aileron control against the spin has a tendency to flatten it out a lot and will louse up the rudder and elevator control a great deal. Then too, if you get a spin stopped while still holding in aileron pressure, the chances are good that the ship will flop and spin in the opposite direction. So remember, when you have an aft CG condition, keep the ailerons in the neutral position.

Actually, in discussing forward and aft CG positions, I am trying to brief you on any possible spin condition you might encounter. Normally, the only time most pilots will fly the F-94C in an aft CG condition is after the nose rockets have been fired. If no rockets are carried, ballast or dummy rockets are installed to maintain a forward CG position.

Here's another good thing to remember—and, this applies to most aircraft, especially if the CG is aft. If you are a bit early on the stick when affecting a spin recovery and haven't given the rudder time to take hold and stop the rotation, then you are very likely to experience a momentary speed-up in rotation. This can be disconcerting to a new pilot and has probably led to some premature ejections.

Just to prove my point, I've deliberately cranked the F-94C into a spin and then pushed the stick clear forward while continuing to hold hard rudder with the spin. The plane begins to revolve like the well-known button and there is no indication of a recovery. She just keeps on boring around. Some airplanes will get real nasty under these conditions, but fortunately that does not apply to this one. All you have to do for recovery is pull the stick way back, feed in opposite rudder, and *after* it takes effect ease the stick forward.

You've all heard of getting out of phase in handling controls. Well, that can happen in a spin recovery attempt. You yank, pull, push, panic and eject! 'Tain't necessary. Just get back in phase again. Remember, feed in opposite rudder to the direction of rotation and keep the stick back. Rotation will stop. Then release back pressure for a normal spin recovery.

Now here's another point to remember which applies to any well designed airplane. If you get in a spin with full tips and the CG is well aft, and all of a sudden get in such a hurry to stop the spin that you leave opposite rudder poked in, well in all probability, the plane will stop spinning, pause for a second or two and then flop the other way. Maybe you'll say that's elementary stuff, and you're right. But, I've known some real sharp guys that forgot elementary stuff.

You're probably wondering how long it takes for the "C" to stop spinning under normal conditions and in clean configuration after recovery control pressure is applied. That's an easy one. Allow about one-eighth of a turn and you'll be right.

If you decide to wind up this plane with a lot of garbage out, such as gear and flaps, about the only real difference you'll note is the increased oscillation; the aircraft oscillates toward the horizon on the average of once per turn. This is especially true if you make your entry into the spin on the fast side.

On the first turn the nose will tend to come up pretty high and then as you progress into the spin, a dampening effect occurs and every turn will find the nose lower. Of course, center of gravity enters into the picture too. The further aft the CG, the higher the nose will ride for a while. In spite of this, recovery is the same as any spin and just as rapid. With dive brakes out, rudder is not quite so effective.

Maybe you're wondering about the altitude loss in a spin. Octually that depends on configuration and altitude upon entry. At 25,000 feet, for example, with all the garbage in, you'll lose about 5000 feet or so in a two turn spin. This includes recovery. With gear and flaps extended you'll actually rotate faster, and consequently the altitude loss per turn will be less. At lower altitudes, say from 15,000 or thereabouts, the loss is almost cut in half.

I guess it's the same old question, but someone always inquires about flat spins. Does the F-94C tend to get into flat spins? My answer is an emphatic *no*. I've been able to force a flattening effect by crossing controls but the bird won't stay there long, so we can scratch that problem. It doesn't exist.

On the subject of asymmetrical configuration as related to spins, my advice on the F-94C is the same as with any airplane with an uneven wingtip loading. Don't spin 'em. If you do accidentally and recovery is not effected within a turn or two—drop the tanks.

When I first started to get my ideas on paper, I didn't intend to get into the subject of inverted spins. My reason for thinking this way was because the F-94C makes the same kind of an inverted spin as any other good airplane. However, the more I thought about that subject, the more convinced I became that a few tips might be extremely valuable to a new pilot. For, although inverted spins are a prohibited maneuver in the 94C, sometimes a pilot enters one inadvertently. Even if only one of you new boys gets some help from the following ideas, it will be worth covering this subject.

For the experienced pilot I do not feel that the inverted spin presents any particular problem provided he initiates recovery upon recognizing it as such. The '94C does have a control reversal, similar to many other airplanes. You can work the stick up to a certain point where it will become neutral or negative. Then it'll want to go forward on you. At that point watch out. The airplane will continue to spin even after pressure has been released. Recovery is sluggish and it is possible that you could aggravate the situation until an uncontrollable condition developed.

Until a pilot has experienced an inverted spin, he'll probably be a bit leery of it. When the first one occurs you may wonder which rudder to use for recovery, which way the plane is rotating and so on. Actually, there's not much to it.

The best advice for the beginner is to forget whether the plane is spinning right or left. Merely push rudder against the way the plane *appears* to be turning and hold the stick back in your tummy! If the spin has not been prolonged or aggravated that will stop it, but fast.

You've always got to consider the possibility of slopping into an inverted spin from some acrobatic maneuver, such as stalling out on top of an Immelmann. Fortunately, the F-94C is just as spin resistant on its back as right side up, and here again you've got to work to make it spin, either side up.

Here's another thought to tuck away for future reference: *If you ever get into an inverted spin, you can recognize it at once because both your hands and feet will be pulling away from the controls.*

Incidentally, that is why I feel that although this business of holding the stick back while using recovery rudder in a spin may have been overstressed somewhat, it's still good business. Figure it out. Right side up or inverted, if you can just kick rudder against the apparent direction of rotation, the spin will stop and you can then complete the recovery from either type of spin, as the case may be. I say this because sometimes normal spins, in some planes, can get violent enough to fool the embryo pilot. I don't feel that this latter statement applies to the F-94C, but it's worth remembering.

That's about all I have to offer on inverted spins except this: Unless a new pilot has a few demonstrated while in flying school, the chances are good that he'll not recognize the fact when he suddenly goes from a right side up to an inverted spin. Here's the reason why.

For the sake of discussion let's say this pilot is making a normal spin to the right. Everything is going along okay until he starts the recovery. At this point he fouls up. Let's see what happens.

He applies left rudder against the spin but does not wait long enough for it to take effect. Before rotation stops he shoves the stick forward and is startled to note that the spin is speeding up. A split second later the aircraft goes into an inverted spin. Now, the rudder he was using to stop the erect spin is holding the plane in an inverted spin. Confusion reigns supreme!

If he doesn't get wise, but fast, he's going to run out of sky and luck at the same time. Maybe someone should have told him that he would feel the pull *away* from the controls in an inverted spin.

I would like to re-emphasize one point on erect spin recovery technique for the F-94C. It is really important *not* to use the stick ahead of the rudder, and personally I wouldn't use it simultaneously. If you do come in first with stick the aircraft may wind up for several turns before it wants to recover. The reason for this is that as you use forward stick pressure, you deflect the airflow in such a manner that it misses the rudder. And the rudder is the *primary* control for stopping the spin.

So keep the stick back until the opposite rudder is in and has really taken effect.

I guess that's about all I have to cover on spins. If I've sounded like a primary instructor, it wasn't intentional. However, I would like to leave you with this thought: *When asked about the spin recovery of the F-94C, your answer is — — "No sweat."* ●

Russell M. Roth, Test Pilot, Republic Aviation Corp.

FLYING the F

THE best way to learn how to fly an airplane is to fly it. And I believe that the best way to describe any airplane is to detail each step of a flight from walk-around inspection to landing. So let's get out on the flight line and start from scratch on an F-84F.

You jet jockeys who will be becoming acquainted with the Republic F-84F will have a completely different bird surrounding you than the old F-84 series aircraft.

The F-84F is a swept-wing fighter designed for flight in the subsonic and sonic speed ranges. It is powered by an axial flow J-65 Curtiss-Wright engine, developing 7200 pounds uninstalled thrust. The aircraft lends itself readily to fighter-bomber and long range operations, since it can carry heavy external loads.

The cockpit of the "F" was designed with an eye to pilot comfort. It is similar to the 84G, though slightly larger. The pressurization system provides for greater quantities of air at comfortable temperatures and allows cabin pressurization at lower effective altitudes. A double wall canopy, an anti-fogging dry air circulating system and a flat front windshield provide good visibility.

The aircraft is 43 feet long, has a wing span of 33 feet and is 14 feet from the ground to the top of the fin. Gross weight varies from 18,500 pounds for a clean aircraft to over 25,000 pounds for the aircraft with four external tanks installed.

Actually, in discussing the "F," I will refer to two variations of the aircraft. The first planes that were delivered to the USAF had two-piece tails. A later version of the "F" was modified to include a flying tail. For simplicity, I will refer to each type as two-piece tails and slab tails.

Special Preflight Check

During the usual walk-around check list inspection, I note the position of the horizontal stabilizer, so that when I get in the cockpit, I can see that the stabilizer position corresponds with the cockpit position indicator. Next, I trim the stabilizer to see that the direction of the stabilizer motion corresponds with the position indicator. At this point also, I check the emergency override switch for travel on the longitudinal control to make sure it by-passes the stick grip.

This aircraft is equipped with an irreversible control system, and all control surfaces are actuated by hydraulic pressure. No air loads or surface forces are felt by the pilot. An artificial feel device as nearly as possible simulates in-flight air loads. With this control system, forces present on the ground are nearly identical to those encountered in flight. Forces are proportional to stick motion rather than airspeed and loading. Don't rely on stick forces; rely on airspeed for proper aircraft control.

For a preflight check after the engine is started and hydraulic pressure is available, deflect the stick full forward, full back and to the side and apply full rudder. If the entire control system is okay, the stick will re-center itself after each control movement, and the rudder will return to neutral. In conjunction with this check the artificial feel devices incorporated in the aircraft give you approximately 38 to 40 pounds for full back stick deflection, 12 to 14 pounds for full forward and 18 pounds laterally for full throw. In addition to the above forces, approximately a $1\frac{1}{2}$ pound force is required for initial movement of the stick from the centering detent.

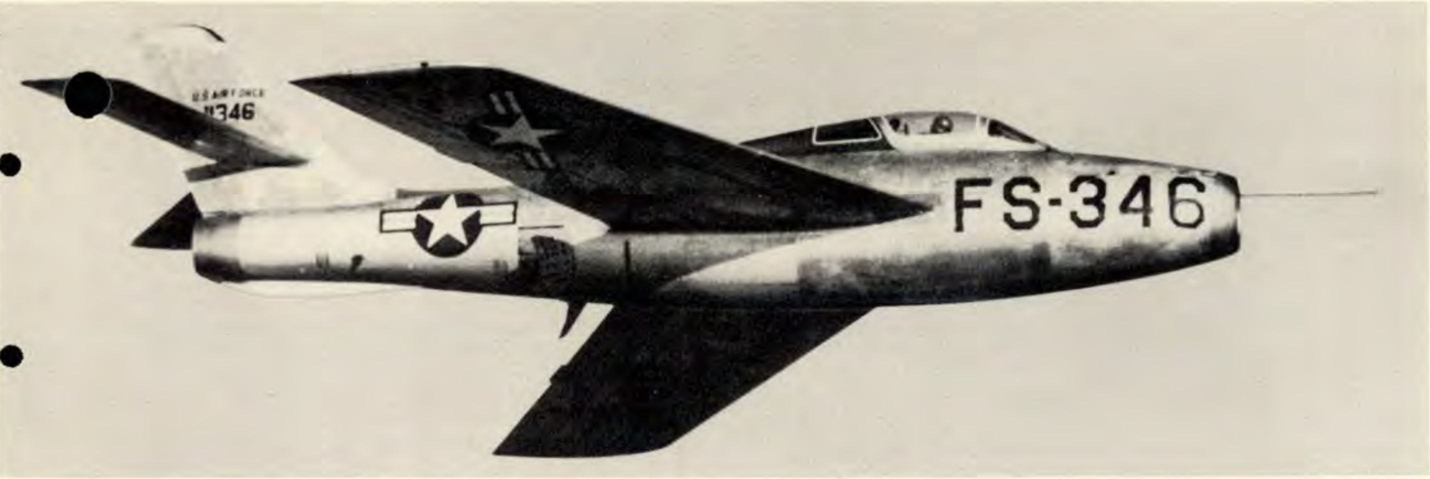
Just before takeoff I arm my jettisoning switches. The inboard jettisoning switch drops the inboard tanks or stores, the outboard jettisoning switch can be used to jettison the outboard tanks or stores, and the panic (emergency salvo) switch eliminates all four tanks and the pylons in case you have to dump them in a hurry during a takeoff emergency.

