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Aerospace SAFETY

THE MAGAZINE DEVOTED TO YOUR INTERESTS IN FLIGHT

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August 1968 — AFRP 62-1 — Volume 24 — Number 8

SPECIAL FEATURES

LOST IN SPACE — *round table discussion of an oldie* 1

A GOOD CREW — *coordinates and performs expertly* 6

GROUND EFFECT — *earthy type phenomenon* 8

CORROSION UNMASKED — *it comes in many forms* 10

ANYBODY FOR FOOTBALL? — *beware the built-in hazards* 16

LIFE SAVERS — *kudos to the Civil Air Patrol* 18

T-STORMS — *avoid 'em* 20

STABILITY AND CONTROL — *man-made nerves and muscles* 22

REGULAR FEATURES

THE IPIS APPROACH 13 • X-C NOTES FROM REX RILEY 14 • MISSILANEA 21 • AEROBITS 26 • MAIL CALL 28 • WELL DONE 29

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PREFLIGHT

Spatial disorientation continues to be a problem to pilots; therefore, it will also continue to be a subject in safety magazines. When some figures we saw indicated that such an article was due, we set about trying to get a different approach.

We finally settled on a round table discussion with pilot, medical and editorial participants. And we taped the proceedings. It's amazing how much a half a dozen people can say in a couple of hours, especially if they're extremely interested in the subject.

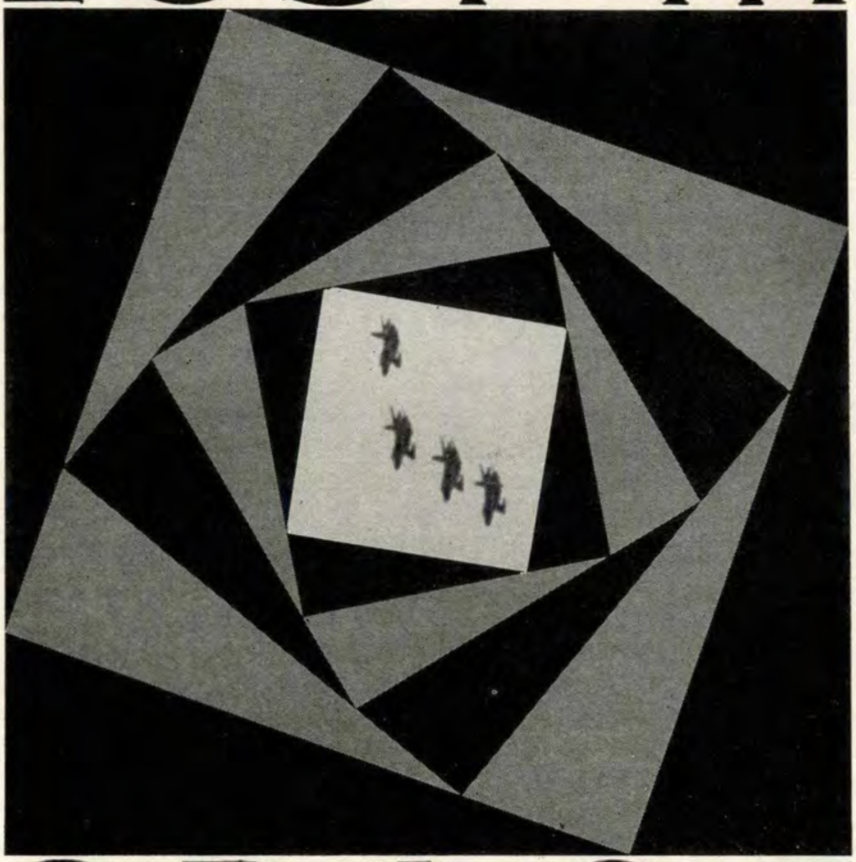
After editing, the item is still too long for one issue, so we plan to present it in two or, possibly, three parts. We think you'll find it interesting. It's called *Lost In Space*, and begins on page 1.

Stability and Control, page 22, is a semi-technical discussion of a typical stability augmentation system. Read it and you'll have a fairly good understanding of how such a system works. Many aircraft now contain this system, and it won't be many years until all our aircraft will be so equipped.

Incidentally, last month's magazine had an error in the chart on page 4, referring to vortex decay rate. The figures across the bottom (Time, minutes) should have been 1.0, 2.0, 3.0, 4.0 and 5.0.

Major Kyron V. Hall is the subject of this month's cover photo. He is known as 'Mr. Helicopter" since he's the first Air Force pilot to fly over 6,200 hours in helicopters. The photo was taken at Udorn Royal Thai Air Force Base.

LOST IN SPACE



SPATIAL disorientation is a frequent contributor to aircraft accidents. How frequent we don't really know because the pilots don't always survive. For an article on this subject, AEROSPACE SAFETY decided to try a little different approach, so we invited some medics and pilots to a round table discussion. Members of the group were Colonel Thomas A. Collins, Chief of the Life Sciences Group, Directorate of Aerospace Safety, Majors Victor Ferrari and Charles Sawyer, all flight surgeons; Dr Anchard Zeller, psychologist in the Life Sciences Group; Major Robert Bond, a fighter pilot and project officer; Lt Colonel Henry W. Compton, editor and long-time transport pilot, and Bob Harrison, managing editor.

