JULY 1957

FLYING SAFETY

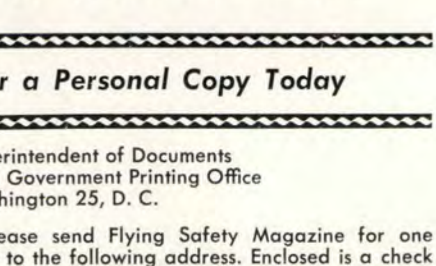
UNITED STATES AIR FORCE

the Power Plant

File Thirteen

Our cover—front and back—seemed most appropriate to typify our theme of the month, The Power Plant. As we've tried to suggest, there are a lot of things to talk about, yet. Both recips and turbojets come under consideration in this issue. . . . Our April 1957 issue contained an article on jet stream flying, entitled "High Signs." This presentation was a simplified explanation of a complex phenomenon based upon the necessarily restricted experiences of an individual pilot. It contained some observations not entirely supported by later investigation. . . . The October issue of FLYING SAFETY will publish a more detailed and documented discussion which is based on USAF Project "JET STREAM." Believe you'll enjoy this expanded presentation. . . . 'The old Editor changeth, yielding place to new.' With profound apologies to Tennyson, his bit was paraphrased to tell you that your Editor of months past, Major Perry Dahl, is on his way to seek fame and fortune on the other side of the fence. He heard the story about the grass, and is off to Command and Staff School for now and then to you. . . . Meanwhile, back at the ranch, a new shingle, etc., etc.

'til August,



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USAF PERIODICAL 62-1

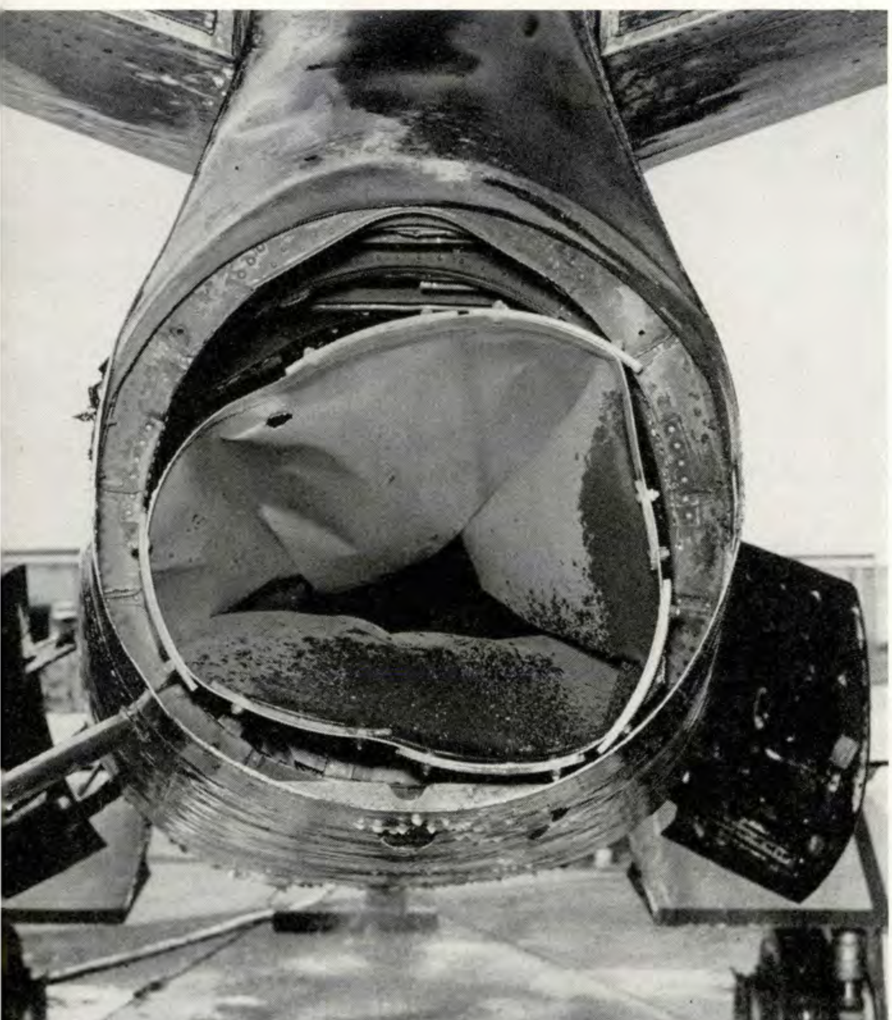
Check with the Chief....

Whether it pushes or whether it pulls, you've got to have power in your bird. When the power plant fails, your mission comes to a screeching halt. Last year's record was bad enough. This year we expect 303 major accidents resulting from engine failure, a careful prediction based on everything we know.

One of the things we know is that some of these accidents are preventable. You can prevent them. Knowledge in this business is always power. A thorough knowledge of the engine in your bird will give you power when you need it most, when you might not have it otherwise.

That puts it up to you. You have to know your power plant as you've never had to know it before. Your next guess might be your last. There isn't time for guesswork anymore. You have to know each little sound and sign that your engine makes, perceive at once the meaning of any change in the pulse and pressure of the bird you ride. So, check with the chief, the crew chief who maintains your aircraft and its power plant. He's the doctor who keeps things up to snuff. Tell him whenever anything goes wrong, no matter how trivial it may seem to you (that's what the Form 781 is for). That little gasp you heard may flash the big red light for him. Now more than ever he too needs to know everything that happens while you're in the air. And now more than ever, you have to know the things he knows. Listen to what he has to say. Take his know-how and skill along with you on every flight. And when you land again, check with the chief. Leave the guesswork to someone else.

The following presentation is based on an article written by Mr. E. E. "Bud" Hopkins, Field Service Representative of North American Aviation, Inc., stationed at the Lockbourne Air Force Base, Ohio. The information here should not be construed to be the last and final word on compressor stalls but instead should serve as a foundation to one seeking a more comprehensive knowledge of these phenomena. The discussion applies to axial compressor stalls in general, rather than to any one type or brand.



If you need convincing that compressor stall can be serious and cause extensive damage, check the photos. All three pictures are of the same F-86F aircraft.

AFTER COMPLETING an hour-long flight, a Lieutenant from the local fighter squadron parked the bird and sat there for a few minutes just staring at the Part II. What to write?

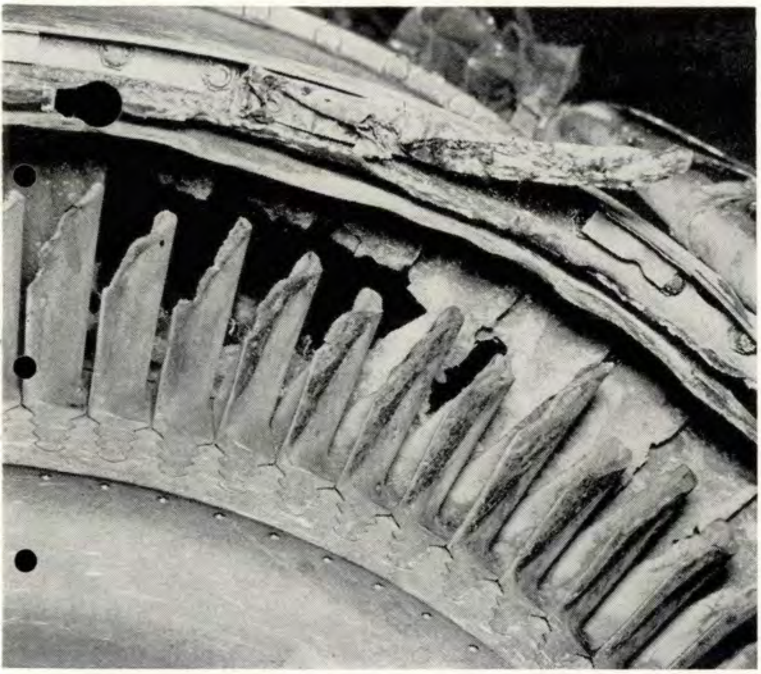
The crew chief saw the puzzled expression and called, "Got troubles, Lieutenant?"

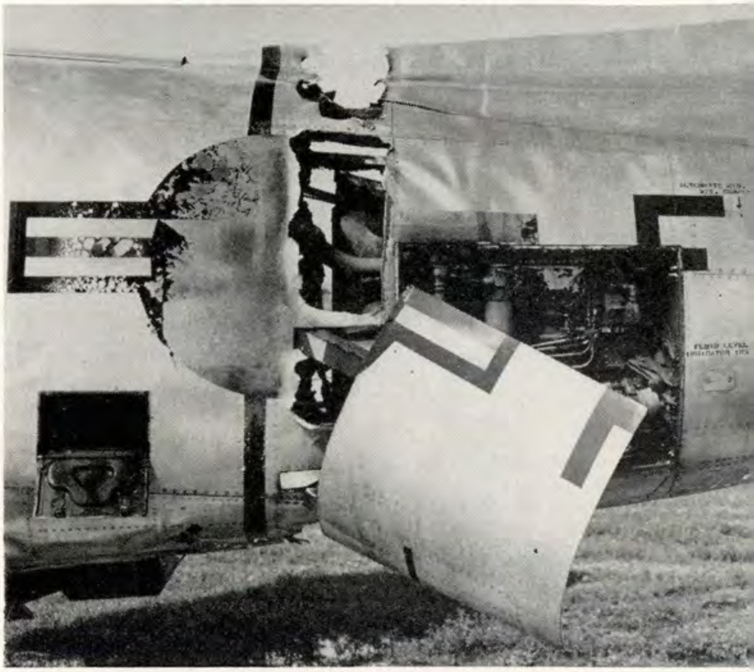
"Yes—but—I don't really know what kind," came the answer. "It was like an engine surge and yet it wasn't. It was too harsh for burner roughness—. I wonder—?"

This was going to take some explaining. Something had happened all right. It just isn't normal for an engine to act like that *without a reason*. But from the sketchy explanation, neither the pilot nor the crew chief could really say what it was.

"Why don't we go and talk to the maintenance officer? He's had about everything happen to him that can happen in flight. Maybe he will recognize this one," the Sergeant finally proposed. "He likes to be clued in on this sort of thing anyway."

"Good thinking, Sergeant, he'll





Compressor Stalls

probably call me on it, anyway," agreed the Lieutenant.

The Maintenance Officer was just reaching for his hat as they entered his office. A civilian was with him.

"Got a minute, Captain?" asked the crew chief. "The Lieutenant's got a real screwy one here. He doesn't know how to write it up and I don't know what to tell him."

"A minute is all I've got," returned the Captain. "I'm on my way down to the Flying Safety Meeting. What's the problem, Lieutenant?"

As the story was unfolded, the Captain interrupted, "Hey, Sam," he called to the civilian who was with him, "are you listening to this? It sounds like what you're going to talk about." Turning to the Lieutenant, he said, "This is Sam Lindley, the Tech Rep on our birds. We were just on our way down to the Fly Safe Meeting where he is supposed to talk about this very thing. Sergeant, tell the line chief to round up everybody he can spare and send 'em down to this meeting. Looks like everybody can stand a shot of it."

"I suspect so," said the Tech Rep. "Lieutenant, from what you've said, I'd say you had a compressor stall. Are you coming to this meeting?"

"Yes, sir," the Lieutenant replied. "I landed a little early so that I could make it. If this is what you are going to talk about, I wouldn't miss it."

"Good," laughed the Tech Rep. "I needed a straight man and you'll be perfect for the job. But don't feel badly 'cause you didn't recognize this thing. There are a lot of other guys who are right in there with you."

As pilots and mechanics settled themselves in the briefing room, the FSO teed off. "I requested this special joint meeting for the simple reason that we have a joint problem. All of us need to know more about compressor stalls. We need to know what causes them, what they mean, and how to prevent them. We had one happen in this squadron less than an hour ago. Bailey, come up here and tell 'em what happened to you and then we'll let Sam analyze."

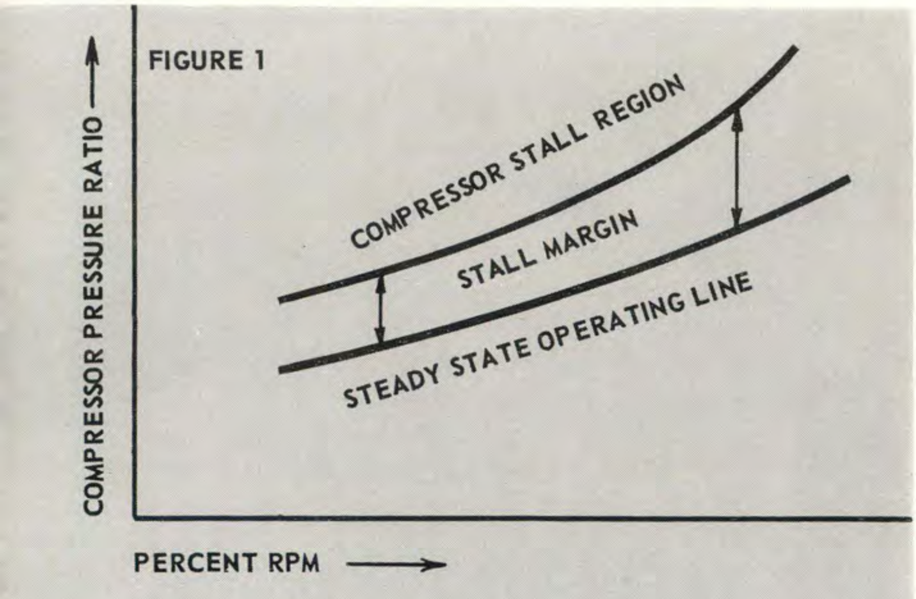
The sketchy account was quickly repeated, and the Tech Rep was introduced.

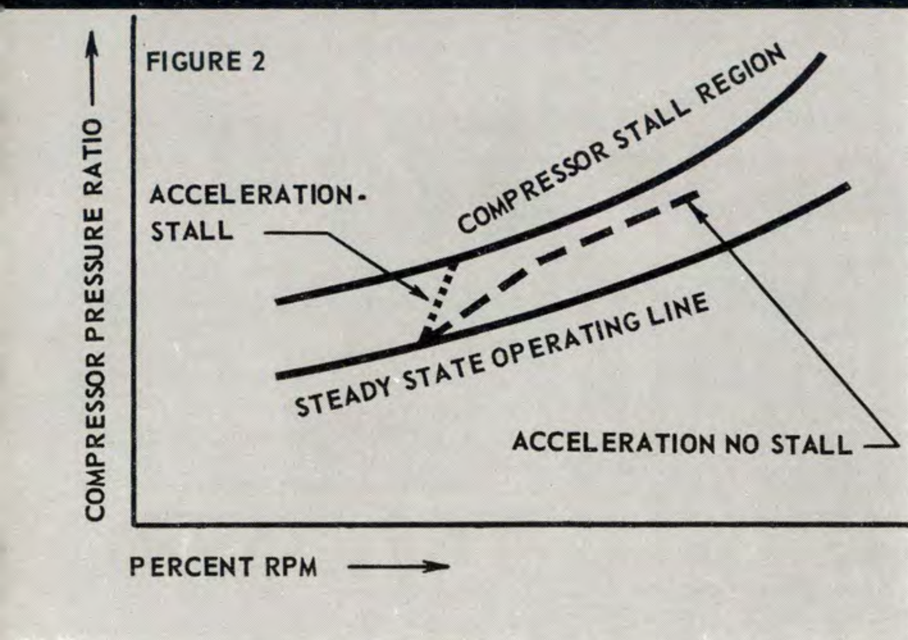
"What happened to the Lieutenant here has probably happened to many of you at one time or another. Because it is difficult to describe (unless you call it what it is) probably explains why there aren't more write-ups in the 781. It is a compressor stall. There's nothing new or complicated about it but it can mean trouble. To treat it properly you have to know about the causes involved.

Nothing New

"First of all, let's not deceive ourselves into thinking that compressor stalls are a mysterious offspring from the Jet Age. This is a problem that has been lived with since the days of turbo-supercharged, reciprocating engines. It has merely increased in stature with the advent of jet engines.

"To get at this thing, let's begin with the known and lead to the unknown. The unknown in this case happens to be the compressor stalls, and the known, the stalling characteristics of the basic airframe itself. It is general knowledge that an airplane wing can be stalled by increas-





ing the angle of attack. The air passing over the top of the wing at very high angles of attack tends to take the path of least resistance and thus begins to separate from the wing. This results in a loss of lift. The airplane is in a stalled condition and no longer able to accomplish its intended purpose.