Before takeoff I run the engine up to 100 per cent and recheck all the engine instruments, particularly the oil pressure, fuel flow, tailpipe temperature and RPM.

On takeoff, rudder breakout forces may cause a slight tendency to overcontrol at the beginning of the takeoff roll. Care and experience will eliminate this tendency after a few flights.

Watch That Attitude

I would like to emphasize one point concerning the takeoff run. I never make any move toward pulling the aircraft off the runway until I have nearly reached takeoff speed for the particular configuration. Naturally, I have referenced the Dash One for this, prior to starting the flight. When the plane has reached the de-



sired speed range I use a gentle, sustained back pressure to get the nose off and hold a shallow angle of attack. In this attitude, the plane flies itself off as acceleration increases.

The important things to remember here are airspeed and attitude. If a pilot starts the nose up too soon and holds it off at lower speeds, and he has elevator power to do this, he stands a good chance of getting on the back side of the power curve, especially with external stores. You all know what happens then. The plane may break ground but it is going to return in a hurry.

Slab tail aircraft have another built-in safety factor. This model has an auxiliary electric hydraulic system which is available to the flight controls. This alternate control system cuts in automatically if the regular system pressure drops below a critical value.

In addition to the normal and the emergency hydraulic systems, an electrical actuator is connected to the longitudinal control system, and the slab tail can be controlled by actuation of the stick trim button. This system by-passes all mechanical linkage and is an excellent battle damage control, as only the electrical wiring from the stick grip to the electric motor in the slab tail is necessary for longitudinal control.

The above control systems give the slab tailed "F" three separate longitudinal control systems: regular hydraulic, emergency electrical - hydraulic and direct electrical control.

You jet jockeys will be pleased with the way the aircraft accelerates to climb speed; you get to altitude in a hurry.

Okay, the plane is now at altitude, trimmed and ready to go. Let's run through some of the flight characteristics and see how the "F" handles.

This plane was designed for high speeds at all altitudes; flight characteristics are excellent throughout the speed range. The speed is limited only by the thrust available and by total aerodynamic drag. In level flight at high Mach numbers the few trim changes are made easily by using the trim button to readjust the stabilizer.

Aircraft buffet or heavy trim changes are not problems through the trans-sonic speed range. The aircraft remains stable except for a slight tendency to wing heaviness, which is overcome easily with a small amount of aileron.

Stall warning is very good on both the two-piece tail and the slab tail aircraft. First warning is light buffeting, followed by heavy buffeting, and finally by a softening of the controls immediately before the complete stall. Upon stalling, some nose-up tendency is noticeable, but there is sufficient longitudinal control to stop it. In fact, in the slab tail models there is far more control available than ever could possibly be needed.

When the aircraft is stalled, there is a pronounced yaw, usually to the left. This gives an additional stall warning. This tendency is no cause for sweat on a landing, as plenty of rudder control is available to correct the yaw before touching down. When the aircraft yaws, just remember it is ready to pay off.

On any stall, accelerated or unaccelerated, the 84F comes out flying, with no tendency to spin. This is equally true for aerobatic maneuvers. In fact, to spin this plane, a pilot would have to make a deliberate entry and then hold the plane in the spin. To date, spin tests haven't been run, and the F-84F is restricted from spins. Wind tunnel tests with a scale model F-84F have been accomplished and the "F" displayed normal aircraft spin characteristics.

After going through the usual acrobatic maneuvers and observing how well the plane handles, let's go downstairs and see how it handles at low altitudes and on a landing.

Low Altitude Dives

A word of caution for you boys who like to play downstairs at high speeds. This aircraft accelerates rapidly and can really wind up. A bit of explanation from our engineering people as to what can happen if you get too gay might help at this point.

A high speed aircraft loses some of its control effectiveness in the vicinity of and above .9 Mach, so be careful. The point is, don't get in the wrong attitude at any altitude where control effectiveness is essential.

In an emergency some help can be obtained by judicious use of the stabilizer trim. However, be extremely careful about overloading the airplane. As airspeed decreases, control effectiveness returns, and if excessive trim has been applied, high accelerations may be experienced. Use full elevator travel before applying stabilizer trim, so that full opposite surface travel will be available in case you pull excessive G.

I'd like to stick my neck out a little bit in discussing landings. I think it is almost impossible to make a bad landing in this airplane. Okay, I know some joker will make a liar out of me, but he is going to have to try real hard. I just don't believe that today's high performance jet aircraft, and I mean all of them and not just the F-84F, can be flown correctly in the landing pattern if the pilot insists on wracking around in steep, tight turns. I don't mean that you have to fly a Gooney bird pattern to be right; just a modified pattern with normal turns and power.

Although I could quote some figures relative to pattern speeds that generally apply, I believe you should reference the Dash One and thoroughly memorize them all. Inasmuch as a definite pattern is a must in my book, I make my break and bring the plane around smoothly for the downwind. Then the gear and flaps are lowered while holding the recommended speed. I prefer to maintain a good margin above stalling until on final and then begin slowing down as I cross the end of the runway, using a shallow approach. I retain power until I have it made, as this aircraft has a high rate of sink.

Airspeed and Power

I still say that you really have to try to make a bad landing. The point is, control your rate of sink with power and sufficient airspeed and there's no sweat. True, the rate of sink may be deceiving to an inexperienced man, as the plane feels good and solid until he looks out and sees the ground coming up real fast. Then when he comes back on the stick, there is no round out left. Remember airspeed and power, and the problem is non-existent.

After touchdown a pilot has plenty of braking action to bring the plane to a stop. In fact, it is easy to slide a wheel with the power assisted brakes and not even know it. I try to get the nose down fairly early in the roll and start light brake application immediately, rather than wait too long and then be forced to use too much.

Assisted by four JATO units delivering 4000 lbs. thrust, the F-84F really leaps into the blue.

In case a landing is made deadstick, engine frozen or with hydraulic pressure not available, the brakes a on a hydraulic-mechanical syste Brake forces are high, but full action can be obtained, even to sliding the two main wheels.

The F-84F can carry a tremendous load of external stores and still get off well. I think both takeoff and landing run compare favorably with other aircraft, especially considering the weight that can be carried.

I have made flights with the airplane in an asymmetrical configuration, with the equivalent weight of a full 230-gallon inboard pylon tank on one side. Landing in this configuration presents no problem; at slightly above normal approach speed with gear down and full flaps there is still enough aileron for lateral control. However, in case an outboard tank is lost, I recommend dumping the other before landing.

As an added check-up on the two-piece tail aircraft, a factory test was flown on each plane with boost off. This test was made to determine at what maximum speed the aircraft could be controlled properly with boost off. This precluded the possibility of getting an aircraft so out of rig that it couldn't be controlled higher speeds. Ordinarily, when flyi with boost off in the upper speed ranges, the aircraft has good rudder control and fair elevator and aileron control. All flight control in the lower speed ranges is very good.

I suggest that all new F-84F pilots practice flying the two-piece tail model with the boost off. This will enable them to find out just what the aircraft will do under this condition and to familiarize themselves with the changed control characteristics. To practice boost-off flight, trim the plane for straight and level flight in the mid-speed range and turn the system off. When ready to turn the boost system on, retrim the aircraft to reduce high stick forces. Incidentally, on the slab-tail model this is not a problem as it has an auxiliary control system.

In writing this article I tried to mention some of the F-84's features and some of the things about the aircraft that deserve your respect when flying it. To summarize it all I would say this is a fine aircraft; big, fast and rugged. It will do the job for which it was designed and do well. I think you'll like to fly it; know I do. ●

Spinning the SABRE

Flight Test Section
North American Aviation, Inc.

IT IS mid-afternoon as an F-86F airplane prepares to take off. The test pilot's schedule indicates that today he is to practice spin recovery. If you were that pilot, would you have any questions on the spin recovery characteristics of the F-86F?

Probably not, for you know that the F-86 airplanes have consistently demonstrated their ability to recover from any type spin using the standard recovery procedure or the hands-off method. However, maybe in the back of your mind a little doubt still persists; maybe you remember hearing about an accident which indicated that an F-86 was lost because of failure to recover from a spin.

Loss of an F-86 in this manner is somewhat puzzling, to say the least. The factory in over 100 actual spin tests has never been able to find an F-86 series airplane that would not recover from any type spin.

On page 13 you can follow a pilot through two spin tests. In one, the spin is entered from a normal, upright one G stall; in the other, the spin is entered from a three G climbing turn.

As an example of the extent of factory flight and wind tunnel spin tests, F-86s equipped with the slat or extended leading edge have demonstrated their spin characteristics in all of the following situations: in both clean and drop-tank configurations; with flaps and gear down and with flaps and gear up; both erect and inverted at low speed; ailerons neutral, against and with the spin; with speed brakes open and closed; power on and power off; forward and aft center-of-gravity positions, and out of accelerated stalls at low

". . . factory test pilots say they have never experienced any kind of spin or spinning maneuver from which recovery couldn't be accomplished satisfactorily using standard recovery technique."

speed and at Mach .9 (snap rolling).

Factory test pilots who have had extensive F-86 flight time say they have never experienced any kind of spin or spinning maneuver from which recovery could not be accomplished by use of the standard recovery technique. In fact, the pilots report that it is difficult to keep an F-86 in a spin.

For example, to maintain spins entered by snapping out of a high Mach number turn at altitude, a stick pull force of 50 to 60 pounds and a rudder force of 200 pounds are required from trimmed level flight. Thus, the test pilots are convinced that merely neutralizing the controls is sufficient to effect spin recovery, although recovery in this manner may take an extra turn to complete. Therefore, it is concluded that in all non-spin-recovery accidents reported, the wrong recovery procedure was undoubtedly used.

All pilots should remember that they have a flying tail which is powerful enough to hold the airplane stalled and in a spin, regardless of rudder manipulation, if the stick is held back. Spins have been entered and recovery completed with the throttle positioned at Military Power; however, retarding the throttle to idle reduces altitude loss during the spin and recovery.

Inverted Spin Characteristics

Inverted spins may occur if the airplane stalls during aerobatic maneuvers. The inverted spin is characterized by a roll into a normal 45-degree dive during every three quarters of a turn. Recovery can be initiated at any time by neutralizing controls and dropping the nose as the airplane rolls upright.

When spin entry occurs from an accelerated turn with external drop tanks installed, it is different from an entry with the airplane in the clean configuration. With drop tanks, the airplane *momentarily rolls into a spin in the opposite direction* to the original turn. It spins one or two turns in this direction and then sharply reverses itself and spins in the original direction (direction of accelerated turn).

Recovery is accomplished as during a normal spin by applying hard opposite rudder and moving the stick forward to neutral simultaneously. Remember, the only difference between spins with and without drop tanks installed is the initial spin entry. The first turn with drop tanks on the aircraft is opposite to the original accelerated turn direction.

Factory spin tests indicate that on the average a normal spin turn requires five seconds, and the airplane loses between 1000 and 2000 feet per turn.

Once spin recovery is initiated, airplane rotation will completely stop within three-quarters of a turn, and altitude loss to complete spin recovery and pull-out will be approximately 5000 feet. Therefore, it is recommended that if a spin is entered below 7000 feet terrain clearance, the pilot should bail out. ●

To help prevent further accidents resulting from spins, the following information and recommendations are offered:

★ Do not trim into a turn.

★ If the airplane snaps out of a turn at any speed, enters a spin from a low-speed, straight-ahead stall, or enters any form of a spin-type maneuver, NEUTRALIZE STICK AND APPLY OPPOSITE RUDDER SIMULTANEOUSLY.

★ It is of utmost importance that the stabilizer be released or the stick brought forward to approximately neutral. RECOVERIES CANNOT BE RELIABLY EFFECTED IF THE STICK IS HELD BACK. Also, because of recovery attitude, full-forward stick is not recommended.

★ If confused as to what recovery technique to use, release all controls.

★ A recovery characteristic of the F-86 is that THE SPIN SPEEDS UP MOMENTARILY DURING RECOVERY. Therefore, don't let this mislead you into thinking your recovery technique is ineffective.

★ It is considered that the spin recovery procedure in the Pilot's Handbook is the equivalent of that given in recommendation No. 2.

★ After rotation has stopped, BE CERTAIN you have sufficient airspeed before initiating any pull-out.

★ To minimize altitude loss in a spin and recovery, retard throttle to idle.

First spin will be entered from a 1G stall straight ahead.

Now at 35,000 feet, 70 per cent rpm. Pulling nose up. 140 knots, buffet starts. 130 knots, airplane yawing. 120, 112 knots, 36,700 feet, fully stalled. Full right rudder, stick full back. Into right spin. Throttle retarded.

Airplane noses down to vertical.

Nose comes up to horizon, wings level.