We taped the two hour session, then edited it somewhat to come up with the version printed here. We had too much material for one issue, so we are presenting it in two or three installments.

We hope some of the ideas expressed stimulate thinking as to approaches to the problem of disorientation. And we would like to hear from readers. Just drop a note to the magazine.

Dr Collins First, what is the scope of the problem? I have a sheet here which indicates there were some two dozen accidents involving spatial disorientation and vertigo, or rather where these were possible factors, last year alone. And this year, including day before yesterday, there were numerous messages that I read, particularly relating to formation accidents, where the pilots got into adverse attitudes too close to the ground, and they couldn't recover. The problem is very real in view of the fact that losses due to disorientation are continuing.

. . . because of the heavy overcast at night, the scattered pinpoint lights below

Mr Harrison Vic, I saw an item I think you wrote on this subject, briefing several of these accidents. Was there any common pattern to these things or were there several differences?

Dr Ferrari This was based on a questionnaire that Col Collins worked up and distributed to all of our well qualified pilots in the Directorate. We took a very close look at it. Our numbers are too small for us to have any comfort in statistical significance, but you can recognize definite patterns. You can categorize these in two main groups—low and high performance aircraft. The latter have a distinct problem in their operational requirements. Those pilots are much more subject to disorientation, not only because of their operational requirements but because of the performance capabilities of the aircraft. These make the people much more subject to disorientation, especially dangerous disorientation. You can contrast this with the cargo-transport type of aircraft which have more inherent stability, a more stable autopilot, this type thing; their performance is such that you avoid many of the parameters that induce pilot vertigo or spatial disorientation. I believe that you can prophesy definite hazards associated with these two basic types of aircraft. We are going to follow up on this study as we get new pilot populations to sample. We hope to come up with something a little more statistically significant.

Dr Collins In a review that I made, just kind of a cursory review, we found it is very difficult to get a feel for the magnitude of this problem. You go through the records and you find a considerable number of accidents in which the cause was undetermined and the Board put down spatial disorientation as a possible cause. But when you get into the *probable* cause factor, the number goes way down. The number of definities or probables in that study I made was only 14 per cent of the cause-undetermined accidents; in other words, 14 per cent of them had a probable or definite spatial disorientation cause factor, even though the final cause remained undetermined. So we don't know; we do know, of course, that the percentage of cause-undetermined accidents each year runs between 10 and 14 per cent, and that is a sizable number of losses. It is an area that we talk a great deal about but one in which we haven't made many inroads because we have not seen a steady reduction. I am personally convinced that spatial disorientation remains not necessarily the biggest of these factors that we lump together there as probables or possibles, but certainly a major one.

Dr Sawyer A good point here, in our cause-undetermined accidents, is that we have a high pilot fatality rate. This is true in spatial disorientation accidents. The pilot doesn't often know what happened, in contrast to the fire/explosion type where the pilot leaves a disabled aircraft. He usually has a very detailed idea of the sequence of escape, but in spatial disorientation, in these cases where the pilot does come back, he often is very foggy about what actually happened. He doesn't know the specific details; he just lost the bird, bailed out, and the next thing he remembers he was on the ground.

Dr Collins I think in our study here there was only one, or maybe two, that transmitted over the radio.

Dr Ferrari There was one, and another who alerted his copilot. This was a guy in the B-52 who alerted his copilot that he was having severe vertigo. But there were only these two incidents; the rest of the time they kept their mouths shut.

Col Compton Does mental befuddlement and the inability to concentrate automatically go along with disorientation?

Dr Ferrari We could philosophize about this for a long time. From my personal experience with vertigo and from talking with a lot of people, I think the psychological impact of a severe disorientation episode can completely disable a person and impair his judgment. It seems to me, and I might be reading something into it because I've had this idea for years, that people who frequently experience a disorientation have little or no trouble, or it is not as severe. They are used to it, they anticipate it. But the man who has flown for years and is very, very proficient knows, if he flys at a certain amount of power and establishes an attitude and lets things *him became his sky reference . . . he fought it but he almost made a decision to eject.*

stabilize, he can predict his performance within one per cent. He has flown this way, so mentally he builds up his crosscheck. As he does his crosscheck he expects to see a certain performance and over the years it is always there. You expose this man to a situation where he is relying on this built-up confidence and suddenly he looks over and things have gone to pot. This has never happened to him. I think many times these are the people who really become disabled. You can see evidence of the severe psychological trauma or stress these people are exposed to. We had one man who entered clouds in a 30-degree bank, rolled level, and had some very severe disorientation. He then broke out under a high ceiling, at night, over very sparsely populated land. It was pretty clear but he had a lot of lights under him. He had the illusion (this is not the vertigo where you feel things) that he was getting false sensations from his visual perception, that he was inverted. Because of the heavy overcast at night, the scattered pinpoint lights below him became a sky reference. The heavy overcast above him became his ground reference. He had the illusion that he was upside down. It upset him badly; he fought it but he almost made a decision to eject. About that time he passed over something he recognized in the lights and immediately he was O.K.