"Now, how does this apply to a jet engine? In this way: Each compressor rotor blade is essentially a "tiny" wing and is affected in very nearly the same manner as the airplane wing. Bear in mind this difference: That whereas the airplane wing may be "flown" into a position of high angle of attack, the rotor blade is fixed. But virtually the same results may be obtained by varying the relative magnitude and direction of inlet airflow velocity (per cent of RPM remaining constant) which will, in effect, vary the blade angle of attack. Conversely, if the airflow remains constant and the rotor RPM is varied, you'll get the same results. You can see then that the rotor blade effectiveness is a function of airflow velocity and rotor RPM.

"Now," continued Sam, "after touching on these preliminary factors, let's proceed to compressor stalls. There are basically two ways of inducing a compressor stall—and notice the word I've used, *inducing*. They are:

"(1) Reduction or distortion (localized reduction) of airflow velocity at the engine inlet while RPM remains constant. These are sometimes called "cold stalls." They are induced by a distortion of airflow at the intake due to distortions originating at the duct entrance or within the duct itself. This condition would, in most cases, be more prevalent on airplanes where the inlet duct design is such that it is susceptible to distorted airflow. The name 'cold stalls' (also a 'two-dimension stall') stems from the fact that the exhaust gas temperature does not increase noticeably when this abnormal condition exists. You also can get airflow distortions leading to a cold stall with well designed ducts during maneuvers. Any time you get the bird into extreme angles of attack or yaw, you should watch for a compressor stall.

"(2) Improper operation of fuel controls and exhaust area controls—when applicable. 'Hot Stalls' are induced by improper scheduling of fuel to the burner cans. This improper scheduling can be introduced by a malfunctioning fuel control system

Formation flying, gunnery and high angles of attack can result in compressor stalls.

(either hydro-mechanical or electronic). In this case the malfunction would probably reveal itself upon throttle burst. In any event it would result in an abnormally large amount of fuel being distributed to the burner cans. This fuel, when burned, heats the air and makes it expand in volume. The exhaust gas seeks a place to relieve itself. The proper place for the hot gases to escape would be out through the nozzle diaphragm, turbine wheel and through the tailpipe.

"However, the physical construction of the nozzle diaphragm and the tailpipe is such that it allows only a certain volume of gases to escape for a given time. With the extra unwanted fuel burned and expanded, it cannot all escape by this route. Consequently, it begins to back up and oppose the air passing over the compressor rotor blades. This results in a loss of airflow velocity and a compressor stall is induced.

"But, that isn't all. The compressor discharge pressure which has been waging this minor warfare against the compressor inlet airflow velocity, now suddenly finds a place of escape and away it goes out the tailpipe and even the intake. This is possible because the engine is stalled and the airflow velocity and volume have decreased considerably.

"These conditions cause a reduction in engine RPM which is sensed by the engine fuel control, and a greater amount of fuel is scheduled to the burner cans in an attempt to raise engine speed.

"This initiates the whole chain of events again and we have what is known as pulsation or surge. In the meantime, during this little fracas, the EGT is left on its own, and rises to values usually in excess of prescribed limits. The rapidity of this rise, of course, is consistent with the severity of the stall.

Recognition

"Recognition of a compressor stall is usually no problem; the vibration that accompanies a stall is enough to shake your eyeteeth loose. However, it is possible to experience a milder stall which would not even be evidenced by instrument indications. If this particular type occurs, a 'hang up' in RPM will be noted somewhere in the region between 50 per cent and 80 per cent (critical stall region). A gradual rise in EGT would also occur.

"As far as sound is concerned, this would be dependent upon the extent of the stall. Sound will vary in intensity from a low rumble to something like pistol shots. In extreme cases it is more like cannon firing. As you can see, this could 'clank up' a pilot slightly, if he didn't know what to expect.

"Now a few words on the basic types of compressor stalls. There are three classifications that may be used to assort stalls:

• A partial stall, which is the mildest of the three and is usually

tolerated insofar as compressor performance is concrened. This one involves multiple regions of stalled flow extending over only a part of blade height or a limited number of compressor stages. Transition from partial stall is gradual. As the airflow velocity and volume are reduced, the areas of partial stall tend to group together and form a complete stall.

• A complete stall should be avoided if at all possible. A persistent stall of this type not only penalizes the engine performance but also reduces engine life. This type not only

causes high vibratory stresses on the compressor blades but (what may be worse) hot spots on the turbine wheel. By the way, both of these are excellent fatigue aggravators.

"The complete stall is characterized by the fact that it has only one stalled region extending over the full blade height and full length of the compressor. (Consider the wing in a complete stall for comparison.)

"Transition into a complete stall is abrupt. The engine has probably been afflicted by a partial stall which is suddenly transformed into a *complete* stall. Whenever a stall of this type occurs, it requires extreme, corrective measures to stop it.

• Stall surge is the third and most severe condition. We covered this pretty well in the explanation of the "hot stalls." I did not tell you, however, that this condition can lead to either a rich flameout (wet out) or a lean flameout. The reason is that with stall surge, the net airflow through the engine varies with time while airflow during complete or partial stall remains constant. This produces variations in the fuel-air ratio and velocities in the burners and often leads to the flameout conditions.

What You Can Do

"Naturally, upon becoming aware of the problem, my first question as a pilot or maintenance man would be: 'How can I steer clear of these situations or what can I do to diminish the intensity of these stalls?' As for the pilot, the following procedures should prove beneficial:

• Treat the throttle with respect. Although the latest designs allow for throttle bursting, be reasonable about it.

• Bear in mind that altitude increases have an adverse effect on compressor operation. This is a result of what is kown as 'Reynolds Number Effect.' That classy title is just a way of saying that the air becomes thinner as the altiude is increased and therefore has difficulty in following the contours of the airfoil section of the compressor blade. This causes the stall margin to decrease.

"On Figures 1 and 2, you will notice the two curves representing steady state operation and the stall region boundary. The small margin between the two curves is called the stall margin. To obtain optimum engine performance, it is necessary that these curves be close together. In other words, we might say the engine is operating very close to a stall in order that the utmost in thrust may be realized. Figure 2 illustrates a normal engine acceleration and an abnormal acceleration.

• Avoid abnormal flight attitudes, whenever it is not a requirement of your mission. Remember that flying which adversely affects the airframe performance has virtually the same type effect on the compressor.

"If a stall actually occurs, here's what to do: First and foremost, retard the throttle. This will cause the fuel to flow to decrease to a minimum schedule and the engine will begin to decelerate. Reducing the fuel flow permits the gases in the combustion chambers to flow through the nozzle diaphragm and the pressure ratio (between compressor inlet and outlet) is reduced low enough to bring the compressor out of stall.

"This is true in most cases. At high altitudes, however, stalls cannot always be completely corrected by chopping the throttle, because of the high flight-idle setting. Retarding the throttle past the idle detent introduces a possibility of flameout. But go ahead and pull it back within reason. If this doesn't work, leave it at idle and correct any abnormal attitude you may be in. The attitude may have been the cause. Diving the bird will help. The object here is to increase the airflow over the compressor rotor. Or, do all three simultaneously.

"For you lads in the maintenance business, the same deal about handling the throttle applies. Use extreme care in fuel control adjustments and throttle linkage adjustment. In short, follow the technical order.

"There are a few more factors that may be conducive to stalls. They are:

• Temperature effects. As the temperature decrease, the stall margin decreases. This tells you that a stall problem would be more likely to occur during cold weather operation.

• Rocket and gun firing. This can cause stalls in several ways. First, the rocket and gun blasts create disturbances in air entering the duct if located too near. These disturbances provide ideal conditions for cold stalls.

"Second, if the exhaust gases are allowed to enter the duct, they usually cause hot stalls. This happens because the sudden variation in temperature of air produces a sudden change in airflow through the compressor, much like during surge. In addition, the air is depleted of oxygen and the mixture suddenly becomes too rich.

• Close formation flying. During such flights, it is possible to be exposed to the exhaust of the leading aircraft. This produces the same effects as the rocket firing that I just described.

"As a final note I want to leave you with this thought. It is actually for you maintenance troops, but it is also important for you pilots because you're the ones who will have to report it. A compressor stall which cannot be corrected by adjustments of fuel scheduling may usually be traced to an improper size (too small) nozzle diaphragm. However, I want to point out that the same thing can be produced by the pilot by improper operation of the tailpipe area control or trim setting.

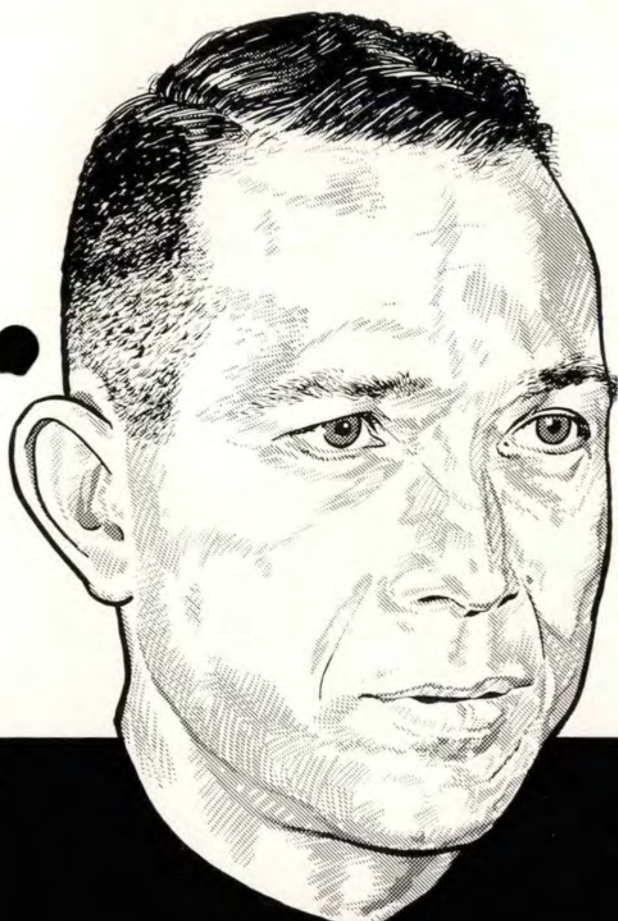
"What I have tried to say in this long harangue is simply this: Compressor stalls can be dangerous just like those that you get on the airplane as a whole. But just like the airplane stall, you can stay out of compressor stalls. It is mainly a matter of knowing what causes them.

"The two types are almost identical. With either case, they sometimes happen when you don't expect them to. But when they do, you can do something about them. What you do will either correct the condition or make it worse, depending on how fast you recognize your trouble and apply corrective action.

"My last point is this, and I can't overemphasize it: Pilots and maintenance people must work together on these things if you are to have reliable engines and airplanes. A mechanic can't fix something he doesn't know about, and a pilot can't complete missions without reliable engines. The one depends on the other —and entirely on you. ▲

WELL DONE

First Lieutenant
Peter T. Nichols
6630th Radar Eval ECM

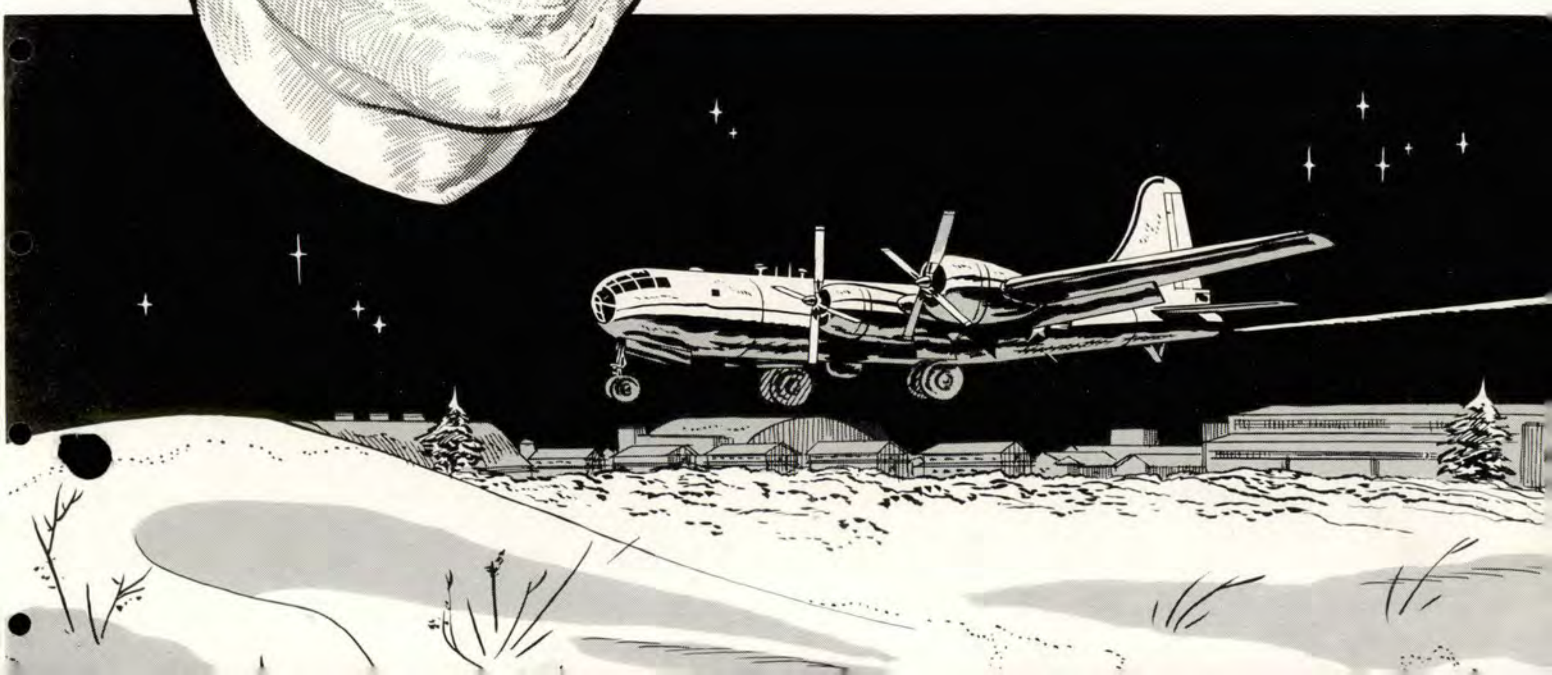


LT. PETER T. NICHOLS was the pilot of a B-29 aircraft on what was to have been a ten-hour navigation mission. He was attached to a Radar Evaluation ECM Flight, operating out of Goose Air Base, Labrador. Gross weight of the aircraft was 120,679 pounds.

Immediately after takeoff, No. 3 showed signs of improper operation. At flaps-up altitude, No. 1 lost all power and had to be feathered. Lt. Nichols declared an emergency and made a turn to crosswind leg at 650 feet. Shortly after this turn, the propeller on No. 2 began to overspeed. An immediate, though unsuccessful, attempt was made to reduce the RPM to 2800. Instead, it dropped rapidly to 1800 then surged back to 2900. Throttle was closed completely and when the RPM continued to rise, Lt. Nichols feathered No. 2. The B-29 was losing altitude at 200 feet per minute, at 175 mph. Full right rudder was required to hold it on a straight course.

The pilot declared "May Day" and requested to land on a runway that crossed the takeoff runway at 90 degrees since there was not enough altitude to complete a normal pattern. Clearance was granted. He made his turn to final at approximately 600 feet and the aircraft touched down on the first 1000 feet of the runway.

Investigation revealed that both engines and propellers malfunctioned as result of materiel failure. An aircraft accident was averted, however, because of the calm and capable performance by Lt. Nichols. WELL DONE!



Joseph C. Dabek
Hamilton Standard

PITCH ON PROPS

ANYBODY WHO has experienced a sudden propeller overspeed knows that it isn't fun. The whine of the engine and the tachometer needle against the peg make you wish that you were some place else. So, what do you do when you're in this fix? You reduce power. Assuming, of course, you have some air under you, plus airspeed, or both—and press the button, hoping that the darn thing will feather. If it does, you'll breathe a sigh of relief and hope that the copilot noticed how cool you remained during the whole operation. If it doesn't feather, then you'll bone up on the problem of flying an airplane with a windmilling prop.

Not only is this situation hard on you, but the engine which went through the overspeed didn't enjoy it, either.

Wouldn't it be nice to have a prop that didn't turn up quite so fast if some malfunction caused an overspeed? Also, if for some reason that prop couldn't be feathered, wouldn't it be nice still to get some useful thrust out of it? This is exactly what has been done in the model 34G60 propeller which is replacing the 24260 prop on all C/KC-97 aircraft. The magic words are "pitch lock."