Rolling to the right, nose drops.

Airplane noses down to vertical. Slight rudder buffet.

Complete second turn, nose comes up to 10 degrees below horizon, wings level.

Rolling to the right.

Airplane noses down to vertical.

Third turn, nose comes up to 40 degrees below horizon, wings level.

Rolling to the right.

Airplane noses down to vertical.

Fourth turn, nose about 60 degrees below horizon, wings level. Heavy rudder buffet.

Now for recovery. Hard left rudder and stick to neutral.

Spin speed increases momentarily, then slows.

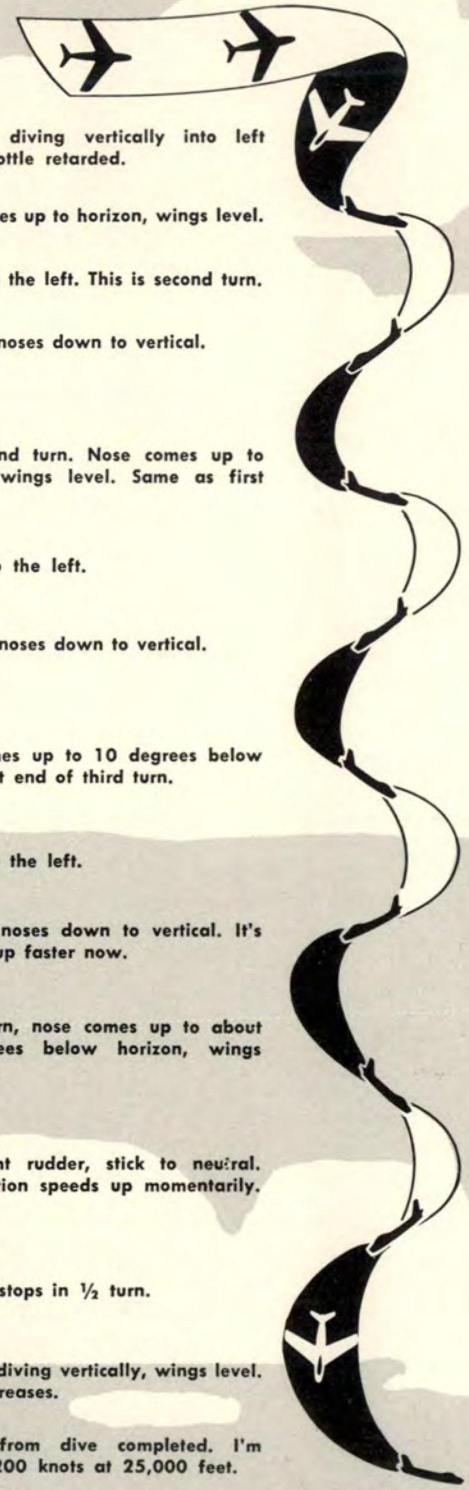
Spin rotation stopped in ½ turn. In vertical dive. Airspeed increases.

Started 3G pull-up at 25,000 feet. 210 knots.

Recovery complete, flying level at 23,000 feet. Everything fine.

This will be a four-turn left spin from a 3G climbing turn.

Altitude 35,000 feet. Military Power and 100 per cent rpm. Now turning to left. 2G, now 2½G. Heavy rudder buffet. 3G at 150 knots. Stick full back, full left rudder.



Airplane diving vertically into left spin. Throttle retarded.

Nose comes up to horizon, wings level.

Rolling to the left. This is second turn.

Airplane noses down to vertical.

End second turn. Nose comes up to horizon, wings level. Same as first turn.

Rolling to the left.

Airplane noses down to vertical.

Nose comes up to 10 degrees below horizon at end of third turn.

Rolling to the left.

Airplane noses down to vertical. It's winding up faster now.

Fourth turn, nose comes up to about 60 degrees below horizon, wings level.

Hard right rudder, stick to neutral. Spin rotation speeds up momentarily.

Spinning stops in ½ turn.

Am now diving vertically, wings level. Speed increases.

Pull-out from dive completed. I'm level at 200 knots at 25,000 feet.

Anymouse  *and his hairy tales*

This Anymouse article is one of the finest hairy tales to brush across FLYING SAFETY editorial desks in a long time. The author leaves no doubt in his readers' minds as to what happened and why.

The most important point of the story is that it happened to an experienced instructor pilot. This pilot planned a flight carefully, and thought he left nothing to chance. But he overlooked the human element, both in himself and in others. Through a series of assumptions, acts of carelessness and because of a bad case of that "ole debbil" get-home-itis he came mighty close to getting in a real jam.

This story has a message for all jet pilots, both the tyros and the old hands. It reads . . . don't let it happen to you.

THERE I was, flat on my back at 45,000 feet on a pitch black night, surrounded by thunderstorms and out of oxygen. This start to the typical "war story" wasn't really that bad, but the T-bird was sure shuddering as she hit the red line while I had my head down tuning in the next range.

It had all started about four hours before when I arrived at operations for a little night flying. Since I've always been bored with "flying around the flagpole," I figured it would be a good opportunity to check myself out on my night navigation and cruise control. So I spent the next two hours planning a round robin with the aid of one of the new experimental Jet Navigation Charts, cruise control chart, E6D computer and a Radio Facility Chart. I really planned the flight, too—I knew exactly where I'd be when I reached altitude, when my tips would run dry, when to start my letdown and how much fuel I'd have remaining when I stop-cocked her. In fact, I was primed for a good three hour and ten minutes flight. I was so sure of my planning, I'd even told my wife to pick me up at 2330. But as someone once said about the best laid plans of mice and men — —.

My woes started when one of the airmen from the tower brought in a fresh jug of coffee for the boys in ops. When he heard I was going round-robin in the T-bird, he asked if he could go along. He assured me (and it was verified by the personnel on duty in ops) that he had had altitude indoctrination. Big-hearted me, I replied that it was just as cheap to fly with two as one, and for him to check out a chute, P-1 and mask from personal equipment. While he did this, I checked weather.

It was strictly VFR except for possible thunderstorms over Phoenix. But no sweat there — they'd top at 35,000, so the forecaster told me. When we reached the ship, it took me longer than usual to check it over, because I was going to have everything right on the ball on this flight! I checked everything on that walk-around. I was also held up an additional thirty minutes while I assured myself of the fit of my passenger's oxygen mask and his knowledge of the operation of a "hot seat."

We finally got off the ground and I climbed on course to 38,000. I ran an oxygen check on my passenger about every ten minutes and indicated to him when we got to altitude that our cabin pressure was 26,000 feet. When I was out about 350 miles, I looked down at the oxygen gage and noticed that I only had 200 pounds of oxygen. I asked my passenger if he was on 100 per cent. His gay answer of "Yes Sir, I sure am," brought a quick reply from me to put it on "normal" and leave it there.

Over Phoenix, at about 560 miles I ran into the predicted thunderstorm activity but had to climb to 45,000 for about 10 minutes to top them. (So what's a 10,000-foot error to a forecaster?) I dropped back down to 38,000 and called the next station to change my penetration altitude to 25,000 feet since by this time the oxygen gage read 100 pounds. I hit my penetration right on schedule and immediately dropped to 18,000 to get cabin pressure down below 10,000, since by this time oxygen was what I was fresh out of.

Naturally, there was my round robin—shot. So I headed for the nearest Air Force base for fuel. Called in and changed my flight plan and explained my difficulty. I came in, landed and was led out to the "pea patch" for parking.

Now, here's where the fun really begins. First, I told the alert crew

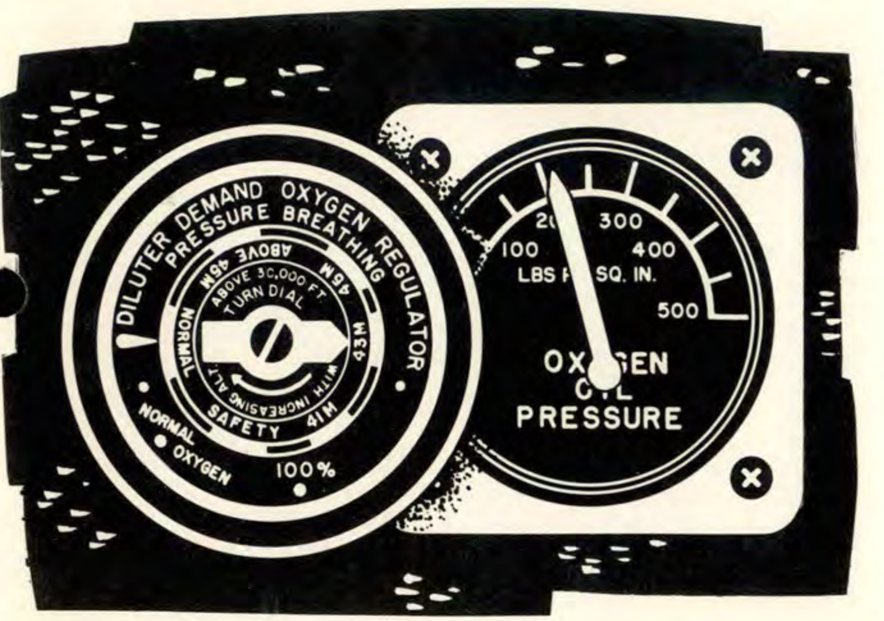
. . . slightly miffed because the Alert Crew had parked him out in the middle of the pea patch.

that I wanted oxygen and fuel, and since I was only an hour from home, I only wanted 50 gallons in the tips.

Second, I went into ops and waited for over an hour until the gas crew came back from chow (those boys must have been really hungry).

Third, I finally got a clearance and headed for the "pea patch" again. It was while headed to the "pea patch" that the alert crewman said he had given me 400 lbs. of oxygen service, but by the time he got up to the rear cockpit and turned the regulator off of 43,000 the pressure had dropped to 200 pounds. That set me off on a tirade about the stupidity of certain individuals who were supposed to know how to use a pressure demand regulator. My passenger's reply was that he had been instructed to (1) go on 100% oxygen above 30,000 feet, and (2) to the pressure system above 40,000. I then patiently explained the principles of pressurization and asked him if he remembered my calling back cabin pressures to him. He did, of course, but believed only the altimeter in front of him.

"... by the time he turned the regulator off of 43,000 the pressure had dropped to 200 pounds."



Fourth, I climbed into the airplane after a very cursory exterior check (after all I'd just flown it myself, hadn't I?) and no check of the Form 1A, looked at the fuel totalizer and set it at 453 gallons (naturally, the alert crew had failed to set it), lit the wick and started taxiing. I wouldn't say exactly that I was in a hurry, but it was after 0100 and my wife was waiting at ops, and she's still relatively new at this Air Force wife routine. Besides, I was more than a little miffed at having to wait for go juice. And in addition I resented having to park in the "pea patch" which was as dark as the inside of a cow. Anyway, as I taxied out, I checked out my tips and found them to be feeding okay.

I couldn't quite figure out why I leaped off the deck so fast when I poured the coal to it, but it only took about 10 minutes to find out. About that time I noticed the red lights for the tips and a drop in the fuselage tank, to about 80 gallons so I switched to leading edge. Guess what — red light! Next the wing tanks — same story. Just about this time I was in the midst of a 3G, 180-degree turn and I heard my passenger say, "Gee, isn't it pretty down there." That, as the expression goes, ripped it. I told him in no uncertain terms to shut up, put his hands in his lap and just sit there until we got on the ground.

As I started a letdown back to the field from whence I came, I grabbed the Form 1 (now he looks) to see how much fuel I had gotten. For the life of me, I couldn't find entry No. 1 as I flicked back thru about four pages of 1A's. Called into the tower for landing again and was asked immediately "wha hoppen." I told them I was slightly short on go juice, but since I was already on initial and 3 out, I had it made. I did qualify it to state that although no emergency existed, it would be "no go-around."