Dr Collins In any discussion of disorientation we use the terms vertigo and disorientation interchangeably and I think this is probably all right. But I think, for the record, that we ought to indicate that they can be used interchangeably for pilots' vertigo and spatial disorientation. The medical term vertigo is a little different, in that it means symptoms such a dizziness, nausea, etc., as a result of a medical condition affecting the inner ear. But when we speak of spatial disorientation/pilots' vertigo we are talking about loss of knowledge of relationship to the surface of the earth.

Major Bond This story that Dr Ferrari was recounting is really very interesting because I went through something almost identical to that several years ago when landing through an overcast down at England AFB, La. As I went through the clouds, I had the sensation of doing rolls. I was flying the wing and when we broke out at the bottom we were about 1000 feet on GCA final. I saw scattered lights off the end of the runway, but I had mentally prepared for being over open swampy terrain with no lights and I very strongly, frighteningly, thought I was inverted. It took me a second or two to realize that I wasn't hanging in the straps. I think that was the thing I made myself do.

Dr Collins Dr Zeller, do you have any feeling that these disorientation events occur more commonly among relatively untrained pilots as opposed to experienced pilots?

Dr Zeller I think they appear more frequently among untrained pilots, definitely. This is like anything else, there is the learning phenomenon. It is possible that the well trained may be as affected but more able to cope. I am not sure.

Dr Collins I would agree that the experienced pilot knows how to handle the situation when he gets disoriented, but I'm not convinced myself that it is any less frequent among experienced pilots than among novices.

Col Compton I'd like to put a recent experience in this. Two weeks ago I was flying a transport mission. When I came out of a solid condition, there was an overcast and the bottom of the overcast off to the left was slanting about 30 degrees. It wasn't parallel with the ground and I had to go back to my horizon and check it with the needle and ball to get rid of the vertigo, because I had it. No two ways about it. It is not infrequent with experienced pilots, but I don't think it bothers them because, like you say, they know exactly what to do. That was not as wild as this thing where Major Bond thought he was upside down.

Major Bond I might mention that I demonstrate vertigo to myself often when I am flying instruments, especially if I am busy in the cockpit with someone flying off my airplane and I'm turning around watching the other airplanes. I get vertigo all the time.

Col Compton I get it but I know how to get rid of it.

Major Bond But the only time that I've ever noticeably been dis-

. . . if all of a sudden you've got the lights, at night, from three and four staring

oriented, that I can remember in recent history, was that time when I was landing. The fact that I have vertigo and that I have it all the time doesn't bother me.

Col Compton Because you have your instruments to get rid of it?

Major Bond Because I know; that is the thing. Where I think you get into trouble a lot of times is when you get behind the airplane or behind the situation. We are talking about high performance airplanes. Any time the airplane is diverging from what you thought was its flight path or its flight attitude, its changes of altitude, attitude, airspeed are much more rapid than with other aircraft.

Dr Ferrari I think you might be confusing one thing here. You say you have this thing frequently, constantly, and you know how to control it. But what you are having frequently is a disorientation which results from a correct, and physiologically correct, sensation that you feel and it is generated by acceleration forces on your inner ear. This is what we call, interchangeably, disorientation or vertigo and this is the old concept of it. Now what bothered you was not this type of vertigo but a visual illusion. You were getting erroneous information, visually.

Dr Collins If we use the term spatial disorientation to mean, as I suggested earlier, the matter of improper knowledge or no knowledge of your relationship to the surface of the earth, then it includes visual illusions, too. When you misinterpret something you see, it is a situation that will potentially put you in trouble because you are not right, so to speak, with your earth relationship. So it is a question of a large number of things that can occur singly or in combination, visual illusions, illusions from the inner ear, etc.

Major Bond We were talking about higher performance airplanes. Perhaps another term that would apply would be airplanes that would fly in formation, one with the other, rather than necessarily high performance. However, the disorientation effects, it appears to me, are very similar for formation flying and instrument flying where you have vertigo or are disoriented. When you fly instruments and you feel disoriented, the way you cure it is by using the instruments to establish an attitude. In flying formation, you can still have vertigo and you don't see the instruments for you are watching another airplane, and you wipe the attitude indicator to see if it agrees with what you say and if it doesn't . . .

Dr Ferrari That's not supposed to be done either, is it?

Major Bond What isn't?

Dr Ferrari Wipe the cockpit.

Major Bond I don't think it is wrong.

Col Compton I think you have to go to something you trust and know is right.

Major Bond The only reason you crosscheck is to know if you are still all right. If you know you are in a left bank and you are in a left bank and you feel it, you are all right.

Dr Collins In other words, you may think your leader is disoriented.

Major Bond Yes, yes. With long experience as a flight commander you push the young guy up front and make him lead, because he may have to recover you someday. You will find that most flight commanders, people who are in the business of training young people, when they are not in that man's airplane and they can't look at his instruments, wipe their own gages from time to time.

Dr Sawyer You can complicate this one step further by flying through cloud layers or penetrating in close formation and lose visual reference. Then you have to break off and transition from your visual contact with your leader to your instruments. This is a known area where we get into difficulty in trying to transition. If you are in and out of weather you need to stay with your instruments, if you are to maintain your reference.

Col Compton That is what motivated me to ask you yesterday and ask Bobby today whether there is anything we can do in any way, shape or form to modify these penetrations and letdowns.

at you . . . you get scared and then you really start compounding your problem.