In this case, it's a hydraulic lock (like you avoid in the engine) because that is the simplest arrangement to design and maintain when provided as an added feature in the proven hydromatic propeller.

Four of these 34G60 props have been going through a service test at Westover Air Force Base for several months now, and we've had a chance to get a first hand look at pitch lock operation. The catch is that during this test, on several different occasions, one or more propellers were locking pitch at an RPM lower than expected. The resulting prop operation was something unheard of since controllable props came in 'way back in the early thirties. This confused the troops.

The following excerpt of a Form 1 write-up will give you an idea what happened:

"A simulated, three-engine approach with No. 4 set at 1900 rpm and 19″ manifold pressure, and Nos. 1, 2 and 3 set at 2550 rpm. A go-around was made with the No. 4 engine still set at 1900 rpm and 19″ Hg.

"Later, power was reduced to 2550 rpm on Nos. 1, 2 and 3 and held around the pattern for another three-engine approach. Turning final, No. 1 went to 1850 rpm; Nos. 2 and 3 to 2200 rpm. No. 2 was selected as master and the sync lever placed in full increase. No. 1 engine went to 2200 rpm; Nos. 1, 2 and 3 remained at

Here is an article about a new piece of equipment which is not electronic, has no wires, and no cockpit controls. It gets into the act automatically.

2200 rpm and No. 4 went to 2700 rpm. The manual switch would not increase the RPM on Nos. 1, 2 and 3 engines. All four, high-limit lights were on. Manifold pressure was approximately 35 inches. A landing was made with Nos. 1, 2 and 3 at 2000 rpm and No. 4 at 2700. After landing, prop check was made, using Nos. 1 and 2 as masters, and the check was completed satisfactorily."

Following this incident, some time was spent in trouble-shooting the prop system, however, nothing tangible was found to account for any prop malfunction. The aircraft was released for local area until this problem could be wrung out. On one of these flights it happened again, but this time we had a clue. Here is an excerpt of this flight report:

"Began go-around: A/C called for 2700 rpm, throttles applied to 55" Hg, all four props surged to approximately 2850 rpm. RPM stabilized at 2680 for No. 1, at 2700 for 2 and 3, and at 2640 for No. 4. A/C called for climb power. Throttles were retarded and props followed to 2200 rpm—NOTE: sync lever was not moved—governor lights stayed on. As the sync lever was retarded through approximately the 2500 rpm position, the governor lights went out—sync lever held in that position for approximately five seconds. Sync lever brought back to 2200 rpm before responding. RPM set 2550 and all props followed smoothly and sync was good."

You will note that in both of these instances the apparently erratic prop operation occurred right after a go-around. Subsequent ground checks were satisfactory. Furthermore, the second case shows definitely that the props were behaving as if in fixed pitch in that the RPM decreased when the throttles were pulled back.

Following the second incident, a test flight was made during which the pitch of any one or all four props could be locked by *purposely* overspeeding the engines with very rapid throttle movement to about 2900 rpm in a go-around. Excessively fast throttle application was necessary to engage the pitch lock.

It was later found that part of the pitch lock mechanism, the bleed shutoff valve, on all four props was set to close lower than the specified 3000-3100 engine RPM. This service test proved that familiarity with the pitch lock feature was very desirable. Here's what you should know about it.

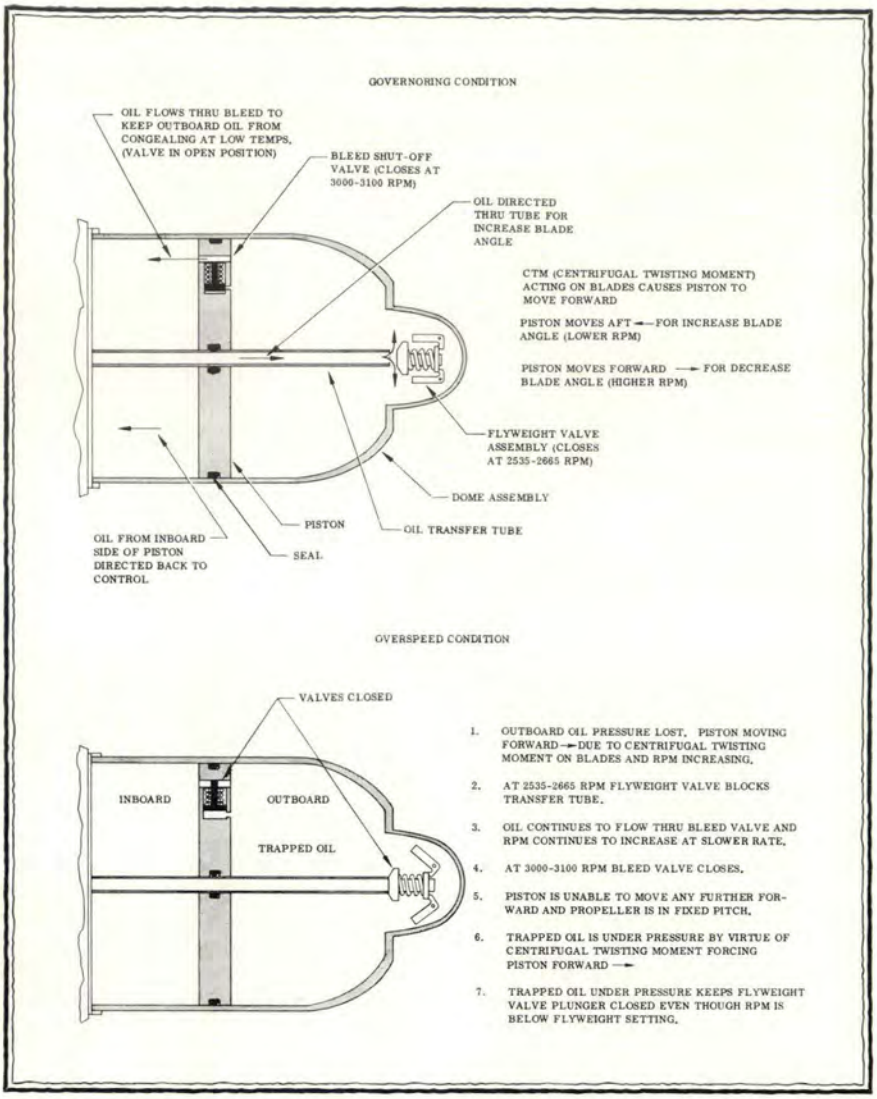
With the present-day powerful engines, aircraft speeds are at the point at which the windmilling RPM of a propeller on the low pitch stop becomes an important consideration. If the blades turn toward the low pitch position because of some malfunction, a severe overspeed can result. Under certain conditions, this overspeed can occur rapidly enough to cause engine damage before corrective action can be taken. If the feathering system has been rendered inoperative, the propeller will continue to windmill on the low pitch stop and produce undesirable drag affecting airplane performance.

In the event of a malfunction which causes the blades to move toward low pitch, it is desirable to limit the overspeed to a moderate RPM. It is also desirable to permit continued operation at reduced power and normal RPM with the propeller still delivering thrust if the situation demands.

In order to understand pitch lock operation, it is good to know some of the fundamentals of prop governing.

The governor is basically a speed control. The engine RPM that you select in the cockpit by means of the prop master lever or toggle switches, will tend to remain constant regardless of airplane attitude or changes in power setting. This is done by automatically changing the blade angle to take a larger or smaller bite of air, which is achieved by oil pressure acting on a piston in the dome. Oil pressure moving the piston forward decreases the blade angle and the RPM goes up while oil pressure moving the piston aft increases the blade angle, and the RPM drops. (It must be remembered that centrifugal twisting moment—CTM—which you've heard of before, is always acting to drive the blades to a zero angle. Increased pitch oil pressure is the opposing force.)

A pilot valve connected to flyweights determines whether the blade angle should be increased or decreased. When the piston is moving forward under oil pressure and CTM, the oil on the other side must move out of the way and is directed back to the control and vice versa.



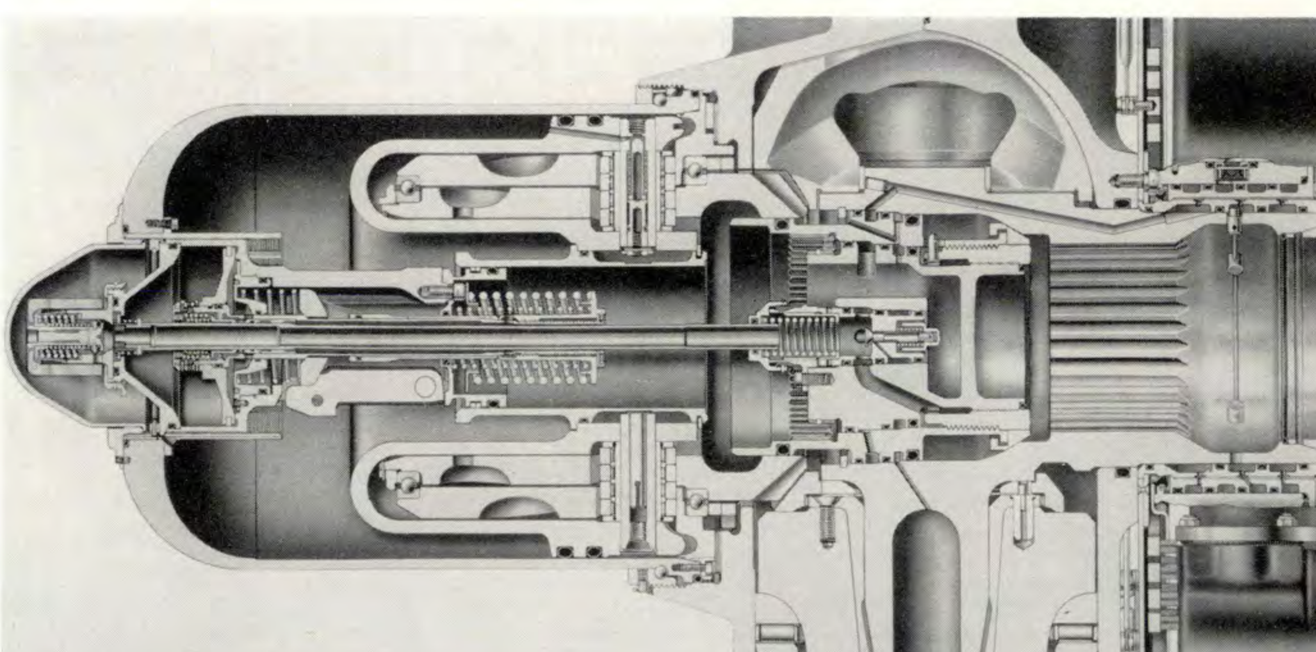
In a prop overspeed, increase pitch oil pressure is lost for some reason and, since CTM is left all by itself, it will turn the blades to a lower angle and this is when things start winding up. Now, if at some specified RPM, the passage for the return oil could be blocked such that the oil on the increase pitch side of the piston would restrict forward piston movement, the blade angle could not decrease and we have the makings of an overspeed limiting device. This is basically what pitch lock is.

Pitch lock is completely contained within the dome assembly and will restrict blade angle change toward a lower angle at a pre-set RPM. It consists of two basic parts: a flyweight valve just under the dome cap, and a bleed shut-off valve in one of the cam roller shafts.

The flyweight valve blocks the flow of oil from the increase pitch side of the dome piston at an RPM of 2535-2665. The trapped oil will hold the valve closed, however, oil pressure toward increase pitch is always capable of opening the valve as during the feathering operation.

The bleed shut-off valve assembly will block the flow of oil from the increase pitch side of the piston when the RPM reaches the 3000-3100 range. This valve is normally open and provides a path for circulation of oil in the dome as is accomplished by the

Below, this is a cut-away of the mechanism.



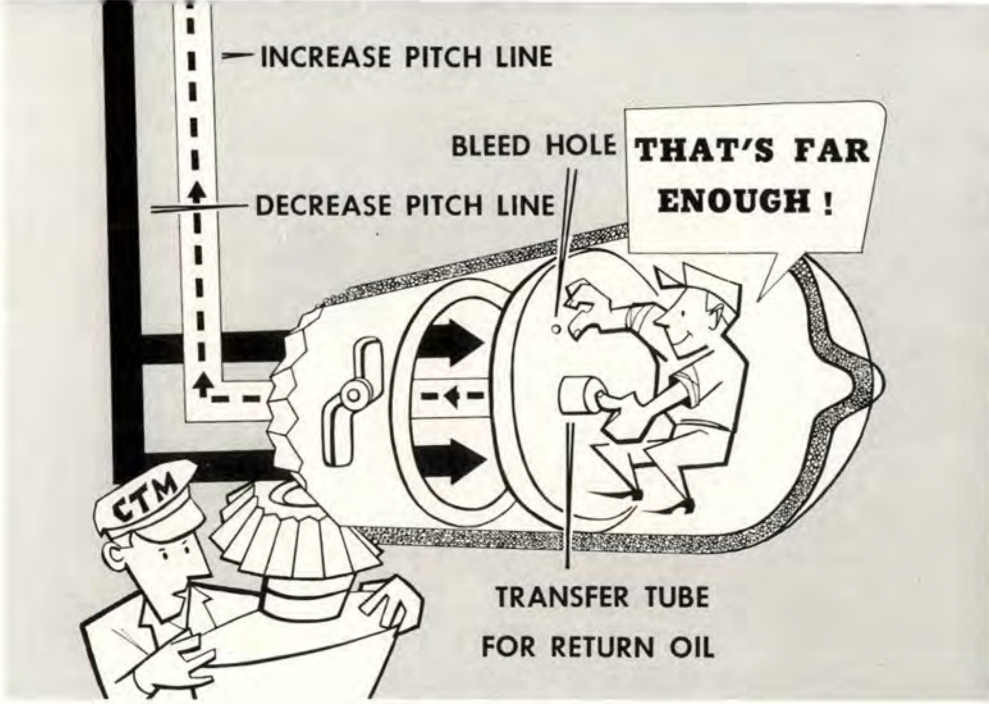
piston bleed hole on other hydromatic propellers. Once closed, this valve is held closed by trapped or by increase pitch oil pressure until the RPM is reduced to 1500-1700. The trapped oil on the increase pitch side of the dome piston creates a hydraulic lock, as you can see, if this area is perfectly sealed. Remember, CTM is trying to turn the blades to a zero blade angle but cannot because the trapped oil is restricting piston movement except for that resulting from minor leakage past the seals.

Let's see how pitch lock normally works. Suppose while you're cruising along comfortably, something unpleasant like the main oil pump in the prop control jams and prop oil pressure is lost. This would be the sequence of events:

- Centrifugal Twisting Moment would start turning the blades to a lower angle and the RPM would start rising. The piston in the dome would be moving forward.
- At 2535-2665 rpm the flyweight valve would close and block the flow of return oil from the increase pitch side of the dome piston at the end of the oil transfer tube.
- Since the bleed shut-off valve is still open and increase pitch oil is flowing through, the RPM would continue to rise, only at a slower rate.
- At 3000-3100 rpm the bleed shutoff valve would close and forward piston movement would be stopped because the oil on the other side is in the way.
- The RPM would not increase any higher and, assuming that you haven't already jabbed the feathering button, you would probably do so now. If the prop could not be feathered for some reason, or if you felt you could use the "bezazz" available from the wounded powerplant at reduced throttle, you would pull the throttle back on the particular engine and the RPM would decrease. The blades are effectively at fixed pitch.

In this case you must remember that the bleed valve will open at 1500-1700 rpm, therefore, with the prop in fixed pitch, airplane maneuvers or throttle manipulation which would cause the RPM to approach this value should be avoided.

- The flyweight valve would remain closed even though the RPM is reduced below the flyweight setting (2535-2665) because the trapped oil is under pressure by virtue of CTM pushing the piston forward.



What does pitch lock do on takeoff? Since the takeoff RPM is above the flyweight valve setting, the valve tries to close. However, increase pitch oil pressure over-rides it and the blade angle continues to *increase* to achieve governing. Should an overspeed occur on takeoff, the pitch lock mechanism will lock at 3000-3100 rpm. The acceleration of the airplane, however, will continue to cause an increase in RPM. The blade angle during takeoff is near the low pitch stop, therefore, reducing power on the particular engine would be necessary immediately.

Reverse Pitch

Now about reversing. In some instances where rapid throttle movement in the reverse quadrant is necessary, an RPM above the flyweight setting may be reached as the blades pass through flat pitch. To assure that the flyweight valve will not interfere with reversing, a mechanical lifter is located on the outboard end of the oil transfer tube which is raised during reversing and prevents the flyweight plunger from seating until after the prop is unreversed.