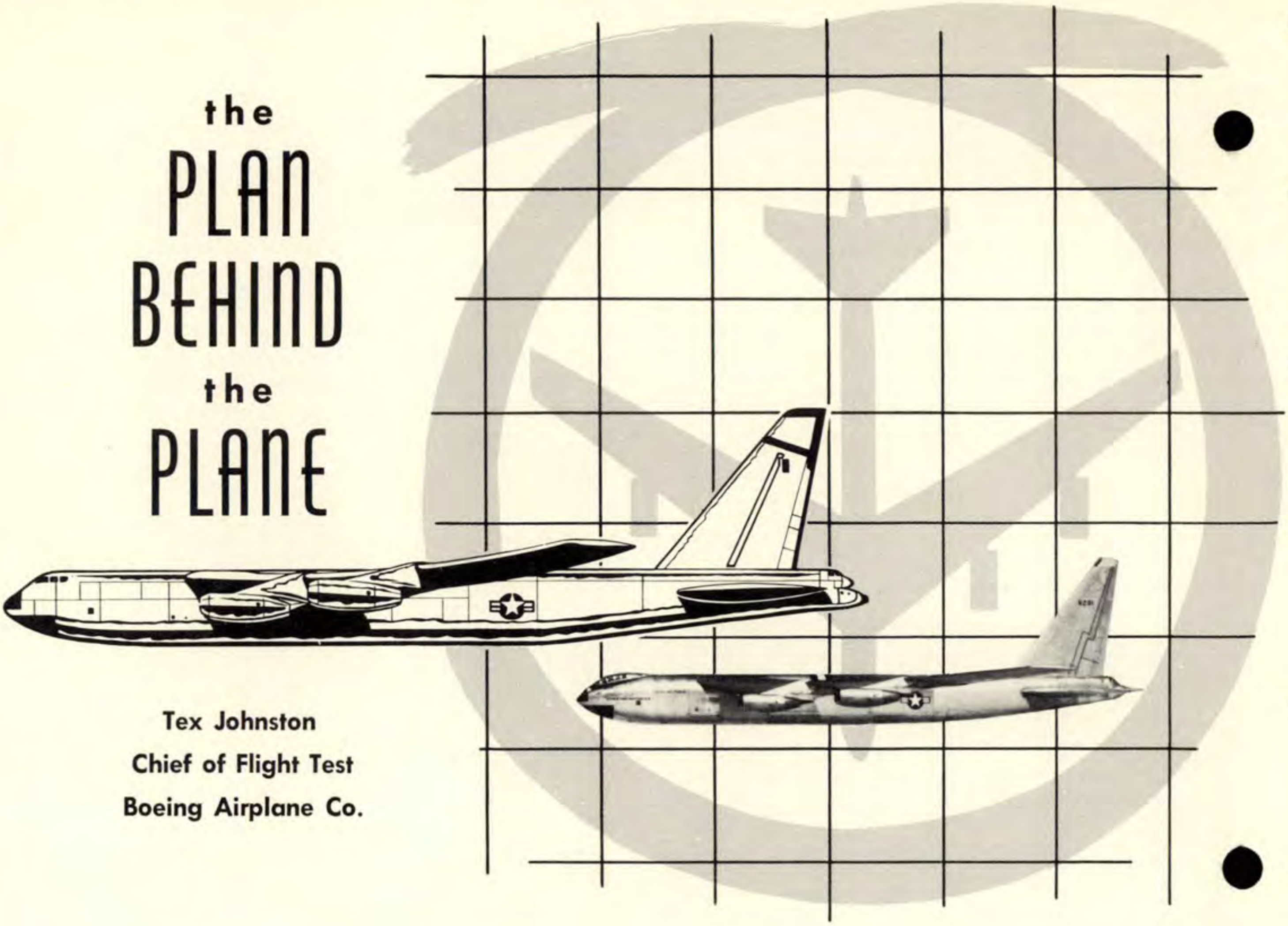
When I got on the ground I started in with the alert crew. Their answer was, "You said only 50 gallons in the tips." This I did, but I apparently made an erroneous assumption—that they had sense enough to service the bird with internal fuel. Next, I jumped the gas crew to find out why no entry had been made in the 1A. "But, it's there, sir!", so I said "Show me." They were right, there it was—exactly eight pages in back of the current form. The best I could figure is that their procedure is to note the gas on the page where the form happens to fall open. Needless to say, I not only checked the tanks prior to takeoff—I filled them myself.

I learned some lessons that night—the hard way. I don't know how many cadets I've "chewed out" for pulling identical tricks to mine. But, of course, that was quite a few years ago when I was instructing—ten to be exact. I guess I've grown complacent, and maybe a little too "hot" just because I've got a green card, a star on my wings and 3000 hours behind me. I know I'm not the only one with this trouble and that's why I'm writing this *Anymouse*. After nights like that one, I begin to feel that I'm still alive *in spite* of my techniques, and not because of them—and believe me, it's not a good feeling.

P.S.—I now fly no passengers on X-C in the T-Bird unless they are rated, and it takes me exactly 20 minutes longer to check out any aircraft I fly, every time I fly it. Also, I don't care if my wife's been sitting in front of ops for 10 hours. As the saying goes "you're a long time dead," and she was only mad for three days. ●

"... a star, 3000 hours and a green card."

the PLAN BEHIND the PLANE



Tex Johnston
Chief of Flight Test
Boeing Airplane Co.

WHEN the Boeing B-52 Stratofortress heavy bomber is delivered to the first Strategic Air Command wing to be so equipped, it will fly to its operational base powered by eight Pratt & Whitney J-57 engines; it will be laterally controlled by spoilers instead of ailerons; trimmed fore and aft by means of a positionable horizontal tail, and landed on a dual tandem undercarriage, which has eight wheels.

These features and others are "firsts" for heavy bombers. They are successful components which add to the big bomber's operational efficiency and ease of handling. They are new features, but there is a long story behind them.

It begins with ideas believed to fill specifications; it continues through careful experimentation and careful design. Then comes construction of the first airplanes; then testing, improving and more testing, while production airplanes are being built and made ready for delivery. This is necessary if the airplane delivered to Air Force bomber crews is to be a dependable weapon which can be used efficiently by those crews.

While all of the background work behind the bomber as it is delivered to Air Force crews is equally important, it is proposed to limit this discussion pretty much to the testing of the airplane, the organization behind the testing and changes for the better made as a result of test flying.

Aeronautical design is becoming more and more an exact science. An airplane produced from the designs of an intelligent engineering organization, and checked out in a wind tunnel and other laboratories, is almost certain to be able to take off, maneuver and land with no great sweat. But this is not to say that it will be the perfect operational instrument throughout its range of speeds and altitudes, nor that every part of it will be okay. It remains for the test crews to determine just how close the designers have come to perfection and in what ways they have fallen short, so that the airplane type can be developed further.

Stated another way, the reasons behind test flying are; to seek out constructively the capabilities of the aircraft, and to produce the best possible information for the airplane's successful development. Thus the test flying activity is a continuing effort to make a new airplane type better and better, to the limit of the basic design's capabilities.

This improvement of the airplane through development testing is called "stretch." It is illustrated perfectly by the case of the B-47 Stratojet. The XB-47, prototype of that bomber, first flew in December 1947. At that time its maximum gross weight was 120,000 pounds. Since then, developmental testing has kept stables of B-47s busy on experimental flying at Boeing flight test centers in both Wichita and Seattle. This bomber type has been improved continually until now its maximum gross weight for takeoff is 205,000 pounds, and development testing still continues.

Experimental testing is not a solo effort by test pilots, of course. While there are six pilots engaged in testing various B-52s experimentally at the Boeing Airplane Company's flight test center in Seattle, and three B-52 production test pilots; there are behind these flyers nearly 500 expert engineers and technicians processing data obtained by the many instruments which can gather more than a million facts in a flying hour. Their job is to determine what the data signifies with respect to the airplane's systems and components and structure, and to keep the flight test instruments in shape.

This work is carried out in a new flight test center at Boeing Field in Seattle, a $5,800,000 facility made up of a hangar capable of housing comfortably five B-52s, drafting rooms, radio rooms, laboratories, offices and shops. The installation was designed as a base for modern and efficient flight test activity and to deal with the complex job of testing modern airplanes such as the B-52. In this way, knowledge gained on test flights can be put to use to develop constantly improving airplanes.

Air Force test pilots of ARDC, from the Flight Test Center at Edward AFB, with duty station at Seattle are assigned to B-52 testing. They cooperate with Boeing test crews in accumulating knowledge regarding the airplane and criticize it constructively from the point of view of the military pilot and crewman.

What will B-52 flight-testing mean to the pilot and crew of an operational Air Force bombing wing?

It will mean, first of all, that the airplane has been proved completely under all conceivable operational conditions short of flak. It will mean that the airplane has been developed with the goal in view of making it a weapon which is dangerous only to the enemy — not to the crew.

Test flying also will mean to the pilot and crew that every system and component of the airplane has undergone checks prescribed by Boeing's flight test organization.

Flight testing the B-52 began in early 1952 when, with an ARDC officer as copilot, I took the airplane off on its first flight.

The testing continued on further flights, as handling qualities, stability and control, performance, structural integrity and other items were investigated under controlled conditions.

At the same time, oscillographs, Brown recorders and photo recorders were gathering data on the airplane's structure, power plants and systems.

There were many new features on the B-52 to be tested—the double-tandem landing gear, the spoilers and the positionable horizontal tail.

As each system and component on the airplane underwent systematic testing in the air and on the ground, improvements were made and incorporated into the test airplanes as the need arose. The process went like this. Something might be discovered that did not function quite as planned when it was originally designed. This would be reported either by the pilots, or by flight test engineers who discovered some evidence of the imperfection through their instrument recordings. Staff or project men in Boeing's engineering organization would then seek some method to correct the imperfection. This "fix," as it is called, would then be incorporated in the airplane and tested in flight to determine if, indeed, it were a "fix." If it were not, another "fix" would be incorporated and if required, another; and each in turn would be tested until finally a proper "fix" was found to cure the imperfection. Then the "fix" would be incorporated into the airplanes on the production line or during modification, and a more dependable airplane would be the result.

While the design of the B-52 was of such high quality from the outset that there were no real major problems discovered in testing it, there were some of smaller proportions.

Some of these were discovered in flight, some were discovered on the ground, some were even discovered in the wooden mock-up. As a matter of fact, the wooden mock-up was the scene of forty mock-up inspections. Both Air Force and Boeing aircrew members and engineers operated controls and carried out simulated missions or observed them.

The test pilots, having a good deal of time logged leaning back against their parachutes, qualify as experts in cockpit requirements. On several occasions they defined a problem in design and suggested solutions.

A case in point was the fuel indicating and control system. The fuel indicators at first were arranged on the copilot's side of the production airplane cockpit in a way which, while clear when considered on the ground, might prove to be confusing during flight in conditions of darkness or when the copilot was fatigued.

It was suggested by an ARDC pilot that it would be better to arrange the fuel indicators in accordance with the arrangement of the tanks in the airplane, with the outline of a wing drawn around them. This gives the copilot an immediate picture of the fuel situation with no confusion. If he wants to know how much fuel remains in the outboard wing tanks, he has only to look at the outline picture of the wing in front of him and check the tank gages on either wing.

Another of the changes brought about through pilot study of the cockpit had to do with the fuel control handles. These, when in the ON position, were at right angles to the diagrammatic presentation of the fuel tanks on the original fuel control panel. Even though there were painted lines across the control handles to indicate the flow, it appeared that the handles were blocking fuel lines in the diagram. It was suggested that the fuel control handles be changed so that when ON they pointed along the fuel flow in the diagram. This suggestion was incorporated into the airplane.

Above and beyond the actual testing and the development of the airplane, the experience gained by the test crews becomes valuable as a means of furthering the reliability and the efficient operation of the airplanes. Pilots and crews, as well as flight test engineers and aerodynamicists, have worked closely with handbook engineers in preparing the pilots notes, the bible of the operational airman. Written from the experience of the test crews and checked closely by them before being printed, these notes are a summation of the total experience in flying the airplane, and as such are a valuable product of experimental flying.

All of the testing the B-52 has undergone and will undergo will be invaluable to the operational aircrews who will finally put the airplane to the use for which it was intended. While the airplane would probably be flyable as it was designed, it has been demonstrated in flight that it is more than that. Improved by the refinements growing out of the experimental and developmental testing by Boeing crews, the B-52, successful from the first, is an even more dependable and practical bomber than it would otherwise have been. ●

IT'S JUST A CASE OF . . . . .

+ and −

Prepared by Hq., Crew Training Air Force
Randolph AFB, Texas

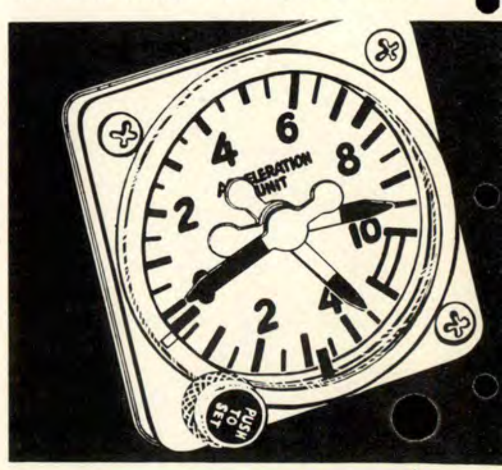
BOTH the design engineers and the Air Force have a pretty good idea of just how many flying hours they should be able to get out of each aircraft manufactured. In fact, they agree on a series of specifications before the aircraft is designed and built. One of the limiting factors in any aircraft is its ability to withstand the effects of gravity and different multiples of gravitational force. To you and me, as pilots, it can be simply stated as G loads.