Major Bond I think you are going to have vertigo and, in some cases, disorientation whenever you are flying formation. We may solve it by not flying formation, but you will continue to have it on instruments, so train the man whether he has vertigo while flying formation or on his own instruments. Normally, you have two things you have to do, but the tools you have to work with are different. If he is a young man, tell him to fly off the other airplane. He trusts that leader. And when he is flying instruments he must trust the instruments. These things require education and training and, of course, he has to recognize disorientation, whether he is on instruments or in formation. They affect him the same way.

Col Compton Would it be within the bounds of the technology in its present state to think about some sort of a heads up display on the left side of the windshield?

Major Bond I would think there would be a mechanization problem. There would have to be some sort of combining glass over there and that would further clutter an already full cockpit.

Col Compton You'd have to be in a relatively known position to use something like that. You would have to be able to see it easily, without turning your head.

Major Bond You can accuse me of being just a little bit partisan, but most fighter airplane drivers, after they have flown for a little while, fly pretty decent gages. Not always on their altitude, but they're smooth because they've got someone sitting on their wing. And as long as the leader is smooth, normally you can wipe the cockpit and check your attitude indicator and never stop looking at him. But if all of a sudden you've got the lights, at night, from Three and Four staring at you, you get scared and then you really start compounding your problem.

Dr Ferrari I'm going to agree with what Bobby said a minute ago about this is something we are going to have to live with forever and ever. The only answer to it is, number one, you've got to make these people understand it, not from a medical or psychological standpoint, but from a very practical standpoint so they can learn to anticipate that this is going to happen. Putting this in your context with Colonel Compton's question, "Should we change normal operational procedures to avoid this?" my answer to this is definitely not. I am not talking about subordinating the mission, but there are many cases when you can postpone one for three or four hours very easily. But when we get into a combat situation it is my understanding that, with the press of recovering aircraft, the formation penetration is mandatory because of the fuel limitation on the birds. You've got to get them in two or three at a time. These people are going to have the vertigo they would have normally, but if they haven't had experience through the years with this same type of stress, and you put them over there with airplanes all around them and with the psychology of being in a combat zone, and they get vertigo, then, I think, we stand to lose a lot more airplanes.

Col Compton Well, if you were in that situation, in the soup, in formation and your instruments, say your artificial horizon, indicated that you were straight and level and your leader was in a 60-degree bank, how would you go about evaluating the situation and making whatever corrections are necessary? Or if you have radio contact with him, how would you go about it? Maybe your gyro is off.

Major Bond Let me answer by building up to that situation. The normal position is that I'm up on his wing in the same plane he is in, so that if he were actually in a 90-degree bank, then I would be in a 90-degree bank sitting up on his wing. Now if I found myself there and felt wrong, glanced at my instrument and it said straight and level, if I just read it and couldn't believe it, then I'd crosscheck my standby. We have two attitude indicators in the airplane and if one of them agreed with him, I'd go with him. If both my attitude indicators were together, I'd tell him my attitude indicators were together and show a 90-degree descending left bank, left turn. ★

(To be continued)

DISCIPLINE, ORGANIZATION, DEDICATION...

THESE ARE THE EARMARKS OF A...

GOOD CREW

A team of professional athletes is a highly organized, disciplined group of men, each of whom must perform flawlessly in order to reach the team goal, which is to win.

Analogous to this is the operation of an aircraft, in which each crew member has certain responsibilities which he must perform in order that the mission can be successfully accomplished. Elementary, you say. And I agree. Then why so many serious, sometimes fatal, accidents due to poor crew coordination?

We all realize, of course, that a normal, routine situation can rapidly turn into chaos brought about by even the simplest catalyst. Something as simple as a red light suddenly coming on in the cockpit, even though the indication might be erroneous, can lead to a catastrophic series of events. A moment of distraction, which frequently occurs to us all, may cause an oversight, an improper action or a wrong decision with unhappy results. A classic along this line is the interruption of a sequence that ultimately ends with a gear up landing.

There was, for example, a major accident in a C-7 in which the aircraft landed gear up. The mission was night transition and the crew consisted of an IP and two students. Traffic was heavy—some 25 other aircraft in the area. On downwind the gear was lowered and the IP noted three green lights and the gear handle light out. The tower then asked the pilot to extend his downwind and advised that his navigation lights did not appear to be on.

This caused the IP to distract his attention from other duties to checking switches and circuit breakers. Meanwhile, the student turned base and retracted the gear thinking he was extending it. This kind of mistake is fairly common. We've seen similar things happen many times. Just why a person would move a gear or flap handle up to get the gear or flaps down we don't know. Possibly your flight surgeon or friendly psychologist can tell you. Anyway, this student retracted the gear on base and failed to check the gear position lights. The IP, having already extended the gear and not being aware of the student's action, let the gear up situation go unnoticed. The first indication he had came when that horn started blowing during flare when the throttles were retarded. By then it was too late.

It would be easy to fault the IP here for not making a last gear check on final. But let's consider another case in which the IP did ask for that last gear check. This one is a little hard to believe and, if things had ended on a happier note, probably never would have come to light.