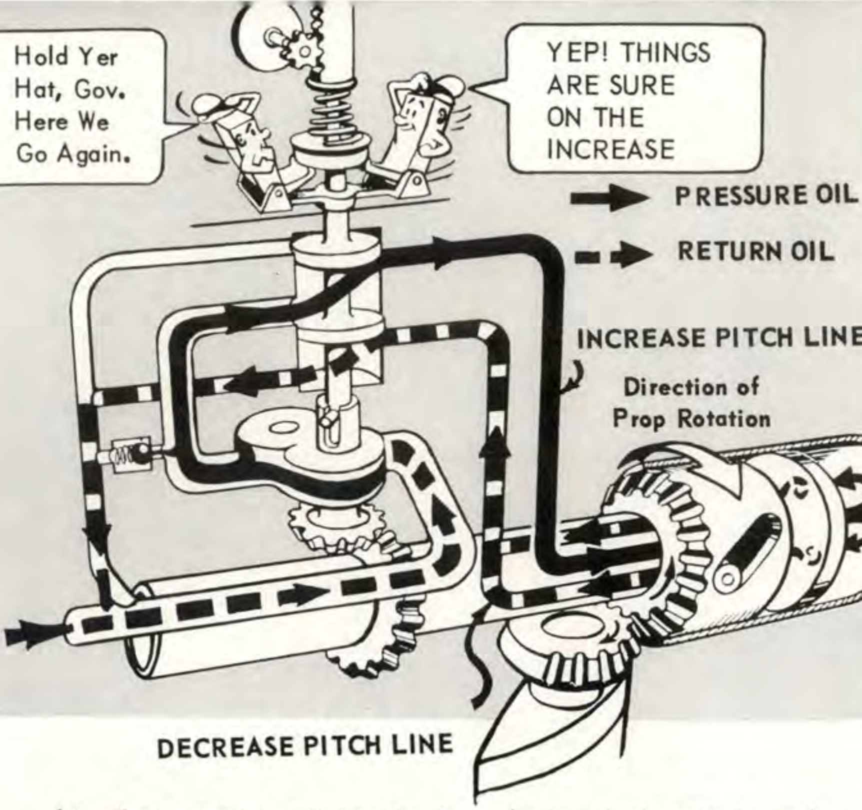
The pitch lock will not normally actuate unless there is some malfunction causing an overspeed. The limiting RPM of 3000-3100 was selected because it is high enough to be out of the normal operating range and yet low enough to avoid severe engine damage. Of course, if you really tried, you could probably get an RPM surge this high in a go-around by starting off at a low airspeed with the prop master control lever set at takeoff and jamming the throttles forward.

Realizing that in some instances this might happen when you are in need of a lot of power and right now, it would pay you to know whether or not you have locked pitch especially if prop operation doesn't look quite right; also, how can you get out of this thing when you're in it.

Say that you make a go-around during which the RPM surges above 3000, let's see what will happen. If this seems too complicated now, we would suggest reading it again after your first check ride when you'll have seen it actually happen.

- After the surge, the RPM will drop to the governor setting since increase pitch oil pressure will unseat the flyweight plunger and governing will continue.
- A normal power reduction can be accomplished to bring the RPM below the flyweight valve setting and, although the bleed shut-off valve may be closed, constant speed operation will not be noticeably affected. With the bleed shut-off valve closed, normal oil circulation will be terminated; however, there will be no immediate obvious change in propeller operation.

NOTE: If the throttles are retarded or if airspeed is reduced by climbing while the master lever remains at the takeoff setting a locked pitch condition will result. That is, the RPM will decrease (follow throttle movement and/or airpseed) since the governor is calling for a lower blade angle such



that oil pressure is applied to the decrease pitch side of the dome piston but the piston can't move, so the RPM will decrease.

The flyweight valve will remain closed, even though the RPM may drop below 2535-2665, because the pressure of the trapped oil will be acting on the plunger. As long as the governor is calling for a decrease in blade angle when the bleed valve and flyweight valve are closed, the propeller will remain in fixed pitch.

Therefore, to determine whether any or all of the propellers have the bleed valve closed, the following check can be made:

• After the RPM has stabilized as we described above, the throttles may be retarded while leaving the propeller master lever in the takeoff position (max RPM lights on). If the RPM decreases, that is, follows throttle movement, it indicates that the bleeds are closed and the propellers are in fixed pitch. If on one or more engines the RPM remains at the takeoff setting, this indicates that the bleed valve is not closed on that particular propeller. It follows then that while the flyweight valve closes when the throttle is retarded from an RPM above the flyweight setting, governing will continue if the bleed valve is open. In this case piston movement toward a lower blade angle condition is limited by the rate of oil flow from the increase pitch side of the piston through the bleed valve.

To observe this condition, the following checks may be performed:

• While cruising at an RPM *below* the flyweight setting, 2400 for example, one of the throttles may be chopped which will result in the RPM dropping but immediately returning to the governor setting.

Then while governing at an RPM *above* the flyweight setting, 2670 for example, when the throttle is chopped the RPM will drop but will return to the governor setting slowly compared to the first case. This indicates that pitch change toward a lower blade angle is retarded by virtue of the flyweight valve being closed and the increase pitch oil is being displaced through the bleed shut-off valve.

To release the bleed shut-off valve (if closed) the RPM on the particular engine or engines may be reduced to 1500-1700 by toggling and constant speed operation will resume.

On Go Around

What does all of this mean? It means that even though you might experience an RPM surge above 3000 during a go-around, with a normal power reduction you'll probably never know that the bleed valves may be closed and the conditions are set for lock pitch. That is, during a normal power reduction after the throttles are retarded a bit you also decrease the RPM with the prop master control lever. Pulling the prop control lever back is a round-about way to tell the blade angle to increase. The increase pitch oil pressure then unseats the flyweight plunger and you're back in business at rated power.

It also means that if the throttles are retarded more than usual before the prop control lever is moved, you will get a pitch lock indication right then if the bleed valves are closed. To get out of this condition all you have to do is pull the prop control lever or toggle switch back to an RPM setting below the tach reading, and the flyweight valve will be unseated by increase pitch oil pressure. To be complete about it though, it is advisable to open the bleed shutoff valves by toggling the RPM to 1500-1700. This will insure normal RPM control for the next approach.

If you haven't already dozed off by now with all this jabber about CTM, governing, and increase pitch oil pressure, you are probably expert enough to go back to the excerpts of the Form 1 writeups and tie pitch lock in with those incidents.

We've painted a glowing picture of pitch lock. Maybe it reads like a sales brochure on the subject and you are sitting there, nodding your head and smiling cynically. Okay, try these three on for size and see whether the foregoing theory talk is worth anything.

One commercial airline had three separate cases where this has come into operation.

In the first case, a Stratocruiser out of Honolulu experienced an overspeed to the pitch lock setting upon reaching cruising altitude. The pilot retarded the throttle to 2250 rpm after the pitch lock actuated. He returned to Honolulu.

In the second case, a Stratocruiser two hours and 24 minutes out of San Francisco had a runaway to the pitch lock setting and the pilot pulled the throttle back to 2250 after pitch lock actuated. He returned to 'Frisco.

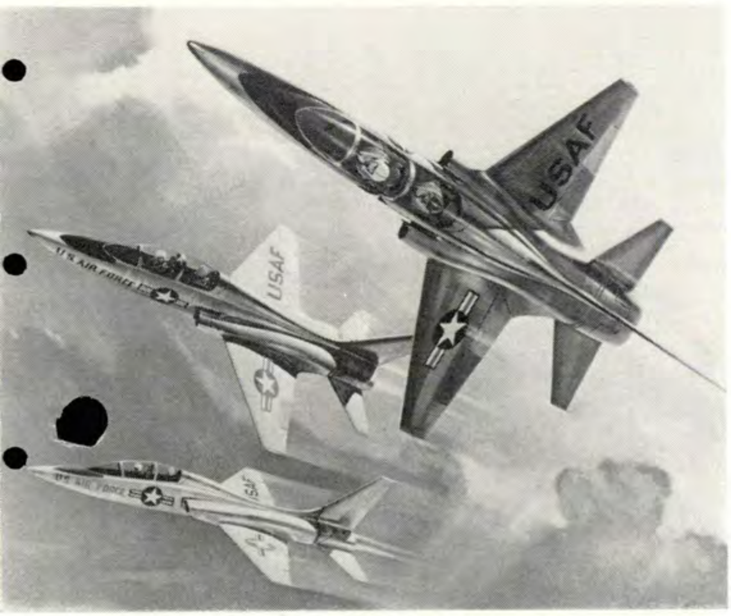
En route to Fairbanks from Seattle, a third B-377 experienced an overspeed to 3100 rpm following which the pilot reduced power to 1875. The aircraft landed at Gustavus, Alaska. Although I've never been to Gustavus, I understand there was no sweat.

So you see, it does work. Our word to the wise is to know about pitch lock, know how you can get into it and out of it and that's the end of it. Perhaps some day pitch lock will give you a hand in a situation which could have otherwise been very hairy, and away you'll go. ▲

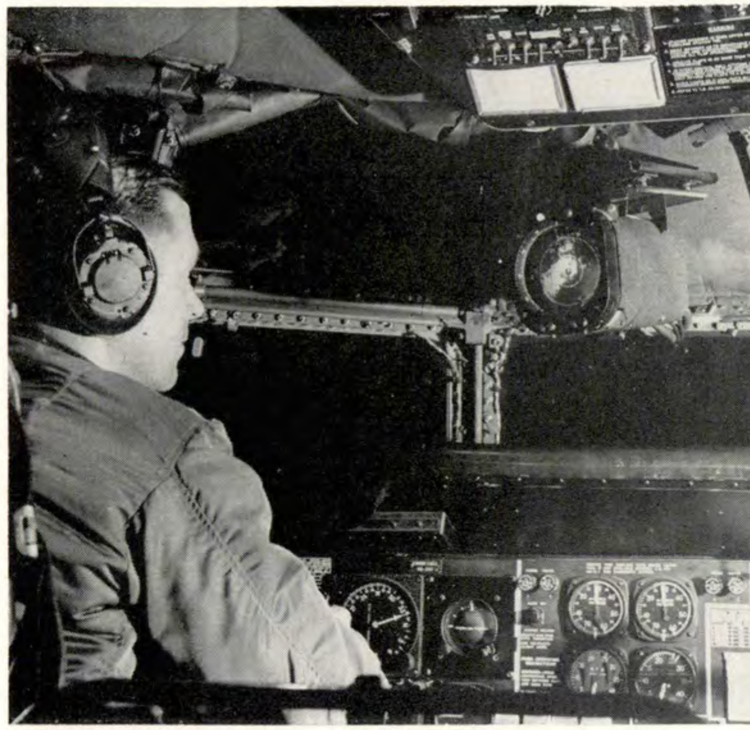
Keep Kurrent

NEWS AND VIEWS

Below, is the first detailed view of the new T-38 supersonic trainer made by Northrop Aircraft, Inc. It features an area rule fuselage.



Captain M. M. Howell, Flying Safety Officer, at Scott AFB, explains the Atkins Anti-Collision Light test project to General Clyde L. Brothers, ATC, Command Surgeon. The light, on this T-33 is on the baggage carrier for evaluation purposes. Normal installation would be on the wing tiptanks. They can be seen for fifty miles.



Latest feature of Sperry's APN-59 radar system is a pilot's indicator shown here mounted in the cockpit of a C-97. Like that used by the navigator, the pilot's indicator uses a 5-inch cathode ray tube with excellent viewing of targets located at distances up to 240 miles.

Here are two views of the detachable "pod" carried under the belly of B-58s. The aircraft was designed specifically to carry this store.

SPLASH DEPARTMENT . . . accidents resultin

An RB-57, returning from an IFR round-robin navigational flight, made a jet penetration and two GCAs. On the go-around from the second GCA, the aircraft passed over the GCA unit at a very low altitude and in a skidding attitude. The pilot advised the tower that he had a fire warning light on the left engine, that he had shut it down, was declaring an emergency and would make a VFR approach. The weather at the time was 1000 feet overcast, visibility seven miles in light rain.

The B-57 turned on final and at an altitude of 200-300 feet the pilot decided to make a 360-degree overhead since he was too hot to land on this approach. The aircraft pitched out with gear and flaps down (still at 200-300 feet altitude); the nose came up gradually, the left wing dropped and began dragging the ground. The B-57 cartwheeled, exploded and disintegrated. Its crewmembers were killed.

Comments:

The investigation and subsequent TDR on the left engine failed to reveal any evidence of an engine fire. The Board determined that the pilot probably had experienced a false fire warning light and had needlessly shut down the left engine. He could have completed a successful landing if he had not attempted a 360-degrees overhead approach with gear and flaps extended from an altitude of 200 to 300 feet. Once committed to land with the garbage out, he would have been better off to have landed hot, and at worst, let the '57 roll through the boondocks off the end of the runway.

■ ■ ■

Approximately one minute after takeoff, a garbled transmission was received by the tower from a B-57 pilot, stating that he had "a . . . warning light and was returning to land." He did not declare an emergency but requested the aid of GCA, since the visibility was two miles in haze and smoke.

GCA painted the aircraft and issued instructions for landing the 46,000-pound B-57 out of an abbreviated pattern. The pilot overshot the turn onto the final approach and was given corrections to bring the aircraft back to the runway centerline. When four miles from touchdown, he was 800 feet low on the glide path. The aircraft continued low and to the left, on the GCA scope, and the pilot was advised to pull up. The '57 crashed two miles from the end of the runway and approximately 2100 feet to the left of the centerline extended. Both crewmembers were fatally injured.

Comments:

A false fire warning light influenced the pilot to return to the base and make an emergency landing with a full fuel load.

The gear, flaps, speed and dive brakes were in the extended position. The Investigating Board believed that the pilot probably attempted to apply additional power to the operating engine when he realized that he was low and short of the runway. The additional

power at low airspeed caused the B-57 to roll into the inoperative engine and the aircraft struck the ground in an inverted position. Inspection of the engine failed to reveal any evidence of inflight fire.

The pilot didn't use the correct single-engine procedure; he extended gear, flaps, speed and dive brake when he didn't have the landing in the bag.

There is no substitute for following the Dash-One procedures under emergency situations.

■ ■ ■

A B-47E, scheduled for a five-hour, round-robin, IFR training mission, departed its midwestern base under weather conditions of 1000 feet broken, 2000 feet overcast, and three miles visibility in light rain and fog. As the aircraft broke ground, the No. 1 engine fire warning light came on. The aircraft commander notified the crew to prepare for possible bailout, then pulled the No. 1 fire button out and placed No. 1 throttle in the idle cut-off position. The fire warning light remained on and the crew bailed out—only 90 seconds after takeoff.

Comments:

An examination of No. 1 and No. 2 engines showed no signs of fire. TDRs were performed, still no signs of fire could be found.

The Board determined that the aircraft commander's decision to abandon the B-47 was premature and that the fire warning light came on because of a malfunctioning fire detection system.

One interesting item—and one which all pilots should know—is that under certain conditions, vapor or condensation will appear in the form of streamers from the trailing edge of the wing and nacelles. This can be, and often is, mistaken for smoke. When this is combined with a glowing fire warning light, it is

g from faulty diagnosis

understandable why the crew would be tempted to leave the aircraft.

■ ■ ■

During an acrobatic mission, an F-100 pilot started a loop from 15,000 feet, with the throttle at full military power. As he approached the top of the loop, he experienced a severe compressor stall. He pulled the F-100 over the top and as soon as the nose of the aircraft came down through the horizon, the stalls stopped and the engine operated normally.

The pilot started another loop from 18,000 feet and as he passed 60 degrees past the vertical, the F-100 again began a compressor stall. The throttle was left at full military power and the nose pulled down through the horizon. The stalls kept dying away but did not stop entirely. The pilot retarted the throttle and noted the tailpipe temperature was approaching 1000 degrees. He placed the throttle in idle but the stalls continued even though the RPM was only 55 per cent. The emergency fuel system was used and the tailpipe temperature went to 1000 degrees again. Switching back to the normal system failed to remedy the situation and the RPM finally started down below 50 per cent. The pilot notified the tower of his difficulties, then ejected.

Comments:

This accident was attributed to design deficiencies in the F-100A, J-57-7 and J-57-30 engines, and the AJ2-A regulator. However, the investigation brought out the fact that many pilots are uncertain as to what action should be taken when the compressor stalls at the top of a loop. They were in doubt as to whether it would be better to reduce power immediately and chance falling into a spin or leave the power on until over the top of the loop. Many pilots erroneously felt that compressor stalls in the F-100 were not uncommon and that before the engine would overtemp from the stall, it would probably flame out.