Each aircraft has a designed maximum G load, which is stated in the Pilots' Handbook; and if we keep the aircraft within this limitation, we can expect it to last through its normal life expectancy. Incidentally, this is a good way to insure reaching retirement age ourselves! But, if through error, accident or ignorance we exceed these limits, we reduce the life expectancy of the aircraft and perhaps even put it in immediate, permanent retirement. The last statement is not the condition that we are really worried about however, because the lad that is foolish enough to exceed the ultimate strength of the airframe usually pays for the mistake himself. It is the area between the maximum allowable G forces and the actual breaking point of the airframe that gives us the greatest concern; because if we exceed the allowable limits often enough, we will still cause the destruction of the airframe. It is surprising the limited number of times this excessive G load can be imposed before failure is possible.

Let's take a typical fighter aircraft and say that the maximum G load allowed in the Pilots' Handbook is 7G. Theoretically we could fly around in a 7G turn for the entire life of the aircraft and nothing would happen. In practice this is true for two very important reasons. First, because the maximum G force allowed is considerably less than the ultimate or destructive G force and, secondly, because we would wear the aircraft out through normal usage before this G load could cause any damage. Let's also state that the ultimate load factor for this airframe is 11G, and when we impose this load factor, the airframe fails, falls apart, disintegrates or what have you. So now we have established two limits: one which is the maximum allowable 7G that we may pull as often as we like and the other which is the ultimate destructive force of 11G that we may pull only once. But how about this area in between?

We all know that the 7G limit is exceeded quite often, and seemingly with impunity. Who ever heard of a pilot getting into trouble pulling 8 or 9G? But it's the ones that we don't hear about that cause the doubt and wondering. Design engineers tell us that there is a definite number of times that we may get away with exceeding the maximum allowable G load, and the number decreases progressively and drastically as we increase these loads. Considerable study and research have been conducted on this problem, and although it has not been reduced to an exact figure, they state that an airframe with limitations such as we have discussed may be loaded to 8 or 9G about eight times. After that it will possibly fail!

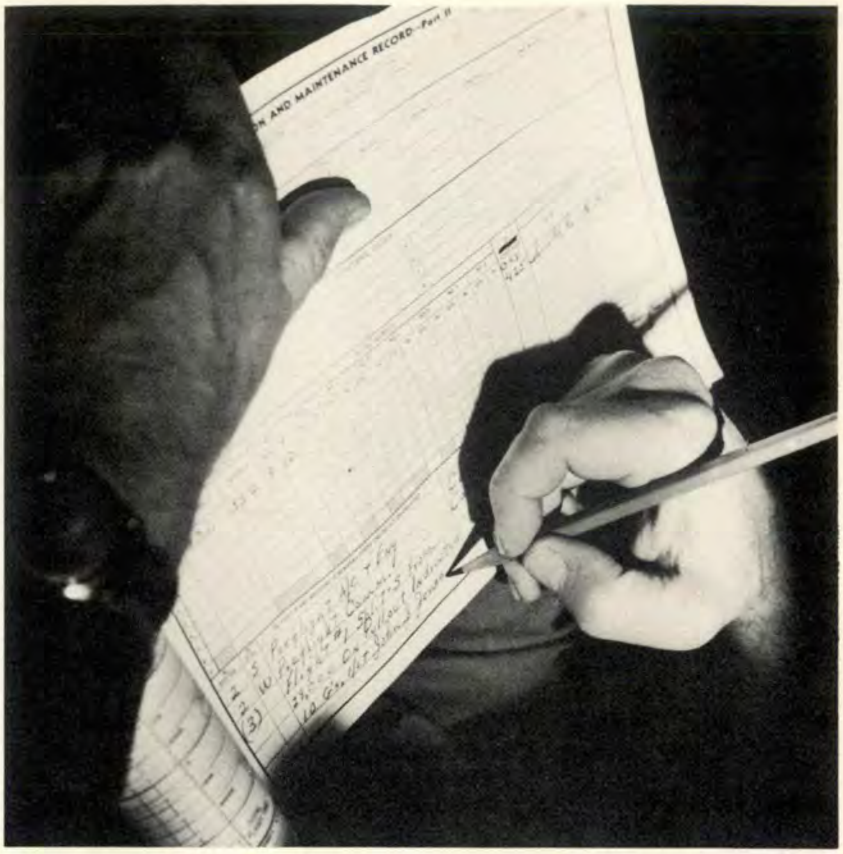
Engineers state there is a definite number of times max allowable G's may be exceeded.



Each load imposition beyond the maximum allowable force reduces the life expectancy of that airframe. Our objective in expressing and stressing this is to acquaint you with the inherent danger of exceeding the G limitation and to point out the very obvious danger of not regarding these over-load conditions if they do occur. The insidious part of the whole situation is a lack of visual evidence after an over-load condition. Usually it is impossible to tell that the aircraft has been subjected to excessive G even after giving it a routine inspection, and it is normal to reschedule it for further flights. However, the pilot who pulls 9G on our hypothetical aircraft after seven other lads have done it before him is in for a rude shock. Whether he meant to exceed the limits or not, the darned thing is going to come apart on him because he has used up the last bit of available life in that airframe at that particular G load.

We could also compare this situation to a given amount of money in our bank account. This amount is a fixed sum, adequate to see us through our normal life span provided we never exceed a maximum monthly withdrawal, and reducible at any given rate we choose. If we draw the whole amount at once for a bang-up time, that's all there is; we're through, finished, on our uppers. The same is true of the aircraft and the 11G. If we withdraw sums larger than our maximum monthly allowance, we reduce the principal by that much, and it is obvious that we cannot make it through the full life span on the amount we have left. Sooner or later, depending on how often we make these excessive withdrawals, we are going to be without support. So, too, with the aircraft when a pilot toys with the area between the allowable limits and the ultimate limit. We can pull these extra G loads, the option is up to us, and we can get away with it—for a while. But each time we do, the life of the aircraft is reduced by a definite amount, and sooner or later we use it up. If we use our heads and never exceed the maximum monthly withdrawal, there will be plenty to last our life time; with the aircraft life we have even a more rosy picture; if we abide by the maximum allowable G forces, the aircraft will still be in good, usable shape when it reaches retirement age.

". . . if we exceed limits, we reduce the life of a plane, perhaps retire it permanently."



". . . if you do pull excessive loads inadvertently, write it up in the Form I and give the other guy a break . . . after all, there's no question but that you want him to write it up there for you."

This, then, is our story. It is true for all types of aircraft — fighter, bomber, cargo, trainer and even gliders. Each has a designed life span, and each has an ultimate G load, or the point of destruction.

But the type of aircraft that is most likely to be overloaded is the high-speed one with the powered flight control system. Types available to us in the past required a good deal of brute force applied to the controls to get us into situations similar to those mentioned above. Now, with the advent of powered controls, it is easy to understand how a pilot could exceed the limits without really trying to do so or even intending to; he just doesn't realize the terrific potential he has at his command through the use of powered controls.

We must educate pilots in two ways: in the use and limitations of their aircraft in regard to the allowable G loads and the ease with which they may overstress the aircraft, and in making an entry in the Form 1 each time the maximum G loads are exceeded. If ever there is a case to which the Golden Rule applies, it is here. If you do pull excessive loads inadvertently, write it up and give the other guy a break — after all, there's no question but that you want him to write it up for you!

In conclusion, there's not a single maneuver which can't be executed within the allowable G limitation. If you're pulling excessive G, you're not flying the airplane—you're horsing it around, and you're in the bank, yank and crank category. ●

STRAIGHT and SWEPT

R. J. White and A. T. Curren

Boeing Airplane Co.

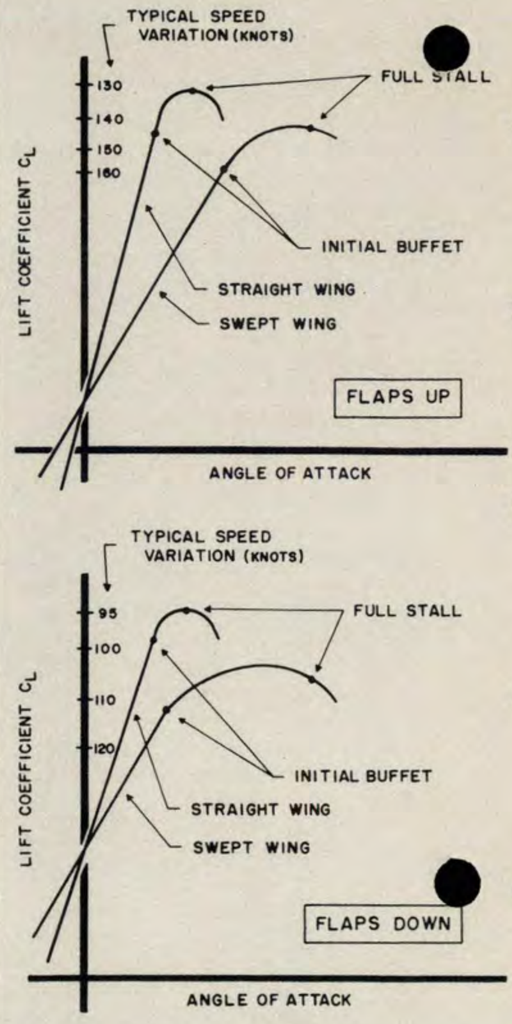


FIG. 1

For many years aircraft designers have toyed with the idea of introducing swept-wing designs. As airspeeds have increased, so too have the problems that crop up near the sonic barrier. Buffeting, aileron buzz, pitch-up and other allied ills have accompanied attempts to squeeze more speed from our aircraft. The logical question then was, will a swept-wing design solve some of these problems?

Some manufacturers firmly believed that maximum performance could be achieved with straight-wing aircraft. Others were of the opinion that a swept-wing design was the answer. As a matter of fact, both schools of thought have merit. As aircraft designers progressed further into this swept-wing business, certain flight characteristics manifested themselves that bear careful consideration. One particularly undesirable trait concerns stall tendencies when the aircraft yaws. This is more pronounced in some types than others, i.e., fighters vs. bombers, and consequently the Directorate of Flight Safety Research believed that a survey of design thinking would be valuable to our readers.

Accordingly, a series of questions was submitted to two manufacturers, one for swept-wing and one for straight-wing aircraft. In general, the questions covered the following:

- *In what maneuvers or attitudes are swept-wing aircraft exposed to loss of control because of difference in airflow over the swept-wing as compared to a straight-wing?*
- *What are the effects on control when operating multi-engine swept-wing jets with engines inoperative on one side or with partial power on both sides?*
- *Is yawing the most significant or the only maneuver which should be avoided?*
- *What degree of yaw (or other maneuver) is considered dangerous in swept-wing aircraft?*
- *At what airspeeds is yawing considered dangerous on swept-wing aircraft?*
- *What corrective or precautionary action is recommended?*

THE introduction of high speed swept-wing aircraft into widespread military operation has resulted in many questions from flight personnel concerning the basic design differences between the conventional straight-wing and the swept-wing. This article will explain some of the stability and control characteristics of aircraft with wing sweep in the order of 35 degrees.

We will review several of the main characteristics affected by sweeping the airplane wing and will compare these characteristics with those of an unswept-wing plane, where possible.

In general, the flight characteristics may be discussed by considering stalling, pitching and lateral and directional control. These will be discussed separately in detail.

Stalling Characteristics

Basic differences in the stalling characteristics of swept-wing and straight-wing aircraft are clearly illustrated in Figure 1. These plots do not represent any particular aircraft.

Note that with flaps up the lift curves are similar, and stall warning margins are good in both cases—10 to 20 knots. Maximum lift and minimum speed occur at a greater angle of attack or steeper attitude in the swept-wing airplane. (Attitude or angle of attack may be considered as interchangeable in this discussion.)

In flaps down configuration the straight-wing demonstrates a smaller spread between initial stall warning attitude and the full stall attitude.

With flaps down the swept-wing has a gradual rounding of the lift curve similar to that for flaps up. Figure 1 shows the top of the lift curve to be quite flat. Here the stall warning is definite, but a substantial increase in angle of attack is necessary to complete the stall. As the angle of attack increases, the drag also increases very rapidly, so that a large rate of sink may develop prior to the full stall. In fact, at low engine thrust the stall break may not be apparent to the pilot because of high sink rates. The full stall is usually accompanied, however, by strong buffeting which is termed "vertical bounce" by pilots.