The bird was a C-47. In the drivers' seats were an IP and a highly experienced pilot who was being checked out in copilot duties. When the aircraft turned final all was shipshape and the landing checklist had been completed. A piece of cake. Then the IP asked for a final gear check and the fun started.

As the right seater gave a gear down indication with his left hand he inadvertently hit the feathering button for Nr 2. It performed as advertised. Noting the power loss, the IP immediately advanced the throttles to maintain the approach. This caused the copilot to think they were going around so he raised the gear. Now the IP was in a bit of a bind so he started a single engine go-around and told the engineer to bring Nr 2 back in.

Rhyme'n Reason

Since man first sought to master the sky,
He has dearly bought the skill to fly,
But all he knows and all he knew,
Can go for naught with a mixed up crew.

This is where things really got sick. The engineer accidentally hit the wrong button and feathered Nr 1. Obviously this go-around wasn't going any place, so the IP had no choice but to continue the approach to a landing. Not wanting to make like a sled, he then called for gear down. The copilot reacted instantly and lowered full flaps. When he recognized this, the by now pretty saturated IP got the gear handle down himself and landed on the rollers.

But don't leave, there's another act. As the aircraft was rolling down the runway the engineer noticed that the gear latch lever was in the "spring lock" position so he moved it to the "positive lock" position. You guessed it. The gear folded.

Since no one got hurt, physically, it is easy to laugh at this one and shake one's head in a kind of resigned disgust. But for the sake of preventing accidents, and fatalities, a little introspection on the part of each of us might be a good thing. Awhile back a friend of mine got into a heck of a thing from which he successfully recovered. "I learned a few things from that," he said, "and the most important was that it can happen to me."

We got on this subject because it seems most appropriate at this time. With the number of crews transitioning to different aircraft, there is bound to be uncertainty, new habit patterns to be formed, different types of missions. All of these put additional stresses on pilots which can and do cause accidents.

Sorry we can't give you a pat formula for handling situations like those recounted here. The obvious thing, of course, is that every man on a crew—like the pro athletes—must know and perform his job, correctly and on cue. If the quarterback hands off to the wrong man, the team might lose five yards. A goof in the cockpit can mean a greater loss by far. ★

Ground Effe

WHILE aircraft spend most of the time at altitude, they get close to the earth's surface at least twice during every flight—during takeoff and landing. And these are normally the most critical portions of flight. Therefore, it behooves every pilot to have a practical understanding of that phenomenon known as *ground effect*.

As you may recall from studying aerodynamics, one of the forms of drag is induced drag, which predominates at low airspeeds and high angles of attack. These are normally present during the landing and takeoff phases simply because higher angle of attack is required at low airspeed in order to provide sufficient lift for flight.

When an aircraft is under the influence of ground effect you get, so to speak, a bonus. Ground effect results from the ground providing a restriction to airflow about the wing. When an aircraft is flying very close to the earth's surface, air displaced downward has no place to go. The result is that there is less induced drag than would be present at a higher altitude. Therefore, you can get a given amount of lift at a lower angle of attack.

The result is that if the pilot held the same angle of attack at, say, 10 feet off the ground as at 100 feet, the airplane would have a tendency to climb on the same amount of thrust. Even with no thrust but enough speed to sustain lift, the same result would occur—a temporary ballooning effect. This explains the so-called "float" that occurs at flare when you've got some extra

airspeed. This could be a handicap during landings on extremely short airstrips such as many of those in SEA and other remote places where USAF aircraft operate. A high density altitude would aggravate the problem.

To get ground effect working for you requires that the aircraft be very close to the ground. It is most noticeable at heights less than the aircraft wingspan.

A word of warning to he who would be tempted to use ground effect as an ace in the hole while engaging in that often fatal maneuver known as buzzing. Don't count on it. Ground effect works on induced drag. It has little influence on parasite drag and that is what predominates at higher airspeeds. So if you are tempted to lay down a few bushes you'll be doing it at a fairly high speed, hence a low angle of attack, hence low induced drag, hence negligible ground effect.

Now, how can you use ground effect to advantage? First, let's talk about a cruise condition. Ground effect has been used to nurse a sick airplane a considerable distance when the pilot, with some engines out, took the bird down to the deck —just a few feet from the surface— and managed to keep flying. Of course, this is not sure-fire. You'd have to have a nearly flat surface, such as water, with no obstacles. And you'd better be prepared to cope with the nerve wracking experience of holding the bird, possibly for quite a long period of time, level near the surface.

Now we are talking about multiengine recips. A jet at sea level isn't going to go very far. You'd have to be real fat on fuel with a relatively short distance to go to get much out of this procedure in a jet. Also consider the high angle of attack you would have to have at a low airspeed with a jet's low aspect ratio wing and you can see the problem.

Ground effect could also give you that last few feet needed to reach the runway. But you had better consider this as an unexpected bonus, and not one you're counting on, simply because that's cutting it a little too thin to win. In jet fighters, for example, with their generally high sink rates during approach, forget it. But if the engine of your O-1 gets shot out, ground effect might prove useful in getting the bird on the ground safely during a forced landing.