Fortunately, modifications have been made on later series aircraft to minimize compressor stalls; however, mechanical devices sometimes fail just when we think a problem has been solved. If possible, considering the circumstances, the throttle should be retarded as soon as the stall occurs. *(See story, page 2.)*

■ ■ ■

Shortly after takeoff on an IFR ferry flight, the pilot of an RB-66B noticed the cabin pressure fluctuating in a regular rhythmic cycle of about once every 20 to 30 seconds. He checked the cabin window de-fog switch-off and the cockpit pressure switch to normal. When the cabin pressure continued the pulsations, the pilot decided to return to his departure point and have the '66 checked.

The ceiling consisted of high clouds, only; however, the visibility was restricted to five miles in haze and smoke. The pilot made three approaches to the field before he could find the runway because of the bright sunshine and haze.

On the third approach, the B-66 touched down near the 4000-foot runway marker. The drag chute failed to deploy and at the 6000-foot mark, the pilot used the emergency brake system. The left tire blew out at 6400 feet and the right one at 6900. The airplane continued off the runway and the pilot retracted the gear when it appeared that he might run into obstructions off the end of the clear zone.

Comments:

Although the base was above VFR minimums, this pilot should have used GCA, considering the difficulty he had in locating the runway. Further, he continued his landing when it was obvious that he wouldn't touch down in the first third of the runway. He probably relied on the drag chute to counter balance his error in judgment. Although he had four hours of fuel on board, he made no effort to go around.

Oddly enough, the pulsating cabin pressure was believed to have been caused by the wing, empennage and radome anti-icing, de-icing switch being in the de-icing position. The drag chute did not deploy because the actuating handle was not pulled out far enough.

This is another case of incorrect diagnosis of a minor problem which resulted in a costly accident.

Payoff In Performance

Captain Robert H. Jacobson
Experimental Flight Test Pilot School, Edwards AFB.

To better understand the factors affecting the performance of an airplane, you should know some basic aerodynamic theory. Now, don't let the word "theory" flip you. Nearly all aerodynamic phenomenon can be explained in a manner understandable to all pilots. It doesn't have to be mystified by engineers' vernacular and it doesn't have to remain a forbidden realm to you. Familiarity with some of the terms will perhaps make for faster reading, but that's all. For most of us, here is something vital; for the engineer, here's a review.

The drag and performance curves discussed here do not apply to any specific aircraft. But the performance shown applies approximately to a turbojet powered fighter such as an F-84 or F-86 flying at an altitude of 30,000 feet. There are other conditions, such as wind, temperature and aircraft configuration which affect the performance of your bird. These may be investigated later. To do so will require knowledge and understanding of the basis of it all—which lies before you here. Whether or not you make your next destination may depend on how well you know and understand the lesson presented.

HAVE YOU looked at the back of your Dash One recently? Where all those neat little tables used to be, there is now what may appear at first glance to be the doodlings of an idiot. A nightmare, perhaps to some, of curves and graphs that talk of many things heretofore unthought of. Why? Because people didn't need that sort of thing to fly? Some thought they didn't.

Others never dreamed that this was the sort of thing that is the very basis of it all. As airplanes become more complicated, fly higher and faster, the basics become all the more important. What are the basics? Thrust and drag—and their causes.

The terms are not new to you but the fine points that are brought about by them (and which are translated to you on every flight you make) may surprise you. Whip out your trusty pencil and let's analyze.

You've probably heard that the total drag on your aircraft increases as the airspeed increases. This is true for the speeds you fly most of the time. You know this from the fact that a higher power setting is required if you want to fly at a faster speed. At low airspeeds (from the stalling speed to the recommended best glide speed), the drag decreases as the airspeed is increased. Figure 1 shows a typical drag curve for a range of true airspeeds.

To better understand why the drag curve decreases and then increases as the airspeed increases, take a look at how the parasite drag and induced drag changes with airspeed. The total drag at any airspeed is the sum of the parasite and induced drags. (Figure 2) The induced drag may be explained simply as the drag resulting from lift.

In straight and level flight, the lift is equal to the weight of the airplane. Whenever lift is produced by the wing, some induced drag will result. The magnitude of the induced drag produced by an airplane depends on the attitude or (more correctly) the angle of attack of the airplane and the airspeed.

The angle of attack is the angle between the direction the airplane is pointing and the direction it is moving. Early in pilot training you realized that when flying level at low speeds, the nose was high above the horizon. In other words, the airplane is flying at a large angle of attack, or mushing, as some pilots say. When flying fast, while holding your altitude, the nose is level or even below the horizon, so the airplane is at a small angle of attack.

The different angles of attack for different airspeeds cause the induced drag to be greater at low speeds than

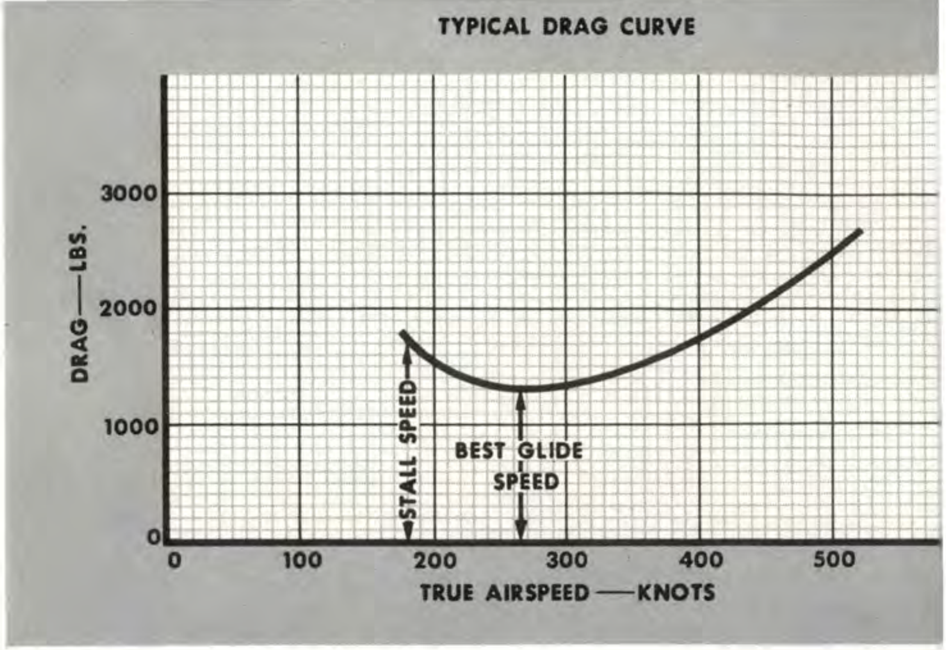


FIGURE ONE

at higher speeds. This effect is illustrated on Figure 2. The attitude or angle of attack required depends on the lift produced by the wing (which is equal to the weight in straight and level flight) in addition to the airspeed.

At a given airspeed, a heavy weight airplane flies at a larger angle of attack than lighter airplane. From this you can see that the induced drag depends on the weight of the airplane as well as the airspeed.

The parasite drag is caused primarily by the friction of the air moving over the skin of the airplane. Air actually has an apparent stickiness or viscosity, like molasses, and this property produces a resisting force (parasite drag) to any object moving through the atmosphere.

Up to relatively high speeds (Mach numbers of 0.80 or 0.90, depending on the particular airplane) the parasite drag increases as the square of the true airspeed.

$$D_p = KV^2 \qquad \text{(Equation 1)}$$

Where: D_p = **parasite drag**
V = **True airspeed**
K = **Constant**

The value of the constant (K) depends on the skin area exposed to the air, the roughness of the skin and the density of the air. The variation of parasite drag with airspeed is shown on Figure 2. At speeds corresponding to high Mach numbers, the parasite drag increases at a greater rate than the above equation determines but in this article we are discussing only the lower speeds (below Mach numbers of 0.80 and 0.90). When you go supersonic, there's another way to figure.

As mentioned before, the total drag is the sum of the parasite and induced drags. Look at Figure 2 again and you'll see that there is an airspeed where the induced and parasite drags are equal. We could prove that this speed is the speed for minimum drag and is the recommended speed

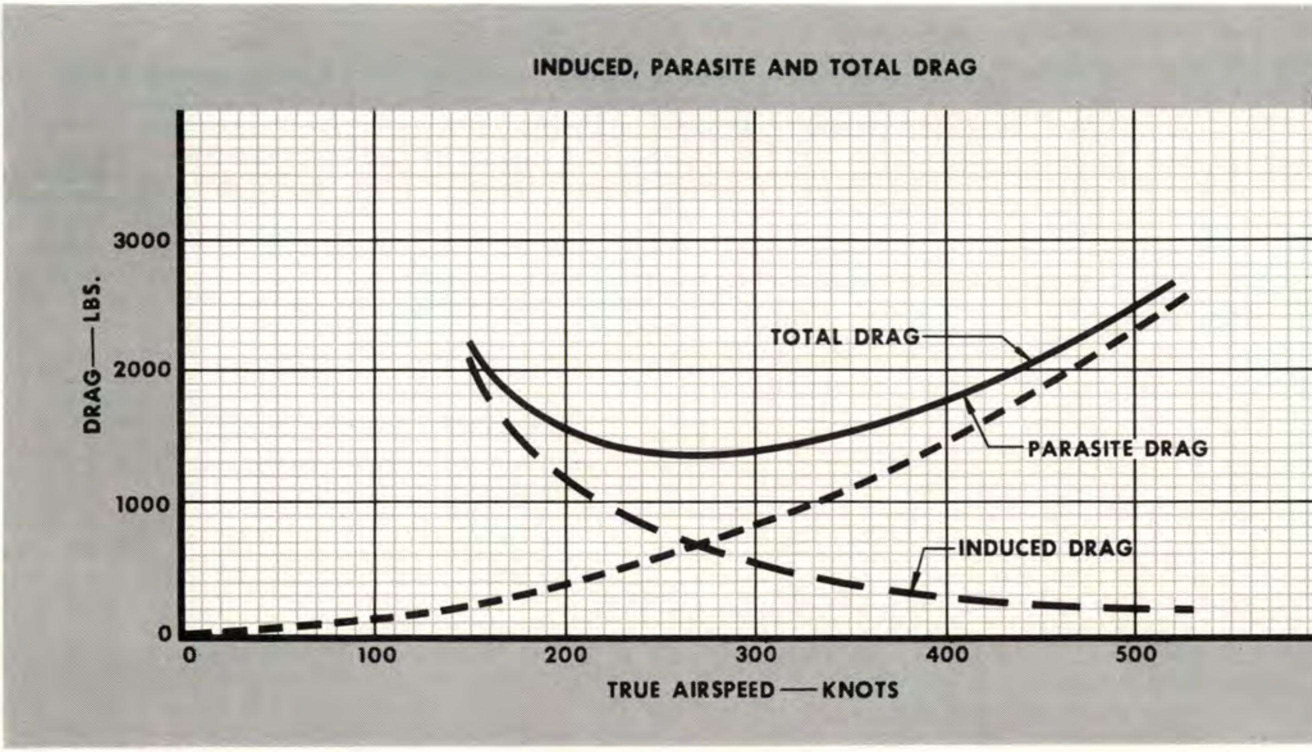


FIGURE TWO

for maximum gliding distance. At low speeds, the induced drag is going to affect you a lot more than the parasite drag so the total is greater than the minimum drag value.

You will find it difficult to fly at these speeds holding the airspeed and altitude constant. This portion of the drag curve is known as the "back side of the drag curve" (or if you prefer, the "back side of the power curve"). At the USAF Experimental Flight Test Pilot School, students are required to determine the thrust necessary to fly at these low airspeeds by experiment.

In the T-33 aircraft, it requires approximately 81 per cent rpm to fly straight and level at 120 kts indicated at 20,000 feet, and only 77 per cent rpm to fly straight and level at 160 kts. So, the existence of back side curve is apparent from flight tests. Try it if you like but watch for the stall. You'll need altitude to recover.

Now let's talk about the effect of the aircraft weight on the drag curves. The parasite drag curve will remain the same. The size of the airplane, skin roughness or viscosity of the air do not change just because the airplane has a heavy load. The induced drag will increase with an increased weight since the required angle of attack is greater. In fact, if the weight is doubled, the induced drag will be four times larger at the same airspeed. This is what makes the total drag for the heavy weight greater than the light weight and it is true at all airspeeds.

A comparison of the induced and total drags for two gross weights is given in Figure 3. Note that as the airspeed increases, the differences between the total drag curves become smaller.

The drag curves, together with the thrust and fuel consumption characteristic of the engine, can predict the range performance of the airplane. Take a turbojet engine operating at 100 per cent rpm. The thrust at this throttle setting remains nearly constant at all airspeeds we're going to discuss. The thrust curve included with our drag curve plots is shown in Figure 4. Note that the drag and 100 per cent rpm thrust curves cross at some speed where the thrust is equal to the drag. This speed is the maximum true airspeed for straight and level flight at 100 per cent rpm. There is a small difference between this speed for the two gross weights.

Now suppose that the airplane is being operated at reduced RPM, such as 90 per cent. A typical thrust curve for 90 per cent rpm is also plotted on Figure 4. The maximum straight and level true airspeed for 90 per cent rpm is indicated by the intersection of the thrust and drag curves. Note that the change in the maximum speeds for 90 per cent rpm between the two weights is much greater than for the 100 per cent rpm speeds.

Specific Range

While cruising, you want to cover the greatest distance over the ground for a given quantity of fuel. Therefore, a measure of the cruise performance is the quantity called "specific range," or "nautical miles per pound of fuel." This is the distance covered while burning one pound of fuel.

The specific range for any airspeed depends on the ground speed and the fuel consumption required to fly at the airspeed. All you have to do to calculate the specific range at any and all airspeeds is to know the corresponding fuel flows.

Remember, we are only discussing turbojet aircraft. The fuel flow of turbojet engines depends primarily on the thrust produced by the engine. At the given RPM the fuel flow decreases as the altitude increases. This is true because the engine delivers less thrust as altitude increases. The

PARASITE...

..or WEIGHT

fuel flow divided by the thrust is known as the specific fuel consumption (SFC). So, once you know the SFC you can figure the fuel flow for a known value of thrust. The SFC of turbojets vary from values of 0.8 to 1.3, depending on the engine model.

Let's take a specific case for example. Let's say that we have zero wind conditions where the ground speed and true airspeed are the same. The equation for specific range is:

$$S.R. = \frac{V_g}{F.F.} \qquad \text{(Equation 2)}$$

Where S.R. = Specific range in nautical miles per pound of fuel.

V_g = Ground speed in knots (same as true airspeed under no wind conditions.)

F.F. = Fuel flow in pounds per hour.

The SFC of a given engine may vary slightly with RPM and airspeed, but let's ignore this variation and assume that it's going to be constant for the sake of simplicity. And to make it more simple, let's use an SFC of 1.0 for this f'rinstance. A specific fuel consumption of 1.0 means simply that the fuel flow is 6000 pounds per hour when the engine is delivering 6000 pounds of thrust. Or, the fuel flow is 2000 pounds per hour when the thrust is 2000 pounds, and so on.