Flaps Down Approach

The flaps down approach characteristics are important because the pilot is operating close to the ground and near the initial stall buffet speed during the approach for a landing.

There are both straight-wing and swept-wing jet aircraft which have low drag in the approach configuration due to aerodynamic cleanness. Some of these aircraft are also equipped with jet engines with poor acceleration capabilities. On these planes the low drag requires a fairly flat approach at low engine thrust to avoid building up excess approach speed which can result in a long floating distance before the aircraft settles down on the runway. Because of the relatively long time (6-10 seconds) required to accelerate from idle rpm to moderate thrust values, pilots must be alert for the following sequence during landing.

With the aircraft on final approach, flying approximately 10 knots above the initial buffet speed, the pilot may attempt to maintain the desired flight path by raising the nose of the airplane slightly and accepting the loss of a few knots in airspeed. Only a small increase of lift coefficient is required to balance the speed decrease. However, due to the shape of the liftdrag curve (C_L versus C_D curve), a large percentage of increase in drag occurs. This is illustrated by point A to B in Figure 2. Unless thrust is immediately increased, a further speed decrease occurs because of the additional drag, and the cycle repeats itself until the first stall warning occurs. Figure 2 shows a plot of rate-of-climb or rate-of-sink versus airspeed at low engine thrust.

From this it can be seen that if the airplane is flown at an approach speed too near the first stall warning, high rates-of-sink may be encountered very easily. This rate of sink can only be checked by nosing down to re-establish speed or by applying power. A loss of altitude will occur when a pilot noses the aircraft down to pick up airspeed. This will occur also in any instance where the jet engines require too long a time to accelerate up to speed from idle.

The only way to avoid this situation is to plan ahead. Allow the necessary time to accelerate the engines up to the required power, or to have sufficient extra drag in the approach configuration so that a larger percentage of power can be used during the approach. This latter will permit the engines to accelerate faster and will permit the pilot to effectively adjust his glidepath by use of engines only.

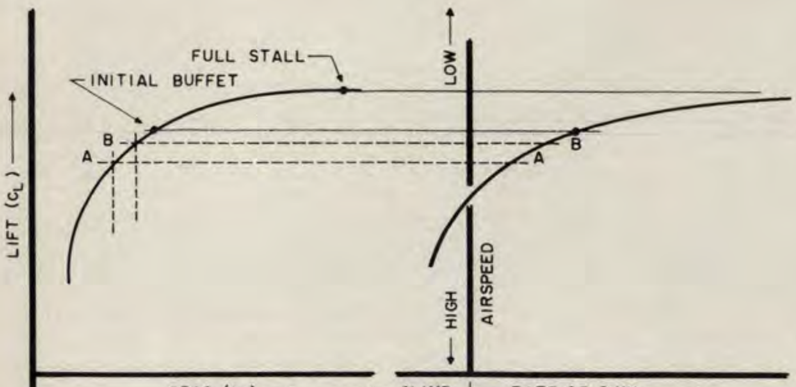


FIG. 2

Pitching Characteristics

Unlike the airplane lift characteristics, there can be no direct comparison between the pitching moments of swept-wing and straight-wing airplanes. The reason for this is that undesirable pitching moments may occur for either type airplane, and in each case these must be modified during the airplane design to give satisfactory pitching moments.

The swept-wing at low speeds first showed that pitch-up (unstable pitching moment slope) can occur at the higher lift coefficient. This pitch-up is due to the stalling of the tip areas which are behind the center of gravity. This causes the inboard lift ahead of the airplane center of gravity to rotate the airplane in a stalling direction. The low speed pitch-up tendency can be cured completely through proper wing, tail and nacelle design. This is essential for a good flying airplane.

As airplane design approached sonic speed, the effect of Mach number produced a high speed pitch-up tendency for many airplanes, both swept and straight-wing. In addition, variations in the pitching moments occurred with increasing Mach number, giving rise to an additional flight effect referred to as tuck-under.

There are, therefore, three pitching moment problems which must be controlled or reduced to a minimum in the design of any high speed airplane. These pitching problems are:

- *Low Speed Pitch-Up*

Low speed pitch-up may occur during a low speed stall. Here the nose of the airplane may gently come up as the stall is approached, after which a pitch-down will occur. If this effect is mild, the airplane may still be satisfactory. A severe pitch-up tendency without a following pitch-down cannot be tolerated.

- *High Speed Pitch-Up*

The high speed pitch-up may occur during an accelerated pull-up. Here more G is suddenly realized than can be momentarily controlled by the pilot. This effect is, of course, undesirable, but can be tolerated if the tendency occurs well above the normal operating conditions of the airplane, and if the pitch-up does not result in excessive load factors.

- *High Speed Tuck-Under*

The third pitching moment effect is tuck-under. This condition is associated with a change in airspeed and trim during level, unaccelerated (1G) flight. Here, at a certain high trim speed, the airplane may have a tendency to increase airspeed gradually and nose down, requiring the pilot to retrim. If this condition is mild and does not occur in the normal operation conditions, the airplane is satisfactory, providing the pilot has sufficient elevator and trim control to bring the airplane back to the desired trim speed.

Lateral and Directional Control

The lateral control for the swept-wing airplane must be increased over that used on the straight-wing airplane. The reason for this is that the airplane rolling moments developed when the airplane is yawed are greater for a swept-wing than for a straight-wing during low speed flight. Here it is necessary to provide sufficient lateral control to hold the wings level when flying at yaw angles up to the maximum yaw that can be supplied by the rudder.

The rolling tendency produced by yaw is the same as that which would result with a straight-wing having a large dihedral angle. When an airplane with dihedral is yawed, each wing experiences a change in angle of attack which results in a rolling moment. A 35-degree swept-wing with no dihedral has the same rolling tendency at low speeds as a straight-wing having 15 to 20 degrees of dihedral. The effect of excessive dihedral requires the pilot, during steady slideslip maneuvers, to use more lateral control than would be required on a straight-wing airplane. By providing sufficient lateral control with low control forces, desirable flying qualities can be obtained.

It should be noted that the large dihedral effect is in the stable direction. In airplanes with insufficient dihedral, the advancing wing drops when the rudder is applied in a sideslip, thus producing undesirable flying characteristics.

It should be noted that many airplanes are limited in the yaw that can be produced by the rudder at the higher airspeeds. This yaw restriction is purely a structural limitation to save weight in the vertical tail and associated body side bending material. The general way of limiting the high speed yaw angles is to increase rudder pedal forces with airspeed.

In regard to the dynamic effects, stability theory indicates that excessive dihedral will produce an airplane lateral instability referred to as "dutch roll." In many present day aircraft, because of high wing loadings and undesirable inertia characteristics, this instability results even in straight-wing airplanes. This has led to the development of the yaw damper which is used to improve the "dutch roll" characteristics.

Engine-Out Flight

A yawed flight condition can occur when an engine fails on a multi-engine airplane. In a propeller-driven airplane, loss of an engine reduces the slipstream over the wing resulting in a loss of lift and an increase in rolling moment, in addition to the expected yawing moment. In the case of a jet airplane, only the yawing moment and the roll induced by yaw will be present. This relieves the amount of lateral control required for a jet airplane for the engine-out condition. Any airplane, swept or straight-wing, must have sufficient rudder and aileron control to handle the engine-out condition.

Crosswind Landing

During the approach on a crosswind landing there should be more rudder and aileron control available than that necessary to hold an airplane in its yawed condition. By having an additional amount of control, proper corrections may be made for any upsetting gusts. The additional rudder control can be used to increase momentarily the yaw just prior to touchdown if it is necessary to reduce any existing crab angle. In the case of a swept-wing airplane, the rudder may be used effectively to obtain an additional rolling moment if such is necessary during the landing. Lateral control is, of course, necessary to lift the wing should it drop while near the ground. Both swept and straight-wing airplanes should have sufficient control to meet the crosswind requirements for which they are designed.

Conclusions

Some of the fundamental differences between swept and straight-wing airplanes have been discussed. Here it may be concluded that the low-speed handling characteristics are the major differences between swept and straight-wing airplanes. Other problems are common to both types and must be solved through proper design of the airplane.

The difference in the stalling characteristics of these airplanes must be considered carefully by the designer and should be understood fully by the pilots. ●

STRAIGHT and SWEPT

Wm. F. Ballhaus, Chief Engineer, Northrop Aircraft, Inc.

THE chief handling quality problems that arise because of wing sweep-back are:

• The tendency of the airplane to pitch-up abruptly at high angles of attack.

• A decrease in aileron effectiveness at high angles of attack.

• A large increase in dihedral effect at high angles of attack.

The pitch-up tendency and the decreased aileron effectiveness of swept-wings are caused by the outward spanwise flow of low-velocity air near the surface of the wing, an effect which increases in magnitude as the angle of attack of the airplane is increased. In the case of pitch-up, this low-energy flow tends to separate from the upper surface of the wing near the tips, rendering the tip portions of the wing ineffective compared to the apex portion. This results in a nose-up pitching moment.

If conventional trailing-edge type ailerons are located in this low-energy spanwise flow region, it can be seen that the aileron effectiveness will tend to decrease as the angle of attack of the airplane is increased, because of the increased severity of the spanwise flow with increasing angle of attack.

A swept-wing inherently shows positive dihedral effect even if the amount of "built-in" dihedral is zero. A simple explanation of this is shown in Figure 3.

When the airplane is sideslipping to the right, as shown, the relative wind strikes the left wing panel obliquely compared to the right wing.

Because of this asymmetry, the lift on the right wing panel is much greater than that on the left panel, thus creating a very large rolling moment to the left. It has been found that the magnitude of this rolling moment increases with an increase in angle of attack of the airplane.

A further consideration in the handling qualities of swept-wing aircraft is the effect of aspect ratio. In general, the higher the aspect ratio the more pronounced are the detrimental effects of sweep, because the spanwise flow effects are accentuated. On the other hand, highly swept-wing aircraft of very low aspect ratio introduce a directional instability problem caused by the severe sideflow effects on the aft portion of the wing and on the vertical tail. The directional instability of this particular type of airplane occurs only at very high angles of attack, and may or may not be readily controllable using the rudder, depending on how fast the rate of divergence becomes.

Specific answers to the questions asked by the Directorate, Flight Safety Research, are as follows:

• Maneuvers which may result in loss of control of swept-wing aircraft can be separated into two types: those involving the abrupt longitudinal pitching up and those in which sideslipping occurs when the airplane is at a high angle of attack.

The abrupt pitch-up tendency occurs during high G dive recoveries and high G turns. It is especially dangerous because a pilot's reaction time may be too slow to apply corrective elevator motion before a destructive G load has been imposed.

Examples of the second type of dangerous maneuvers are intentional sideslipping in the landing approach, and sideslipping when pulling high G normal acceleration. These maneuvers are hazardous because the sideslip creates a large rolling moment because of the high effective dihedral of the swept wing. This requires considerable aileron deflection to balance out, and leaves little additional aileron motion for margin of control.

• On multi-engine swept-wing aircraft, the loss of an engine on one side may or may not result in a serious control problem, depending on the particular design and the pilot technique involved. If the sideslip angle is allowed to become too large, the pilot may have insufficient aileron control to prevent the airplane from rolling, as explained above.

• The abrupt pitch-up tendency in high G maneuvers is probably the most dangerous characteristic of the swept-wing airplane as far as a pilot is concerned. The sideslipping maneuver can also be very significant in this respect, because of the possible loss of lateral control at low altitudes, say, during a landing.

• The permissible degree of sideslip will vary within large limits for each particular airplane. An arbitrary scale for intentional sideslips could perhaps be defined as follows: five degrees maximum sideslip when in the landing approach; 10 degrees maximum for any maneuvers at high angles of attack, and 15 degrees absolute maximum under any condition.

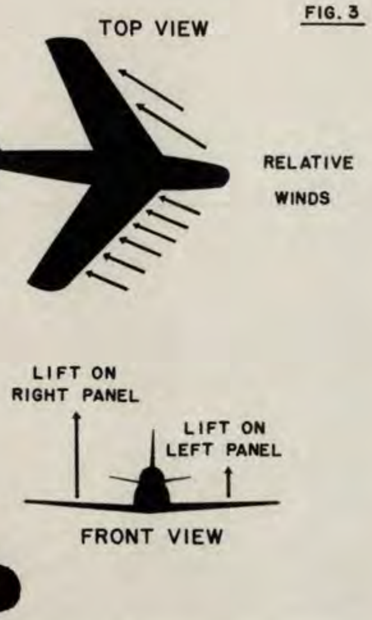
• Based on the above discussion, it is indicated that sideslip maneuvers would be more critical at low indicated airspeeds because of the associated high angles of attack.