Ground effect can be beneficial on takeoff if you use it to advantage. That is, take advantage of the drag reduction to accelerate. But remember, you are in the process of leaving ground effect during takeoff. As you leave it, certain things occur which aren't to your advantage: The aircraft will have a high angle of attack, relatively low airspeed and high induced drag. This means more thrust is required. The important thing here is to adhere to computed takeoff speed. If you're tempted to haul it off prematurely you might get off the ground only to start sinking as you leave ground effect. This is particularly hazardous at high gross weight, high temperature and high density altitude. These are conditions that prevail at many of our fighter bases in the western states during the summer months.

Also keep in mind that an aircraft leaving ground effect usually will experience a higher airspeed indication. The reverse is true as the aircraft enters ground effect. So the airspeed indicator is working against you in both cases. The implications should be obvious.

In ground effect there is a reduction in downwash which will affect aircraft trim. As the aircraft enters there will usually be some nose down moment which might tempt the pilot to use more back pressure. But remember, as the induced drag decreases the coefficient of lift increases so a lower angle of attack is necessary to keep from either climbing or floating, depending on airspeed.

Ground effect, despite certain disadvantages, can be beneficial to the pilot. In fact, we take advantage of it without giving it a thought. This simple refresher is aimed at reminding pilots that this phenomenon is always present and that properly used it can be one more item in the pilot's bag of tricks. ★

CORROSION UNMASKED

Capt Walter S. Yager
Directorate of Aerospace Safety

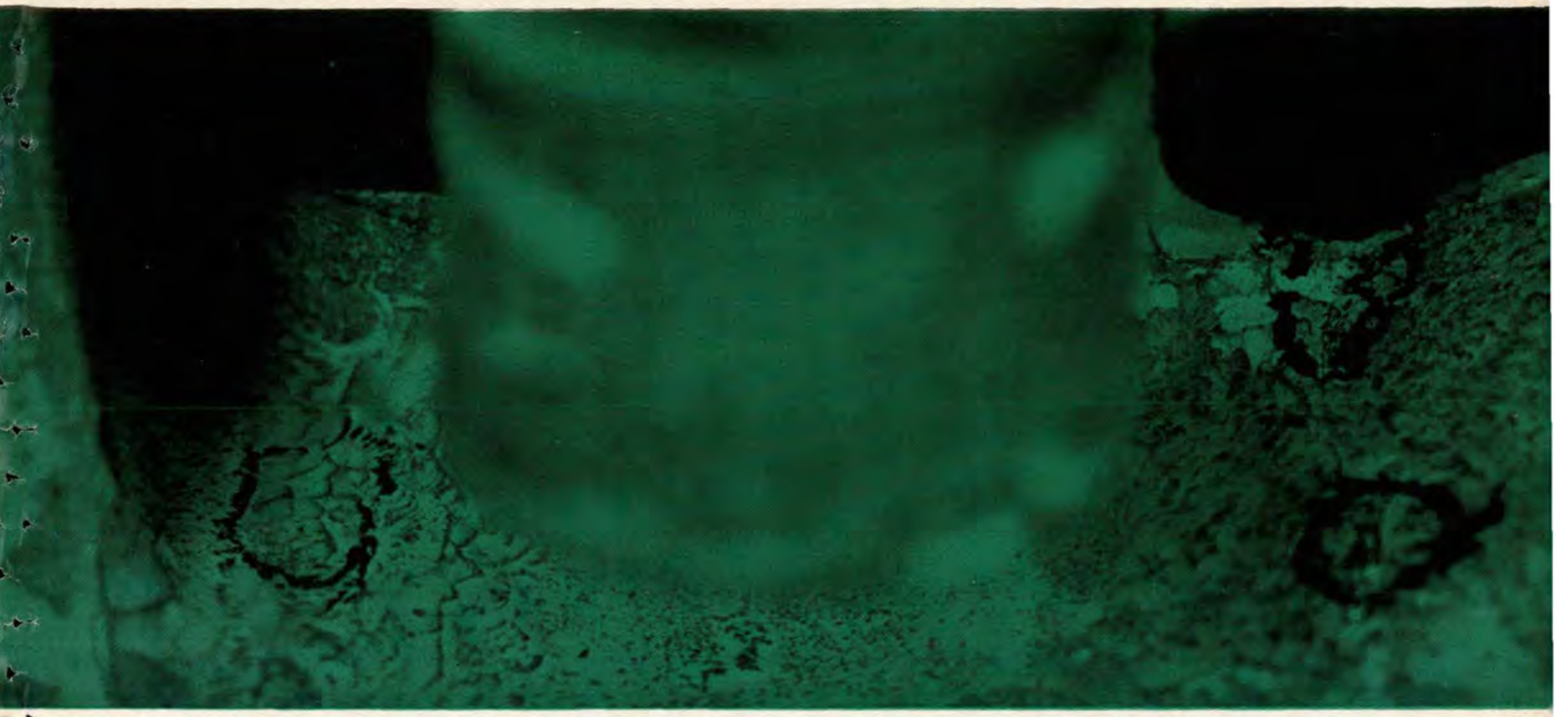
CORROSION is often thought of as rust on a piece of iron. But corrosion can occur in any metal and in any environment. Therefore, it is important to know where and how corrosion occurs and the forms it may take.

A previous article, "What Is Corrosion?" *Aerospace Safety,* March 1968, described one form of corrosion, the galvanic cell, and compared it to an electrical battery. Actually the galvanic cell is only one form of electrochemical corrosion. Some forms, as will be shown, require only air flow or a temperature difference for corrosion to occur.