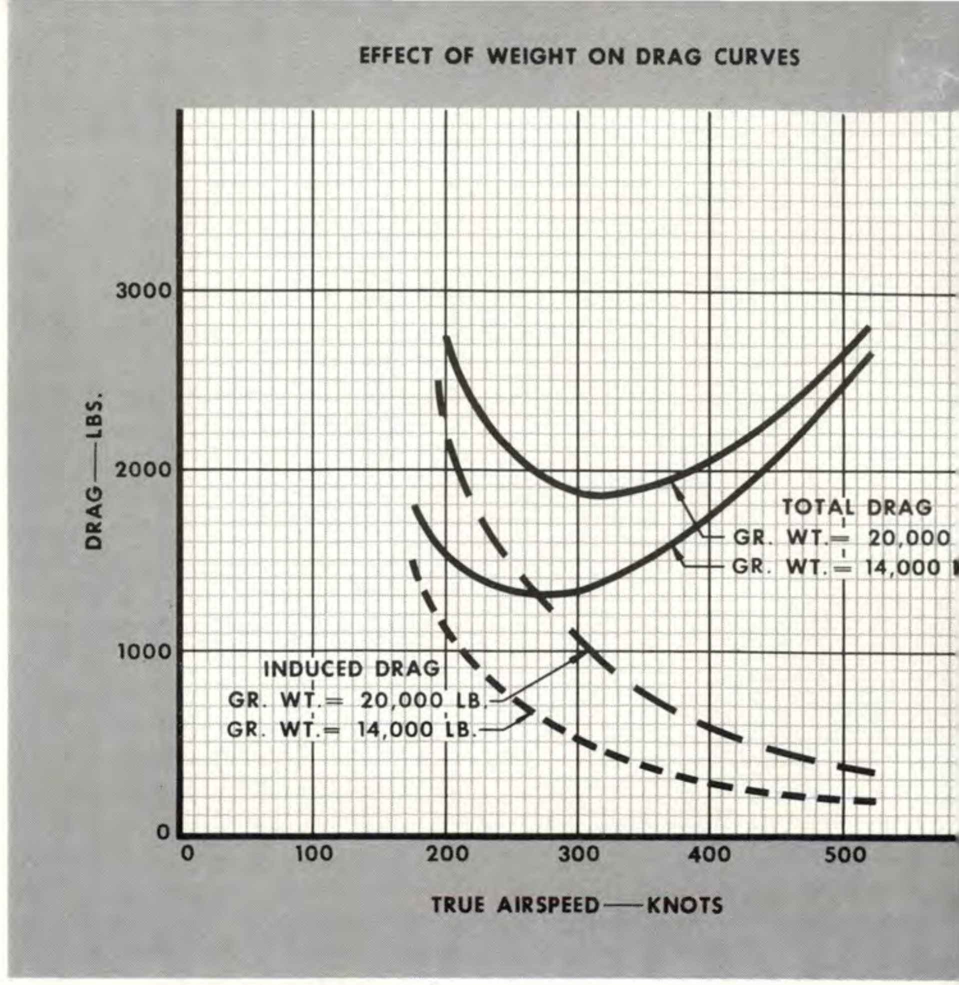
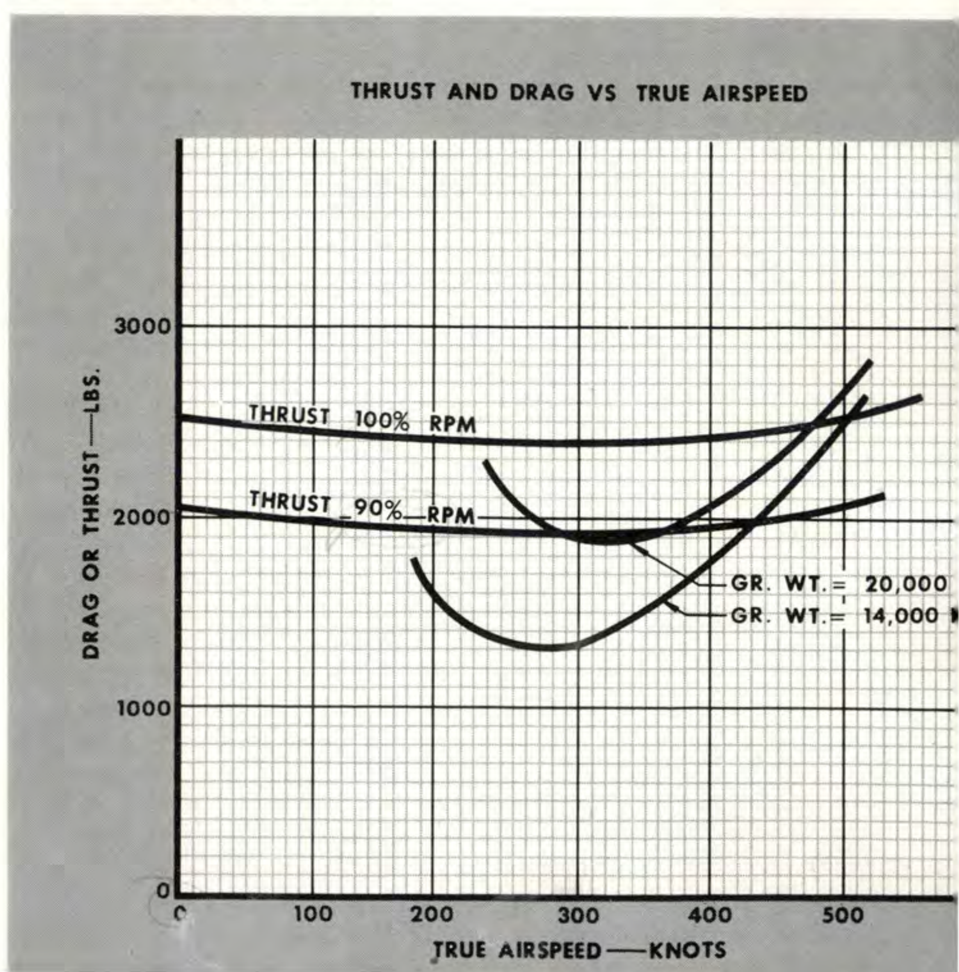


FIGURE THREE

FIGURE FOUR



THRUST DRAG

In straight and level flight at a constant speed, the thrust is equal to the drag. Therefore, if you know the drag characteristics of an airplane and the specific fuel consumption, you can determine the specific range at all airspeeds, gross weights and altitudes. Using specific range you can determine your optimum cruise speed and your best altitude for cruising.

Now that we've looked at these factors separately, let's put them all together. First, let's see what happens to optimum cruise performance at a given altitude, using the same two gross weights we had before and no wind conditions. We will use the same drag curves we were talking about earlier and assume the SFC is still equal to 1.0. Check me on the chart as we go. Figure 4 will work.

At the gross weight of 14,000 pounds the drag at a true airspeed of 320 knots is 1390 pounds. When we move up to a true airspeed of 460 knots, the drag is 2152 pounds. Right? Now, in order to fly at these speeds, the thrust must be equal to the drag. So to fly at 460 knots, you've got to pull 2152 pounds of thrust. Right?

Since the SFC is 1.0, the fuel flow figures to be 1390 pounds per hour and 2152 pounds per hour, respectively. Remember Equation 2? Let's put in our figures and crank. Now, if simple arithmetic doesn't throw us, the specific range can be easily calculated. And you have some usable data.

For $V_t = 320$ kts:

$$S.R. = \frac{320}{1390} = 0.230 \text{N.M./lb}$$

For $V_t = 460$ kts:

$$S.R. = \frac{460}{2152} = 0.2136 \text{N.M./lb}$$

When these specific range figures are plotted on a graph of specific range versus true airspeed along with additional points for other airspeeds, a curve may be drawn. This curve is shown on Figure 5. Look at it for a second and you will see that the peak of the curve represents the speed for optimum cruise. And, you can read off the value of the maximum specific range directly from the curve.

Best Cruise

What does all this mean to Joe Glotz, Pilot? Just that he has to know the specific range value to determine the quantity of fuel he's going to consume in flying a given distance. So it is necessary for flight planning. In order to simplify flight planning, the best cruise calibrated airspeed which will give the best cruise true airspeed is presented in Appendix I of the Flight Handbook —the Dash One.

Now do these curves look familiar? They should. They're the same types that you look at every time you plan a flight. And now you know why they look that way.

The specific range for the gross weight of 20,000 pounds is calculated in the same manner. A table showing the quantities used in the calculations are shown below.

V_t Kts	Drag	Fuel Flow	S.R.
280	1928 lb	1928 lb/hr	.1452 N.M./lb
320	1864 lb	1864 lb/hr	.1716 N.M./lb
360	1917 lb	1917 lb/hr	.1878 N.M./lb
400	2054 lb	2054 lb/hr	.1946 N.M./lb
460	2381 lb	2381 lb/hr	.1932 N.M./lb

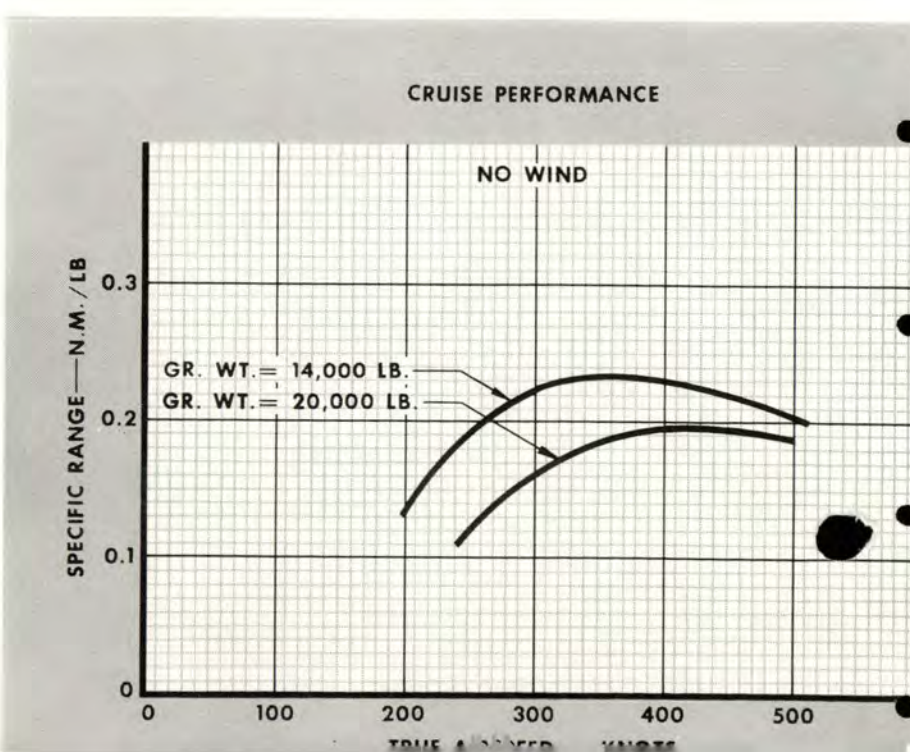
These values also are plotted on Figure 5, along with the curve for the gross weight of 14,000 pounds.

To compare these curves two important facts should be obvious.

First, the cruise performance for the light gross weight is far superior to the heavy weight cruise performance. Compare the optimum specific range to determine the effect of weight on cruise performance.

The second fact is that the true airspeed for optimum cruise decreases as the weight decreases. This means that you should fly a lower calibrated airspeed as fuel is consumed in order to remain at the best

FIGURE FIVE



uise conditions. But remember, we are comparing cruise performance at a constant altitude. We have not talked about the effects of altitude. Take another look at the curves of Figure 5. Notice that the curves are quite flat in the vicinity of the speeds for maximum specific range. What will happen if you cruise at a speed faster than the speed for maximum specific range? Your total range will be reduced but your average speed will be increased. So, the duration of the flight will be reduced. From Figure 5 you can see that your maximum specific range for 14,000 pounds is 0.233 nautical miles per pound of fuel. But you can achieve this specific range only if you fly at a true airspeed of 360 knots.

Now what will happen (in terms of airspeed) if you decrease the specific range? Look at Figure 6. The curve is a portion of the specific curve for the 14,000-pound airplane we were working with in Figure 5. Point A, on Figure 6, is the maximum specific range value. If you are willing to sacrifice one per cent of your range you can fly at a higher speed.

Just One Per Cent

The specific range only one per cent less than the maximum is .231 nautical miles per pound. The curve on Figure 6 gives this specific range value at point B. The speed for point B is 396 knots. Therefore, only a one per cent drop in specific range provides an increase of 36 knots in airspeed for this example. This higher speed (point B) is called the "recommended cruise speed" that you see listed in the Appendix to the Flight Handbook for your aircraft.

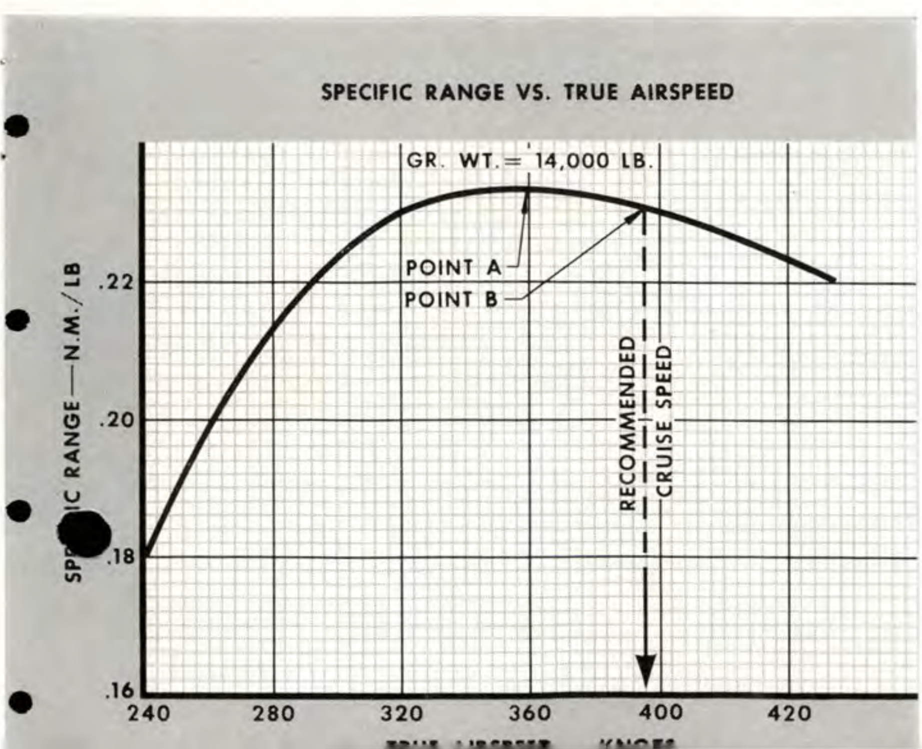
You will notice that the latest editions of the appendix contain the specific range curves for various altitudes and gross weights. The T-33 cruise data in the appendix to the Flight Handbook are a good example of these curves. The specific range is plotted against calibrated airspeed in the Dash One. The corresponding true airspeed scale for standard temperature condition is shown on the bottom of each cruise data page.

Looking at the T-33 cruise data, you'll notice that a change in the gross weight has much more effect on the cruise performance at high altitudes than at low altitudes. The recommended cruise speeds are slower for the lighter gross weights than for the heavier gross weights. The specific range curves in the Flight Handbooks also indicate the power settings and fuel flows for the various airspeeds.

The cruise curves are obtained from calculations based on the drag and engine characteristics determined from flight tests unless they are indicated as estimated data. The curves apply directly to zero wind and standard temperature conditions.

What happens when the wind goes up and temperatures are somewhat other than "standard"? That's for another day. These are the essentials; the very basis of it all. ▲

FIGURE SIX



ABOUT ABORTS

WHICH?

Captain Harry J. Tyndale
666th AC&W Sq, Mill Valley AF Sta. Calif.

There are "line speed checks" and "Line Speed Checks." The ones that really work are those which have been carefully worked out. The "working out" is next to impossible until you know what you are doing and how the whole thing comes about. FLYING SAFETY (August 1956) explained the mechanics of the "working out." In the following article we explain some of the "whys" behind the operation and tell the tale of how a real sharpie used them to his advantage. We highly recommend another look at the August 1956 issue. The charts illustrating that article are reprinted in this one.

CAPTAIN Johnson, the local Flying Safety Officer, was sipping his first beer at the Friday evening get-to-gether. He was casually aware of a deep discussion among a group of fighter pilots next to him. Suddenly one voice rose abruptly in pitch and, in firm tones, said: "Now look, Buster, I don't care how much calculating you do, you can't convince me that you can make a sound decision when you've hardly even begun to roll."

"Sir," a gentle but determined voice answered, "The facts involved in my decision are verified in the Dash One. Furthermore, an article published in FLYING SAFETY about a year ago specifically endorses the procedures which I used."

Nothing else needed to be said to clarify the discussion. Captain Johnson had already heard that a new man had ripped his knickers by aborting at the 4000-foot mark. The remarks made around the Group that afternoon had caught his ear. The squadron commander seemed to think that this might be an early case of fear of flying. It seems that the pilot wrote the bird up for insufficient thrust, although he also noted that the RPM and TPT were normal. Both maintenance and pilot personnel felt that he had not only goofed but signed a written confession. There were many of those sheepish smiles and shrugged shoulders in evidence during the afternoon.

Recalling how the computation of refusal speeds had befuddled him at USC's FSO course, Captain Johnson could not resist the urge to crash the conversation. As he moved in, he immediately recognized the victim as Lieutenant Lovitt, a mild-mannered, aeronautical graduate, with whom he'd had an interesting discussion about a recent takeoff catastrophe. "Hi, Phil," he said to Captain Wright, the Ops Officer. "I heard a little about this deal today and I'd like to buy in—for what my opinion's worth."

"Oh, very well," answered Captain Wright, "but let's go over to the table and sit down."

The large corner table was not quite big enough. Pilots were two deep in places. The Squadron Commander arrived during the shuffling of chairs and was accorded the courtesy of ringside.

Captain Johnson took the initiative and suggested that since Lieutenant Lovitt was the man with the facts, he start by telling what he had done and why.