• Recommended preventive or precautionary action:

With regard to the pitch-up tendency of swept-wing aircraft, it should be expected that the manufacturer provide sufficient alleviation, either in the form of aerodynamic fixes, control force or control deflection G limiters to prevent the pilot from inadvertently overstressing the airplane. Pilot indoctrination and training in this particular handling characteristic is, of course, an important aid here, but it may prove to be inadequate for some aircraft designs now and in the future.

With regard to sideslipping, it is recommended that a pilot avoid large sideslipping maneuvers in swept-wing airplanes. ●

FIG. 3



Fit to Fly

Man and machine. That's our winning combination. If either one of the two elements fails to function, it follows that the duo is out of business. The Air Force has always considered the human as the most important member of this dual combination, consequently, FLYING SAFETY has selected the following two articles on physical fitness for this all jet issue.

The fighter pilot is all alone. He is required to operate at extreme altitudes at high speeds, and regardless of the cause, if he fails to operate . . . that's all she wrote. However, physical or psychological malfunctions affect all air crewmembers, regardless of aircraft type or mission. Imagine if you can, the effectiveness of a B-47 bombing mission with any one of the three crewmembers tied up in knots with acute indigestion, for example.

Today's airman must be in shape for every flight. Being in shape means keeping fit but, if you are feeling under the weather, remember. . . . "He who treats himself has a fool for a doctor."

FLYING SAFETY is indebted to the Douglas Aircraft Company, Inc., for their contributions to the first part of this article.

YOU, as a pilot, should be familiar with certain factors affecting the human body. Knowledge of these factors will assist you to carry out your flight missions properly and in the most efficient manner.

Probably you've been exposed to quite a bit of this information previously. Most of it is contained in various medical publications but is not readily available or expressed in simple terms.

Just as there are restrictions on your airplane, there are restrictions on what you can do. You might say they were determined by design limitations practiced by the Almighty when He built you. These are built-in and must be remembered just as well as those in your airplane. When all's said and done, there is only one way the two of you can function effectively, and that is as a team.

The real purpose of this article is to bring sharply to your attention the fact that you can put additional restrictions on your team. They are under your deliberate control, and you can't blame the Almighty or science for failures occasioned by your own deeds or misdeeds.

Human Restrictions

Restrictions on the human body can best be expressed in terms of the lack of power to overcome physical stresses. These vary depending upon environment. Flying presents a number of stresses which are found only in this particular field. One group is classified as natural stresses because they are built-in and are not induced by our own efforts. Let's examine these stresses and see how they affect your ability as a pilot.

Exposure To Altitude Without Oxygen—We're not going to delve too deeply into this subject. It's a continuing subject with us and we'll be hitting it again in FLYING SAFETY.

However, just remember that oxygen is as necessary for the functioning of the human body as it is for the combustion of fuel. Your body uses oxygen in much the same fashion by combining it with a carbon compound to produce energy, and gives off carbon dioxide as a waste.

Be sure to review your technical directives on the use of oxygen at frequent intervals and carry them out religiously. An occasional review of T. O. 15X-1-1 is a worthwhile move on your part. It contains some mighty good stuff.

Exposure to Carbon Monoxide — Carbon Monoxide, when absorbed by the blood, can be extremely dangerous, as we all know. It reduces the amount of hemoglobin available for carrying oxygen to the tissues and makes the transfer of whatever oxygen is present difficult. It is absorbed by the blood over 200 times more readily than oxygen, and is more difficult to dislodge from the blood stream.

The danger of carbon monoxide, especially in combination with the lowered partial pressure of oxygen at altitude, cannot be over emphasized.

FLYING SAFETY covered the dangers of carbon monoxide poisoning in the May 1954 issue. If you didn't read it, better get a copy and dig in right now.

Exposure To Rapid Altitude Changes—Rapid pressure changes incidental to changes in altitude present no problem if you are in good physical condition, since normal clearing of the ears will permit balancing the pressure between the middle ear and the outside air. The problem arising from exposure to rapid altitude changes when flying with a severe cold may well come under the category of "asking for it."

Exposure To Noise and Vibration—Noises in aircraft are derived principally from the propeller, exhaust, moving parts of the engine and aerodynamic sources. Noise intensity is measured in decibels. Research indicates that a noise level of 116 decibels, when sustained for over a period of six hours for eight successive days, may be of sufficient intensity to cause irreparable hearing loss.

Helmets, earphones and earplugs all have their place and certainly do help but there's no denying that excessive noise over protracted periods of time, causes a lot of fatigue. Keep that in mind and remember that a couple of mills churning in your ear can slow up reaction time plenty.

Exposure To Motion—Some people tend to become airsick easily. Others are never bothered. There's no one single cause for all cases. The symptoms are very clear and unmistakable. If you are susceptible, you will learn for yourself what your best course of action should be, what food items to avoid and how much of what motion you can take. Consult your flight surgeon and together you can work out the best plan for you.

Exposure To Visual Disturbances—There are a number of disturbances and distortions that can occur during flight. Haze, color distortion, motion parallax and vertigo are familiar to all pilots. Also, certain optical illusions such as those caused by lights reflected from water or lights in unsymmetrical patterns on the ground can cause confusion and disorientation. The only answer is "use those instruments!"

The Self-Induced Stresses

Exposure to the following self-induced stresses is within your control. Read 'em and remember 'em. It's your neck that's out, and, quite possibly, several others may be on the block with it!

Inadequate Rest—We don't need to dwell on this one. You know how much sleep you need. If you deliberately skip this one factor, brother, you're looking for trouble. In case you don't know, lack of sleep reduces your efficiency, and this in turn reduces your tolerance to stresses and slows reaction time.

Colds—You've been warned many, many times about leaping off into the blue when a headcold is raising hob with your system. We've classed colds under self-induced stresses because they mean much more in flying than in your ordinary terrestrial existence. The cartoon depicts just how cold germs louse you up when flying.

Alcohol—It shouldn't be necessary to harp on this subject that's so near to the hearts of so many. Alcohol slows down mental performance and reaction time, and it takes many hours for its effects to wear off. In modern aircraft the jockey with slow reactions may well be the dead one. Either join the AA's or play it real cool. Remember, *you* are the worst judge of the effects of alcohol upon your system and perhaps little realize what it does to your fitness.

Poorly Controlled Emotions—An untroubled mind is one of the greatest assets you can have. This is especially true when you consider the mental tasks and reactions required of you while flying. With split-second tasks to perform you may find yourself really behind the eight-ball if you have been flying along worrying about your finances, love life, mother-in-law or other equally disturbing conditions.

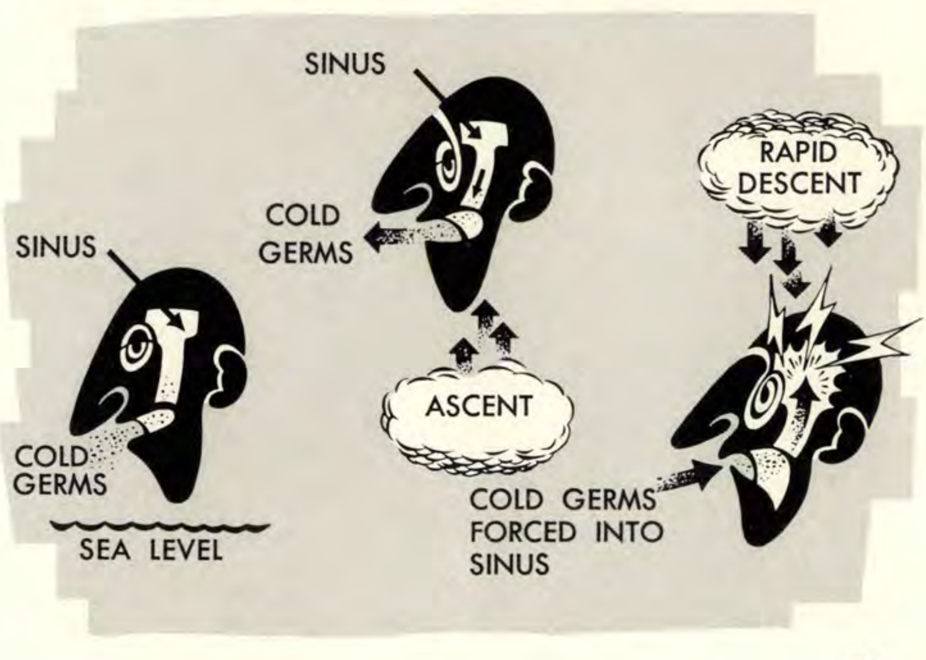
If your problems seem too great for you to solve, if you should worry constantly, you'd better take them to your banker, lawyer, doctor or chaplain. It's a cinch you shouldn't fly under mental strain. It leads to distraction from your normal functions, doping-off and if continued, to a case of psychoneurosis. Then, if you haven't fouled-up enough in the meantime to need an undertaker, you'll probably require the services of a good psychiatrist.

Exposure To Accelerations—There are four kinds of accelerations that pilots may expect to encounter:

★ Moderate G lasting for some time. This is the kind encountered in pulling out of a dive (aircraft, that is). This causes the blood to be thrown into the lower part of the body, and if it lasts long enough, the heart does not get enough blood to keep up the circulation. Black-out may result.

★ High G of short duration—less than a second. This is unavoidably built into the ejection seat in order to get a trajectory that will clear the empennage. Position yourself correctly prior to an ejection and there's no sweat on this one.

★ Sudden forward deceleration. This is encountered in crashes. The threat from this kind of deceleration is the chance of developing a gunsight complexion. Proper use of the shoulder harness takes care of this.



★ Tangential G of short radius. This is encountered in tumbling and buffeting. We can't give too much of an answer on this one, yet! Apparently not too severe unless the blowtorch gets pretty far gone.

Upset Stomach—This condition may vary from a mild tummyache to one accompanied by excruciating pain. Flying should not be attempted when suffering from this condition, since your efficiency and tolerance to inherent stresses will be considerably lowered.

Distension of the stomach and intestines with gas can be the cause of these symptoms. Avoid gas-forming foods especially if you are going upstairs. If you want to know what gas-forming foods are, see your long-suffering flight surgeon.

Smoking—There is one very sound reason why smoking can reduce the fitness of the pilot. The carbon monoxide resulting from incomplete combustion of the tobacco is the same as that which comes from the engine. The combined effects of the carbon monoxide and reduced oxygen at altitude can be harmful.

Remember, too, that excessive smoking can affect your night vision a great deal. The old depth perception can really get knocked off center if you go charging through the black of night, leaving a trail of tobacco ashes behind.

One last thought on tobacco. Maybe this doesn't apply to you, but it could! Many pilots have been known to yank off the oxygen mask long enough for a quick smoke. Figure it out. Mix one faulty regulator (leaking type) with one match (lit) and step clear! It has happened.

Heat and Cold—We could write reams on this subject but for the sake of the record we'll only say: Dress for the occasion. Uncle has invested a lot of dough in developing and procuring adequate flight clothing to meet the demands of practically every clime. When you are issued gear for protection, learn the reasons for it and get familiar with its use. You can't keep fit if you let yourself get exposed to uncomfortable degrees of heat or cold.

Empty Stomach—Food to the human body is like fuel for an engine. Fortunately, the mechanics of energy conversion in the human body do not require a continuous supply of food. Your body also has the ability to store up reserve energy permitting you to function between "refuelings." To function efficiently, however, you must maintain regular meal schedules — preferably on a three-meals-a-day basis.

The reason for this is simple. If you allow too much time between meals, your potential energy level drops below that required for your efficient operation before you refuel your engine again.

To boil all of this down, just remember that important stresses affecting pilots have been covered briefly. This information has been offered to impress upon you that:

- Stresses exist which are detrimental to flight safety.
- Other stresses may develop as a result of your failure to maintain physical fitness.
- These stresses are not only detrimental individually, but their effects are also ADDITIVE, and as such may result in the failure of your mission and may even cost your life.

To quote that well-known Ground Safety cliche, "The life you save may be your own." Play it cool, brother, and stay loose.

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Who's YOUR Doctor?

Col. H. G. Moseley, USAF (MC), Chief, Medical Safety Division
Directorate of Flight Safety Research

IT WAS A clear morning. The kind of a day that makes you want to fly. The sky was blue and the wind was little more than a warm breeze. A wonderful day to be alive.

The captain was being very careful with his flight planning. He cross-checked the strip map against the latest Radio Facility Chart. Ranges were changing rapidly these days and he had discovered early in his career that one could never depend solely on a map.