There are eight different forms of electrochemical corrosion: galvanic, pitting, concentration cell, stress, erosion, dezincification, intergranular, and general. The purpose of this article is to define these eight forms of electrochemical corrosion, show how each occurs, and give some means of inhibiting the progress of each.

The first form, *galvanic corrosion,* was discussed in detail in the previous article. It is sufficient to say here that galvanic corrosion is that corrosion action occurring between two dissimilar metals.

The second form is *pitting*. Pitting is a localized corrosion that results in pits and holes in a metal. This form of corrosion is associated with passive metals, i.e., iron, copper, brass. Pitting occurs when the protective surface of a metal is disturbed by a scratch or nick. A scratch through the protective layer (paint, cladding, etc.) permits the exposed metal oxide to combine with any chloride ions that are present in the surroundings. This combination of the metal oxide with the chloride ions creates a local anode (electrochemically positive). An electrical potential will exist between the pit and the surrounding metal. A galvanic cell therefore is created, and corrosion will occur. Pitting must be inhibited, since it



gives rise to stress corrosion cracking which will be discussed later. Since chloride ions are abundant in most contaminants, cleanliness is a way to inhibit this form of corrosion. Of course the best way to minimize pitting, is by not disturbing the protective layer.

Corrosion in the presence of mechanical stress *(stress corrosion)* can take three separate forms: fatigue, fretting, and stress corrosion cracking. Fatigue is a well known limiting factor in design of structures. However, when corrosion occurs the endurance limit of the material may be completely wiped out. Microscopic intrusions and extrusions are formed during cyclic stresses. These fissures become the anode of a galvanic cell. Adhesion of O_2, H_2O, or both, on the walls of the fissure prevents the metal from rewelding itself, so the fissure grows, forming a sizable crack and premature failure occurs. This means that a part designed to withstand a million cycles of stress loading, may fail much earlier.

The second type of stress corrosion, fretting, occurs when two surfaces that are in contact have relative motion. Because of the contact and motion, metal is torn away from the surface and is then oxidized. Since the oxide is usually harder than the metal itself, further tearing of the metal occurs. Fretting can be reduced by applying more pressure to the contact surfaces, less movement, or by lubrication.

Stress corrosion cracking is the premature failure of an item due to an applied load in a corrosive environment. As stated earlier, a pit may form creating an area of stress concentration, from which an electrochemical process propagates the crack until failure occurs. This process is similar to that described for pitting, but is accelerated by the presence of stress. By preventing the pit, and the stress concentration, stress corrosion cracking may be inhibited. In some metals, impurities or alloying components form crack sensitive paths, or fissures, between metal grains and grain boundaries. The effect of stress is to open up these fissures which destroys protective films and exposes anodic material. Without the presence of stress this is very similar to intergranular corrosion, which will be covered later.

Erosion-Corrosion occurs when a material is subjected to the flow of some substance over its surface. The flow erodes the passive (protective) layer of the surface of this material. When the material itself is exposed, as with pitting, localized corrosion occurs. This form of corrosion is most evident inside tubes and pipes and is therefore difficult to identify. Certain additives are available for injection into flow systems to restore the eroded passive layer.

Another form of corrosion is

dezincification. Although the term dezincification is used, this form of corrosion can occur in other types of metal alloys besides those containing zinc. This form occurs when an alloy, e.g., brass, is subjected to a solution, primarily acidic. Zinc ions, being the most active, will go into solution combining with available negative chloride ions, leaving a porous residue of copper. (This process is similar to the corrosion that occurs in a galvanic cell when the zinc ions migrate to the cathode). This alloy so corroded often retains its original shape, and may appear undamaged except for surface tarnish, but its tensile strength and especially ductility are seriously reduced. Dezincified brass pipe may retain sufficient strength to resist internal water pressures until an attempt is made to uncouple the pipe, or a water hammer occurs, causing the pipe to split open. Certain elements, arsenic or antimony, are added to the alloy to prevent this form of corrosion.

The sixth form is *concentration cell* corrosion, and is caused by dissimilar environments, which are created by metal ion and oxygen concentrations and by temperature differences. First, consider two pieces of metal fastened together with a bolt or rivet as shown in Figure 1. The area between the two metals will be low in oxygen content because the region is stagnant.

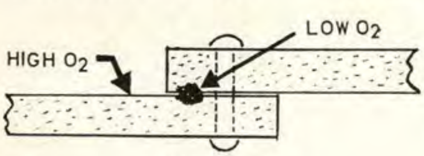


Figure 1

The area with excess oxygen will become cathodic (electrically negative) to the area of low oxygen. A current will then flow and corrosion of the low oxygen area results. Now consider the same two pieces of metal exposed to a flow over the surface as shown in Figure 2. Metal

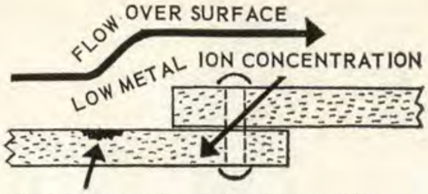


Figure 2

ions evolved from the surface are carried away by the flow. However, in the stagnation region between the metals the ions are not carried away, and an excess of metal ions in the stagnation area exists. This area of high metal ion concentration becomes cathodic, a current will flow, and corrosion results. A concentration cell will also occur if a temperature gradient exists within a metal.