"All right, sir," Lieut. Lovitt began, "this was a pre-briefed mission. I was up for the second ride in 625. Lieut. Thrall was the pilot for the first mission. The Commander specified the use of a 175 so I went down to base ops to plan the flight. I got there early and had to delay the weather entry so that it would hold up through takeoff time. This gave me plenty of time to doodle so I cased the runway distance problem completely. The file of Flying Safety Magazines was handy so I reviewed the article "Runway Check Point," published in the August 1956 issue.

"The forecaster said that the current runway temperature was 93° F. I was told to expect a one-degree rise per hour, to a peak of 98 at 1500 hours. I selected 95 as my best probability. The charts indicated my ground roll to be about 7250 feet. I made a rough calculation for halfways speed (the speed I expected to have in the first half of my computed ground roll). I reduced this by 10 per cent for nerves and came up with a figure of 97 knots. When I hit the 4000-foot runway marker, I only had 98. The RPM and TPT had been right on the button so I chopped it."

Captain Johnson had been watching the expressions carefully. He concluded that he'd better keep control of the discussion. It was obvious that the boys weren't very impressed with the procedures. "Sounds like a pretty good decision to me," he said, to avoid an interruption. "Suppose we take a closer look at it to see if your actions were overly cautious." There was a slight rustling as the group settled into the chairs for what promised to be a typical Johnson analysis.

"You say that the chart called for 7250 feet ground roll. Then, you said that you calculated a halfway speed

for that roll. Would you explain that to us, please?

"Yes, sir," began Lieut. Lovitt, "Since the acceleration of a jet doesn't drop off rapidly until you get up to speeds above 100 knots, it is easy to figure the speed you should have at an early point in the roll."

"Whoa!", interrupted Captain Wright, "I've heard that the power of a jet goes up directly with the speed increase. That should certainly give a better rate of acceleration at higher speeds."

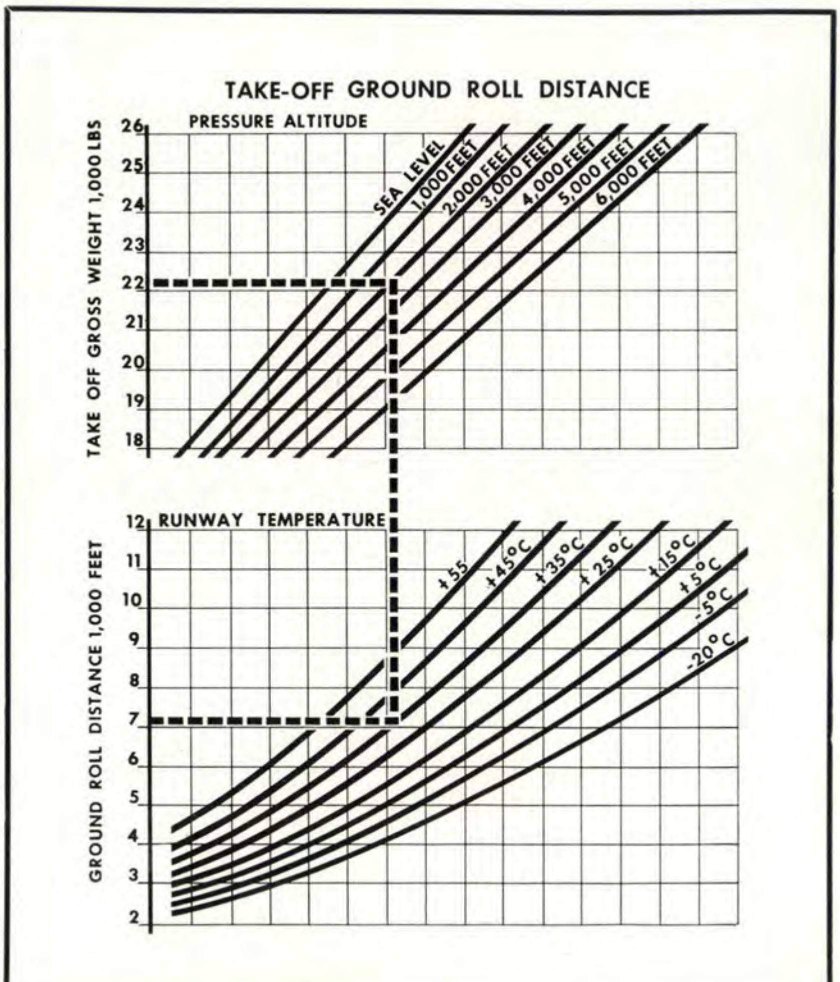
"That's good logic, sir, but it isn't so. You accelerate on thrust, *not* power. Power is a measurement of the work being done. The power does rise with speed but the term refers to the amount of work done in moving the aircraft to some speed in the particular length of time.

"The term 'horsepower' is applied to jets only as a comparison. Thrust is the force that pushes the bird, and thrust in a jet remains relatively constant regardless of speed. Essentially, a constant push, against a steady resistance, will yield a continuous increase in speed, up to the point where increased resistance creates a state of balance. In our business, the increased resistance comes in the form of drag.

"The actual rate of acceleration is governed by the thrust/weight ratio. The presence of drag must be considered, of course. For this reason it is convenient to formulate rules of thumb in the region of operation where drag is relatively low. "For purposes of discussion, let's assume that our aircraft has an average early rate of acceleration of 4.8 ft./sec /sec. This comes to just under three knots per second. It would take about 55 seconds to reach 264 ft./sec., which is unstick speed of 158 knots for our theoretical aircraft. To understand the reason for selecting the halfway mark of your computed takeoff roll for decision, you must visualize the relationship of runway used, versus speed gained.

"In the first second after brake release, you go from zero to 4.8 ft./sec. Your average speed for the first second is 2.4 so you used 2.4 feet of runway to gain your first three knots.

"Now look, Buster, you can't convince me."



Now, look at the top end. If you had constant acceleration, after 50 seconds you enter the 51st second with a speed of 144 knots which is 240 ft./sec. The average speed during this 51st second will be 242.4 ft./sec. So you will use 242.4 feet of concrete to gain the same amount of speed that you get for only 2½ feet in the first second. It is this relationship which explains the fact that you get 70 per cent of the speed in 50 per cent of the run. Actually, the acceleration decreases as the speed goes up so the difference of runway used per knot of speed increase would be even greater.

"If you consider the fact that stopping distance is affected in exactly the same way (70 per cent of the deceleration takes place in the last half), you can see that each second of indecision can cost 400 to 500 feet of runway. At the high end, each second means 240 feet used to gain three knots and 200 or more required to get rid of it if you decide to abort. These are the reasons why I choose to use the halfway mark as my checkpoint."

Since this sounded like termination, Captain Wright posed a question.

"This sounds sensible for us, but what's wrong with using the published distance on other types of aircraft?"

"Two things, Captain Wright. First of all, few bases have enough runway to allow for a rise to takeoff speed, a decision and retard and a safe stop. Furthermore, an abort is seldom associated with a bird that is performing up to snuff. Unsatisfactory acceleration is often the trouble and that is the very thing that uses too much runway for too little speed."

"That's why we emphasize distance instead of speed," offered Captain Wright.

"Yes, sir," answered Lieut. Lovitt, "and in principle, that's good. The only trouble with that theory is that the published distance assumes test pilot technique." (Lieut. Lovitt noticed the raised eyebrows, so he continued.) "I said before that the drag increases slowly in the early stages of roll. When you raise the nosewheel, the aerodynamic drag which accompanies high angle of attack enters the picture.

"This is the item that separates the men from the boys. Many are the men whose status was reduced by an embarrassing stop on the rocky overrun.

"My point is: Since technique is a factor here, and it varies widely, why not plan it right out of the picture? The speed for nosewheel liftoff is usually above 70 per cent of unstick speed. Therefore, the human element doesn't enter the picture during the first half of the roll.

"At this speed there is always enough runway to allow for a delayed decision and a safe stop. Even with a minor airplane or pilot malfunction, why throw all this gravy away just to confirm that your thrust is low?"

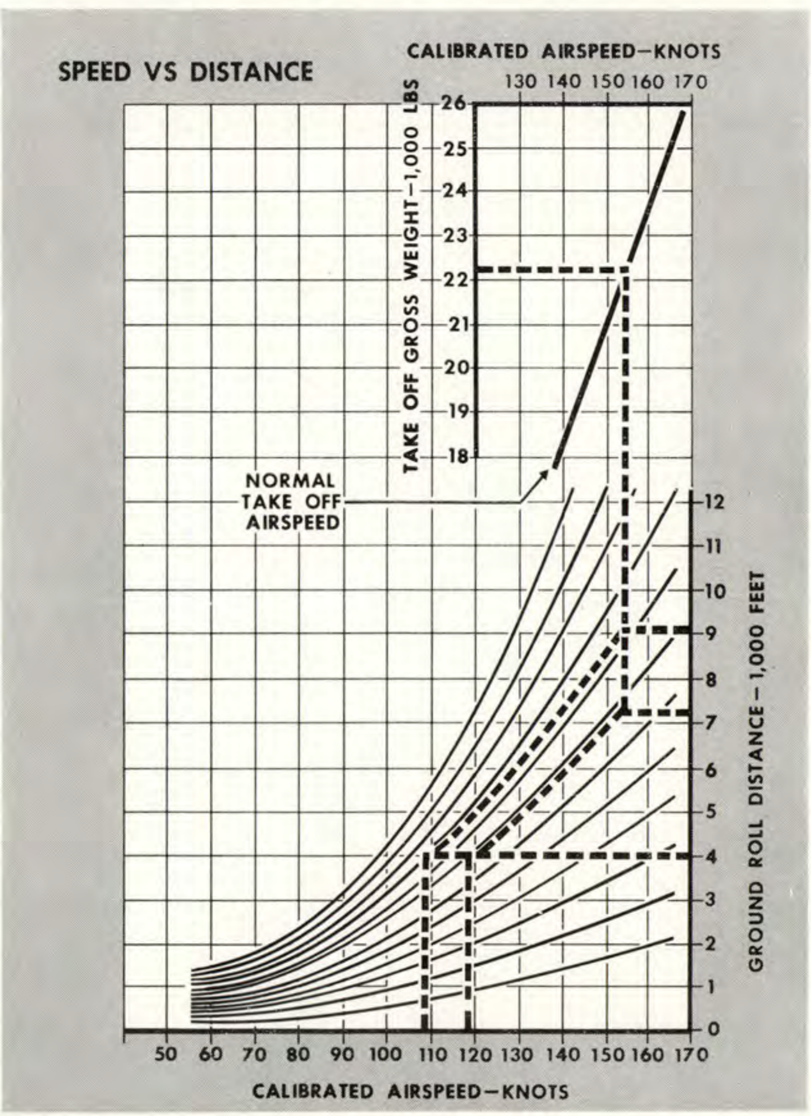
Captain Johnson grasped this opening. "You said that you drew your abort line at 10 per cent under calculated speed. Would you explain that, please?"

"Yes, sir, I will. A 10 per cent discrepancy at ⅔ of speed at least a 15 per cent shortage later. In any airplane it would take 30 per cent more runway to get 15 per cent more speed. The amount of shortage you can accept is governed by the amount of extra runway you have available. In my case today, 30 per cent of 7250 is 2175, for a total requirement of 9425 feet. And, this is the most optimistic picture!

"Frankly, I don't intend to prove anything of this nature in an airplane. When the facts of Physics cast doubt upon a situation, I choose to confirm my decisions in the hangar. I don't intend to debate my case with the members of the accident investigating board."

The utter silence did not surprise Captain Johnson. He thought it very appropriate that the commander broke the silence.

"That airplane will get a full checkup in the morning, Lieut. Lovitt. Meanwhile, the next round is mine." ▲



What's Your Trouble?

HOW WOULD YOU turn an emergency or even a minor malfunction of equipment into an aircraft accident?

It's easy. All you have to do is incorrectly diagnose the trouble; fail to follow the Dash One procedures or make one wrong decision and you have the stage all set.

Perhaps you would like to have some examples. Here are a few from the records on file.

An F-86F pilot experienced partial power failure while returning from a local mission. The RPM dropped to 22 per cent and the tailpipe temperature decreased to 250 degrees. He decided that he had flamed out so he stop-cocked the throttle. When he attempted an airstart, he could still get only 22 per cent rpm and 250 degrees egt. Since he was very close to the air base at the high key altitude, he stop-cocked the throttle again and made a flameout landing without further incident.

What was his trouble? The main fuel regulator had malfunctioned and regardless of throttle movement, 22 per cent rpm was all that the engine would produce on the amount of fuel it received from the regulator. The emergency fuel system functioned perfectly on the post-flight check, but the pilot had made no effort to use it during the so-called emergency. The pilot should have known that he did *not* have a flameout because he had tailpipe temperature. Possibly he was influenced by being over a 10,000-foot runway, but regardless of how proficient you are, shooting a landing while flamed out is doing it the hard way. If this pilot had switched to the emergency fuel system, he would have had normal power.

Three T-33 accidents occurred within the same week when flameouts were caused by fuel regulator troubles. In each case, several automatic airstarts were attempted, without success. None of the pilots tried a manual airstart. Subsequent investigation revealed that the emergency fuel systems operated satisfactorily and manual airstarts probably could have been accomplished. In two of the three instances, a faulty Cook pressure switch failed to alert the emergency fuel system when the take-off-and-land switch was turned on. It was believed that a malfunctioning auto-start fuel sequence switch accounted for the third T-Bird's failure to airstart on the automatic system. Three airplanes were lost from poor troubleshooting.

At a southern air base, many false fire warning lights were experienced after three consecutive days of rain. It was well known that moisture was shorting the fire warning system and pilots were briefed on this item; however, one pilot didn't get the word and on his next flight the red light came on. This boy didn't use all the recommended methods for determining if he really did have a fire. He merely retarded the throttle to idle and when the light didn't go out, he ejected. Inspection of the engine, accessories and tailpipe failed to show evidence of an inflight fire.

A B-57 pilot on a night navigation mission noticed that the fuel flow indicator needle on one engine was fluctuating slightly. He assumed that something was wrong with the main fuel system and decided to go to the emergency system. Carefully throttling back to a lower RPM, he unintentionally flipped the emergency fuel switch on the opposite engine which was operating at high RPM. Needless to say, sheets of flame shot from the engine. It oversped, the tailpipe temperature hit the peg and things in general were not good. The pilot then actuated the wrong fuel shut-off valve and—finding himself with no engines operating—ejected!

After many days of investigation, the Board determined that the small amount of fluctuation in the fuel flow meter was not abnormal for the B-57 and that the pilot had brought his troubles on himself.

The files show far too many poor decisions which have resulted in mishaps by pilots who failed to analyze their difficulties correctly. Mistaking condensation from the pressurization vents for smoke has led more than one pilot to jettison his canopy, dump the cabin pressure or even abort the mission (sometimes upping the gear) when he actually believed he had a cockpit fire.

Of course, the records also contain many reports of commendable feats of airmanship performed by pilots who diagnosed their problems correctly.

Taking off under IFR conditions on a cross-country flight, one pilot was unable to contact any ground station. He could receive all right but couldn't transmit. He finally determined that he had a broken wire in his oxygen mask microphone. Using the tone button on the channel selector box, he transmitted an SOS in the blind. CAA ground stations picked it up, alerted their net and also Flight Service, and the fighter was worked all the way to its destination with advisories.

Obviously, there are times when a pilot will not have time to sit and think about what is happening to him. There are occasions when he must get out of the airplane in great haste, such as in structural failures, fires and explosions, mid-air collisions and the like. However, when time permits, every pilot must know his equipment to such an extent that he can properly determine *what* is happening, *why* it is happening and what he can do about it.

Every known procedure must be used to isolate failures or determine conditions prior to making the decision to get out or crash land. Not only will you save an aircraft, you may also save your life. ▲

Here is an Engineer's approach to an inflight problem. The key, as always, is a thorough understanding thereof. The Dash-One for your bird will give the procedure. You apply the basic knowledge. Without a complete mixing of the two, you may only furnish—

...Fuel for Fire

Lt. Col. John A. Robertson
Engr. Br., Research & Analysis Div., DFSR

FIRE FROM THE burning B-25 still lighted the runway where the aircraft had burst into flames on an emergency landing. Major Hardy, the pilot who had brought it in, watched firemen busily bringing the fire under control from a point where he and his companion, Lieutenant Corwin, had run after hastily leaving the plane. He turned to the Lieutenant and exclaimed: "Boy, are we lucky that engine fire waited 'til we landed instead of happening in the air!"

"You are so right," Lt. Corwin gratefully agreed. After a slight pause he added, "You know, I used to have a commander who always said that accidents don't just happen. He said they are caused."