Then he examined the NOTAM file. Nothing to worry about. One en route air base reported construction on runway two-four and six. One range was carried as unreliable. No sweat. It would be VFR today.

He carried the form 175 into weather. The forecaster was busy getting a C-124 crew squared away so the captain studied the prog charts and mentally selected an altitude that looked favorable. In a few moments the forecaster was finished with the Globemaster pilots and turned his attention to the captain. This was an easy clearance. A very few thin scattered alto-cumulus at 20,000 and nothing else. Scrawling his signature on the forecast, the weather officer said, "Good Luck. See you later," and turned to the next crew.

The captain spent another couple of minutes rechecking his flight plan. Everything appeared okay. He had no doubts as to his personal ability as a pilot but he did have a healthy respect for his aircraft, and this T-33 was not as forgiving of poor flight planning as a reciprocating aircraft with large fuel reserves.

Picking up the carbon copy of the clearance, he walked out to his plane. Again he checked carefully. The machine was clean. The crew chief went with him as he made the preflight.

"Everything looks okay," he said to the sergeant.

"She's a good one," replied the crew chief as he helped the captain adjust his parachute.

The sergeant said "she" subconsciously as men have always said "she" when they spoke of fine ships. And she was a good plane, down to every flush rivet, down to the strength and precision of every stringer and former. She should be good; thousands upon thousands of manhours had gone into her perfection, and now for hundreds of hours she had carried her pilots safely and comfortably around the country.

This morning she was ready for another mission. That this was to be her last flight was not her fault. The captain had wilfully ignored one vital check. As a result, both he and "she" were destroyed. One moment they were cruising straight and serene. Then they entered a gradually steepening dive. There was never a change of power setting; not even the simplest attempt to alter the tragic course. Human control had lapsed.

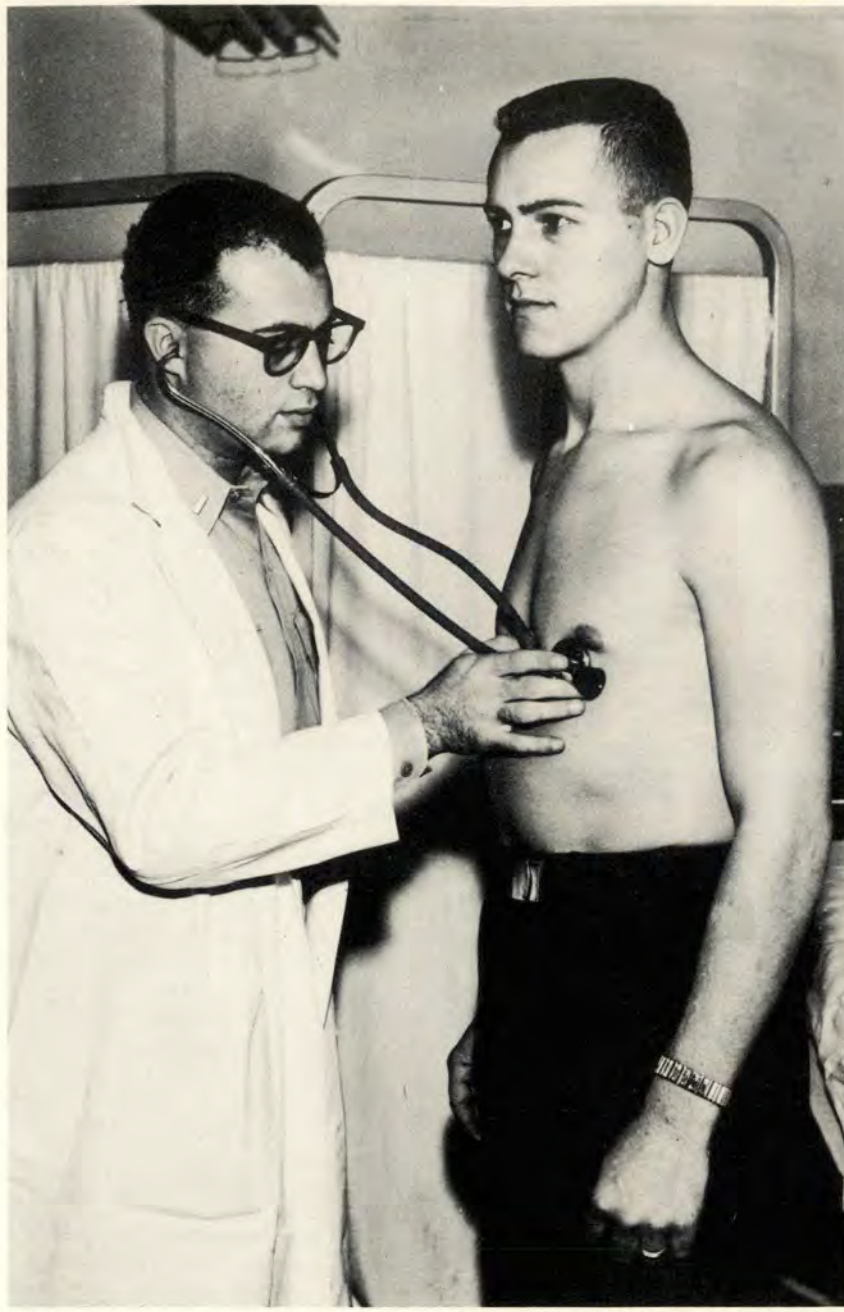
To understand this strange oversight one must go back a year or two. That was when the captain first noticed that something was wrong. It was evening and he was sitting down reading the paper when it happened. If he had been asked to explain what was wrong, he probably would have said he felt something turning over in his chest and that he felt a slight choking sensation. After a few moments it was over, completely gone. Outside of a bit of perspiration on his brow he was perfectly normal. He did not think anything more of it. Not just then anyway.

However, as time went on he began to have additional attacks of this strange sensation in his chest, and twice in recent months he had blacked out completely for a few moments when these spells came. He was afraid that one might happen some day when he was driving. He may have been afraid to think what might happen if he had a spell while flying. Unfortunately he found out. It was too late then.

What is inexplicable is that he never went to his Flight Surgeon. Even on his annual physical examination he denied any trouble or abnormal physical condition. It may be that he thought his trouble insignificant. It is more probable that he was afraid the doctor would ground him. And that is what would have happened in this case.

The Flight Surgeon would have told him that he had trouble with his heart, and probably given it some name such as "paroxysmal tachycardia." How long this man would have been grounded we do not know. Perhaps permanently. Certainly until the cause could have been found and eliminated. One thing is certain, the Flight Surgeon would have saved him.

Fortunately, there are only a few pilots who delude themselves into thinking they can fly while seriously ill or while suffering from an unpredictable physical hazard. However, between serious or hazardous illness and good health, there lie a variety



". . . the strength of the Air Force depends on healthy and willing personnel. Self appraisal of illness or injury has never proved to be of any value to either the Air Force or the individual."

of conditions and a multitude of strange cases.

For our second example we have selected a true story of a lieutenant with a headache.

This case took place in one of our southwestern states during the winter. The lieutenant, who was a new arrival at the base, was living in an off-base cottage of dubious elegance but which did suffice as a temporary shelter for the officer and his family.

The weather was cold, and for several days it had been necessary to keep the windows closed and an open gas heater burning day and night.

For several mornings the lieutenant had noticed a headache when he arose. It was a rather nasty headache associated with some dizziness, but it usually left before noon. He wondered what his trouble was and thought perhaps it was due to a cold that had been plaguing him for about a week. He was partially right at that.

To help in knocking out the cold, he procured some anti-histamine pills. He had heard and read many cure-all claims for this type of self-medication. Now he was taking one of these pills every four hours. He wasn't sure if they helped very much or not. He did know, however, that he was not feeling very well.

Here we can see an accident just looking for a place to happen. There was one more significant item building up toward the accident in which he was to be involved. That was his oxygen mask. It didn't fit very well. In fact, when he turned his head it leaked rather noticeably.

This officer was a walking medical museum of reasons why one should not fly. To start with the simplest of his afflictions, the cold from which he was suffering would have been reason enough to ground him. Further complications evolved around a serious case of carbon monoxide poisoning. We'll get to that a bit later. It's enough to note here that the lieutenant ran out of luck all of a sudden.

Incredibly, this pilot, saddled with a cold, under the influence of hypnotic drugs, suffering from carbon monoxide poisoning and with an ill-fitting oxygen mask, started his jet and took off for a high altitude mission.

What is still more incredible is that this lieutenant flew to over 30,000 feet, cruised there for a while and then brought his plane down for a landing. He was groggy and bleary-eyed to be sure but he still possessed the fundamental rudiments of flying technique. He landed the plane short and wiped out the gear. He, himself, was unhurt.

It was not until the next morning when the effects of his various poisons had worn off, that he was mentally alert enough to grasp the seriousness of his previous day's conduct and probably wonder at whatever Guidance it was that brought him back okay.

From a medical viewpoint, whether or not an individual should fly with a cold depends on many factors. However, in general it may be said that if the cold is still mild there will usually be no ill effects from flying. But if the cold is severe, and especially if it is of the type known as a head cold, serious consequences may occur, particularly if the flight is conducted at high altitude.

Pilots have suffered serious ear conditions from flying with a cold, and there have been cases where pilots and crewmembers have experienced such pain from sinus trouble during rapid descent that it was difficult to maintain consciousness.

The actual decision as to whether or not the lieutenant should have flown with his head cold should have been made by the Flight Surgeon. In this case, however, the cold was the least of his physical troubles.

The treatment the lieutenant was giving himself was a far greater hazard to flying than the cold itself. You probably have heard the saying that "he who treats himself has a fool for a doctor." It's just a dangerous business. That body of yours is a delicate and complex machine.

Some of the so-called cold pills contain a drug which is medically known as anti-histamine. This is the type the lieutenant was feeding into his system. For some people, particularly those whose colds are associated with allergies or hay fever, this type of treatment may be very beneficial. However, like all drugs it should be taken carefully. Furthermore, the anti-histamines have an added property which is known as being hypnotic. In other words, it causes drowsiness and lack of alertness.

Even under normal conditions those drugs should be taken judiciously and under the supervision of a physician. Remember too, that any anti-histamine is not compatible with flying. Current regulations state that no one may fly within 24 hours after taking such medication.

You'll remember that our lieutenant's troubles first started from a series of headaches. The man himself might have been able to realize the cause of his troubles if he had thought back to his cadet training days and recalled something about the lectures on the dangers of carbon monoxide. He might have remembered that carbon monoxide is a toxic gas and that even a small amount, such as may come from incomplete combustion in a faulty gas heater, can produce dangerous physical symptoms.

Certainly he should have been aware of the dangers of inadequate ventilation in his own home. And, if he forgot all of this, he certainly should have remembered the symptoms of carbon monoxide poisoning. We all had it drilled into us time and time again. Remember them? Headache, dizziness, weakness, sometimes nausea and vomiting and then, if too much is inhaled, stupor, unconsciousness and finally, death.

The reason that carbon monoxide is so deadly is that it may be taken up by the blood very easily. In fact, it is absorbed by the blood over 200 times more readily than oxygen. It doesn't take long to put one out of the picture.

What is particularly hazardous about carbon monixide poisoning and flying is the effect of altitude. As in the case of this lieutenant, an individual may have only part of his blood saturated with carbon monoxide and still be able to walk around, although not feeling too well. However, when pilots go to altitude, they encounter conditions where there is less and less oxygen and less atmospheric pressure to push the oxygen into their blood. When the reserve of oxygen carrying power is compromised by being partially occupied by carbon monoxide, stupor or unconsciousness may occur very easily.

The striking thing about all accidents attributable to poor physical condition is that they are 100 per cent preventable. Maintaining good physical condition and giving reasonable concern to health is such a biologically sound principle it's strange that some people attempt to evade it.

No one will ever be censored for turning to the Flight Surgeon in times of doubt. On the contrary, the strength of the Air Force depends on healthy and willing personnel. Self-appraisal of illness or injury has never proved to be of any value to the Air Force or the individual; it has cost us both lives and dollars.

1955

No question, but that this fair damsel is planning to start the New Year off with much fanfare and gaiety. But the day after the ball it's a pretty good bet that she'll be equally firm in resolving—Never Again! From here it looks as if this applies to some of us fly-boys, too. We start off the year with the firmest intentions of making this a trouble-free year, only to see those good intentions shattered through carelessness, poor techniques and procedures and lack of a professional attitude toward our jobs. And no one looks good decorating a statistics page. So this year let's make one resolution and stick to it... shoot for a record-low accident rate in 1955. Remember —accident prevention starts with YOU!

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