"Well, then I guess in his book, I'd be court-martialed for arson," Major Hardy shot back, "but there's a burning B-25 that I don't remember putting a torch to. . . ."

Even as he answered, Major Hardy's mind was weighing the possibility that this fire hadn't "just happened." His words faltered momentarily and then he continued, "Now that you bring up that angle, I remember reading a fire-prevention procedure that's trying to come through to me. I think it's in the Dash One Handbook. Let's go on over to base ops, get some coffee, and hash this operation out from shortly after takeoff when you mentioned a strong smell of fuel. We'll see if we "caused" this accident or if it just happened.

They settled themselves at a table and Lt. Corwin began, "Right after takeoff I smelled the stuff and we immediately spotted fuel running out of the right nacelle. We had normal fuel pressure and the engines were running okay at climb power. Then you called the field and declared an emergency."

"Yeah, then on the final approach," Major Hardy interrupted to carry on the story, "I pulled the throttle back just as we touched down, and Blooey! The whole right wing was covered with fire. I cut the master switch and—wait a minute! That thing let go when I pulled the throttle back."

Major Hardy paused and repeated, "When I pulled the throttle back." He seemed appalled at the dawning realization that he had caused an accident. He continued woefully, "I might as well have put a torch to the thing."

Answering the puzzled look on Lt. Corwin's face, he explained, "I set fire to the leaking fuel with the exhaust flame when I reduced the propeller slip stream velocity . . . and to think I don't let my son play with matches."

"I'm not receiving you. You're coming in garbled," Lt. Corwin broke in on the monologue. "What's all this 'slipstream velocity' business? And just what did you have to do with that? As far as I can see, you recognized an engine fire hazard, called the tower, declared an emergency and brought 'er right back in. So the engine starts to burn on landing. We got out alive. What else do you want?"

Major Hardy took an envelope out of his pocket and started pencil-sketching the story on the back of it. He drew a nacelle, prop and exhaust. Pointing to the nacelle, he said: "We begin here," and printed out FUEL LEAK in the area of the carburetor.

Major Hardy continued, "Now when this leaking fuel becomes vaporized and mixed with air, it is combustible. Check?"

"Check. So why doesn't the fire start immediately?" Lt. Corwin wanted to know. "The exhaust flames are there, ready and able to set it off, aren't they?

"Right you are. BUT."

"Yes, BUT?"

"It's like this," Major Hardy explained. "While we are carrying power on the engine, the slipstream velocity carrying the leaking fuel vapors back past the exhaust stack outlet is faster than the free airstream flame front propagation speed."

"Say it again and this time make it simple," Lt. Corwin urged.

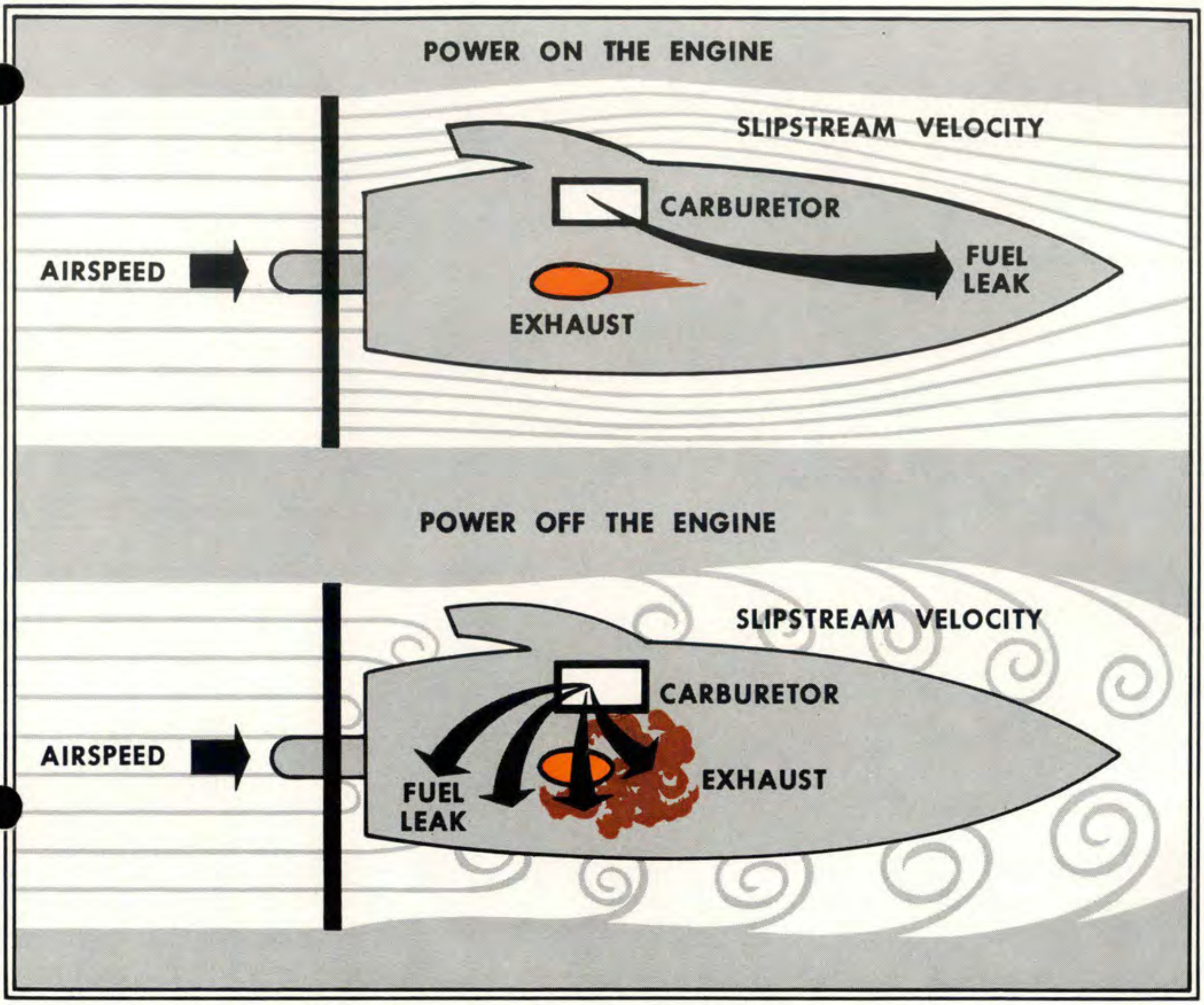
Major Hardy smiled and said, "Okay. Let's make a comparison: If a fish capable of swimming 30 miles an hour is trying to go upstream against a current that is coming down at 100 mph, the fish isn't going anywhere—but backwards. Right? So back to the plane. The flame front propagation velocity is the fish that can't move forward and the slipstream velocity is the water current that is holding it back. The fish can't travel against those odds, and the flame front can't either. Are you still with me?"

"So far," Lt. Corwin nodded. "Proceed."

"If I put that same 30 mph fish in water which is coming downstream at 10 mph, there isn't anything to keep him from heading upstream for home. Similarly, if I reduce power I slow down the slipstream enough to let the then faster flame front (like that fish) head for home." Major Hardy put the finishing touches to his sketch of the problem and concluded: "You see, I could have prevented this major accident and avoided being an arsonist."

"Now, let's not get hasty with incriminating names," Lt. Corwin remonstrated. "I understand why we got the fire when you pulled the throttle but we had to land. I don't understand how you think you could have avoided that. Just how do you figure you could have stopped this bonfire?"

"Simplest thing is the world," the Major assured him. "First, I should have LEFT THAT THROTTLE ALONE and carried cruise power all



the way down the final approach until we touched down, and then cut the engine off by moving the mixture control to idle cutoff."

"I get it," Lt. Corwin's eyes brightened as he completed his own explanation. "You eliminate the exhaust flame, then it doesn't matter whether the slipstream velocity is fast or slow. There is nothing there to set fire to the combustible vapors."

He got about half way out of his chair, assuming that the discussion was closed, when another thought crossed his mind. He sat down and asked: "Just suppose, Major, that we are already at considerable altitude, cruising along, fat, dumb and happy, and the same fuel line breaks. What then?"

Major Hardy responded, "I wondered when that possibility would occur to you. Although you might say it's a horse of another color, it's still a horse. It's a "horse" whether it's a B-25 or any other propeller-driven airplane. This same fuel leak situation can arise on takeoff, landing or—as you have brought up—cruising. The cruising "horse" merely requires slightly different reining procedures."

"Such as?" Lt. Corwin prompted.

"We begin the same way, but not doing something. Would you care to hazard a guess as to what we do not do?"

"Yes, sir!" We DO NOT TOUCH THE THROTTLE. Then what?"

"Then we move the mixture control to idle cutoff."

"I'm right with you," the Lieutenant joined in. "Then we feather?"

"Roger," Major Hardy concluded. "Same problem; same solution."

"You know, sir, it strikes me that any time a malfunction—fuel leak, oil leak or otherwise—requires cutting an engine in flight, the same preventive measures would apply."

"Again, Lieut. Corwin," Major Hardy agreed, "Same problem; same solution."

Major Hardy glanced across the room at another officer approaching them and invited Lt. Corwin. "Here comes the Accident Investigator. And this is one instance where your old commander was right. This accident didn't—"just happen." ▲

CROSS FEED

LETTERS TO THE EDITOR

NCOs in ATC

I have worked in the control tower, Military Flight Service and Base Ops for the past eight years so I found your article "Flying Safety on the Airways" most comprehensive. The information presented therein is informative to enlisted personnel in the air traffic control field as well as to those who do the flying. Articles of this nature should be more frequent since they give an insight into the magnitude of the daily problems confronting the behind-the-scenes personnel; the day-to-day, 'round-the-clock guardians of the airways. Thanks for an indirect pat on the back to those people.

T/Sgt Darwin A. Whitehead
AF Tech. Adv. Mass. ANG

Sarge, it's nice of you to write us. Tentative plans are in the mill to reprint the article under separate cover to meet the great demand from our readers.

■ ■ ■

Wives Help

The 3d Air Transportation Squadron has come up with a novel innovation of the fly-safe program. The Flying Safety Officer has written a letter to the wives of crewmembers about the contributions made by them to their husbands' efficiency. He wrote them about the importance of proper diet, rest and recreation necessary for a healthy physical and mental outlook, thus making those husbands fit to perform the duties and responsibilities demanded.

Then he discussed the need for an effective flying safety program and placed particular emphasis on crewmembers' attendance at weekly flying safety meetings.

Regarding those meetings, part of his letter is quoted:

". . . . Strange as it may seem, we seldom have the opportunity to learn of the hair-raising stories which you probably hear about your husband's last flight. During his next discourse of 'parlor flying,' why don't you remind him to relate his tale during the flying safety meeting so that other airmen can benefit from his experience? By working it this way we can analyze errors, while he can help us prevent making the same ones again."

And with his thanks, he signed it

Your Safety Officer."

Quite often their help goes unnoticed, but really the Gals do a lot toward helping you to be an efficient crewmember.

■ ■ ■

Another Bailout Trainer

Your December issue contains an interesting picture of a bailout trainer and an interesting letter by Captain James McMullen.

We, of this unit, thought some of your T-33 bases would be interested in our trainer which was specially built by Canadair, Ltd., Montreal, Quebec, Canada (A Division of CONVAIR). The trainer is operated by compressed air and controlled by electrical solenoids, which operate the canopy and seat jettisoning systems.

All aircrew personnel on this station are checked out monthly for ejection procedure and timing. We believe it is an extremely beneficial training aid. Inclosed is a photograph.

Sgt. W. Neil and Cpl. D. Christensen
#7 Field Technical Training Unit
RCAF Station Gimli, Manitoba, Can.

■ ■ ■

Yipe

I write concerning an error which was made in the article you printed in the April issue. On page 22, in the fourth paragraph from the end of the article, "Speed Signs," I had originally written:

"Besides the gradual seasonal shi southward in Summer and northwar in Winter of the main position of the jet. . . ."

And this is incorrect. I am afraid that my mind played tricks on me and caused a transposition of two words, namely, southward and northward. To read properly, the paragraph should be as follows:

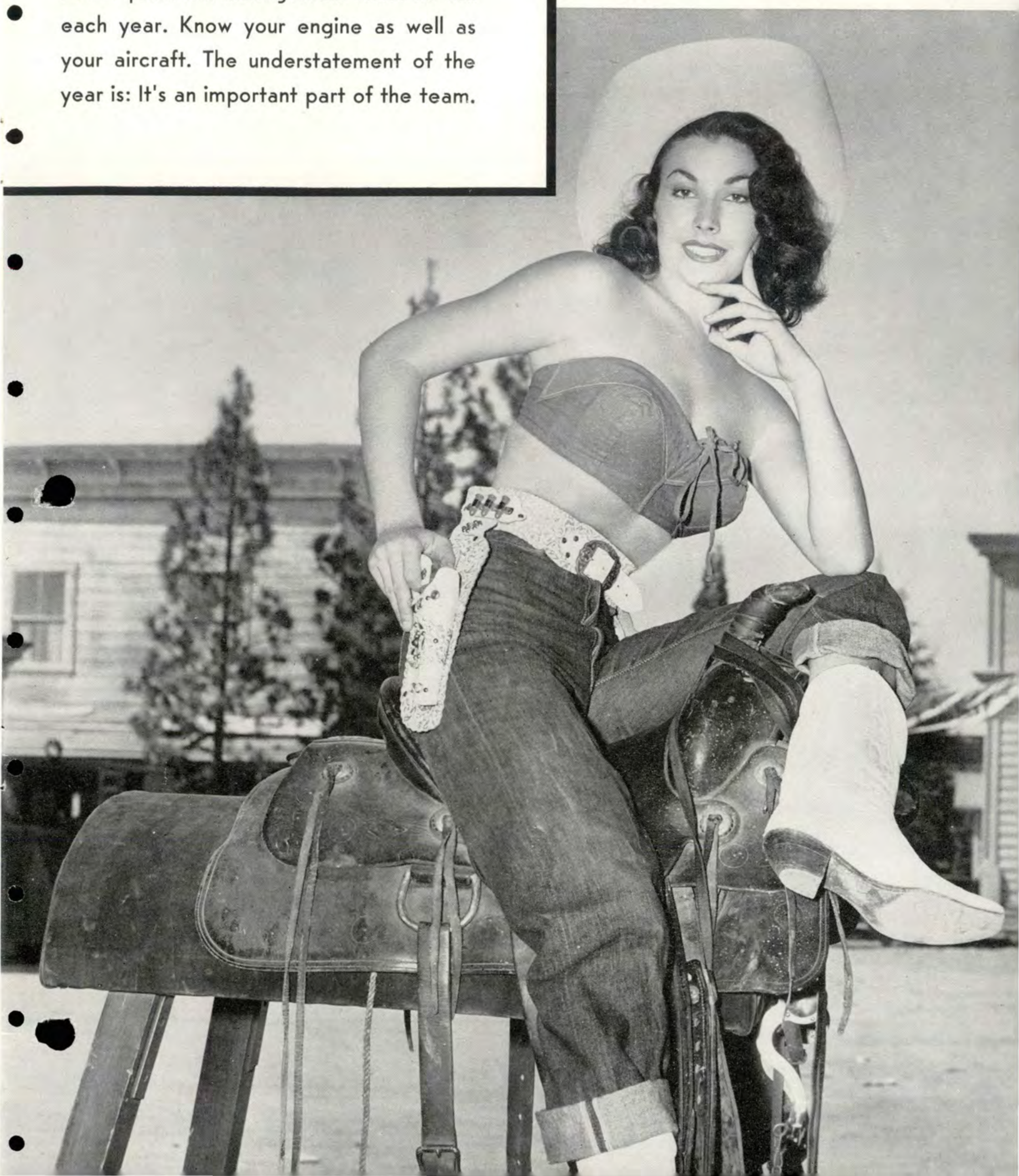
"Besides the gradual seasonal shift northward in summer and southward in winter of the main position of the jet."

A printed correction in a subsequent issue will be the only thing that will save me. Already I have been blasted with comments. I guess by now you also must have heard about it. It is so natural to think in terms of southward when summer is mentioned and likewise, northward when winter is mentioned. Sorry to have slipped this one in on you.

Capt. Robert A. McCauley
509th F-B Sq, Langley AFB

Thanks for the correction, but no need to apologize to us. We should have caught this obvious oversight before going to press. Let's both apol gize to our readers and try to forg the whole thing.

No Horsepower—And that is the theme of this month's Flying Safety Magazine. Power plant mis-management takes its toll each year. Know your engine as well as your aircraft. The understatement of the year is: It's an important part of the team.



Pitch on Props ... page 8