Another form of concentration cell corrosion can occur from the existence of micro-organisms. Both aerobic and anaerobic cells are capable of creating concentration cells and fostering corrosion. Most concentration cells are eliminated or considered in the design of a structure. Methods of fabrication such as butt welding to eliminate lap joints and contouring to eliminate stagnation regions are employed to reduce concentration cell corrosion. Again, cleanliness and inspection are the best means of finding and inhibiting this form of corrosion.

The seventh form of electrochemical corrosion, *intergranular,* requires a knowledge of metallurgy to understand its nature. Basically, intergranular corrosion is a localized type of attack at the grain boundaries of a metal, resulting in loss of strength and ductility. All metals are composed of many individual crystals, arranged in what is called a lattice. The arrangement of these crystals determines the mechanical properties, i.e., tensile strength and ductility, of the particular metal. The grain boundaries, the area between adjoining crystals, provide a discontinuity within the structure of a metal. These discontinuities become especially susceptible to corrosion because during the alloying and/or heat treating process certain chemicals are precipitated that make the grain boundaries less cathodic (electrochemically less negative) than the neighboring crystals. Hence, a potential difference exists, current flows, and corrosion occurs.

Stainless steel is particularly susceptible to intergranular corrosion. Since intergranular corrosion occurs at the microscopic level, it cannot be seen and therefore is difficult to correct. Inhibiting or preventing intergranular corrosion is accomplished by additives in the alloying process and by careful heat treating. Heating of metals beyond their designated use range may affect the original heat treatment and also should be avoided.

As with the classification of anything, we must have a general group. This is the eighth, and last, form—*general* corrosion. General corrosion is a gradual surface recession at a uniform rate. Tarnishing of silver is an example of this form. As with the family silver, the best means of combating general corrosion is cleanliness.

Now that it has been shown that there is no set pattern, environment, or material needed for corrosion to occur, a few general comments can be made. The man in the field cannot control how a system, or component is designed, or what material is used. But he can, to some extent, control the conditions under which the system is used. A common factor for the inhibition, if not control, of all forms of corrosion is cleanliness. The old axiom "Cleanliness is next to Godliness," may depend on the point-of-view, but as far as corrosion control is concerned, there is no substitute. ★

the I.P.I.S. approach

By the USAF Instrument Pilot Instructor School, (ATC)) Randolph AFB, Texas

Q A departing pilot receives an IFR clearance to his destination airport to maintain FL 250 with several climb altitude restrictions included in his departure instructions. Shortly after takeoff, he receives a new clearance changing the final altitude to FL 370. Does the new final altitude clearance eliminate the original altitude restrictions?

A This subject continues to cause undue confusion. Inadvertent deviations from altitude restrictions during departure were the greatest cause of pilot violations last year. Perhaps a brief review of the topic is in order.

To answer the specific question above: When route or altitude in a previously issued clearance is amended, the controller is required to restate all applicable altitude restrictions, or state that altitude restrictions are cancelled.

EXAMPLE: A pilot is cleared to his destination airport to maintain FL 230 and to maintain 10,000 until 10 miles east of the Podunk VOR. With an amended clearance, the controller should issue the following instructions: "Climb to and maintain FL 370, maintain 10,000 until 10 miles east of the Podunk VOR" or "Climb to and maintain FL 370, delete the 10,000 altitude restriction."

If a pilot is flying a SID and, as frequently happens, he is rerouted, he cannot assume that all altitude restrictions are automatically cancelled. Altitude restrictions associated with a specific fix apply only at that fix; whereas, altitude restrictions associated with crossing a radial apply anywhere along that radial.

Departure procedures are frequently complex, and departure planning has assumed the same importance as approach planning. A pilot should ask ATC for clarification whenever he is not positive of what is expected to him.

Q When flying a low altitude nonprecision instrument approach, may the pilot elect to delete a depicted procedure turn?

A The pilot is expected to conform to the clearance he received from ATC. If the pilot is cleared for a specific approach, he is expected to fly the approach as published. A procedure turn, when depicted, is an integral part of the published approach, and the pilot will be expected to fly the procedure turn except under the following conditions:

1, ATC clears the pilot for a "straight-in" approach.

2, The pilot is proceeding to the navigational facility on the published terminal routing which is annotated "NoPT" (no procedure turn required or expected unless cleared by ATC).

Our main concern is that both the controller and pilot coordinate their intentions. If the pilot considers himself inbound to the FAF for a straight-in approach, and the controller believes the pilot is approaching the IAF to turn outbound, serious traffic conflicts can occur. Fly the complete approach as published unless authorization to delete part of the procedure is granted by ATC.

NOTE: Very few low altitude TACAN approaches have procedure turns depicted. Do not mistake published holding patterns, indicated by the *thin* blue-lined holding pattern symbols, for procedure turns. A potential problem area exists, unfortunately, since several approaches still depict procedure turns with a *heavy* blue-lined procedural holding pattern. Until all approaches are converted to the correct barbed procedure turn symbol, confusion could arise.

Instrument procedures continue to change. If you would like a correction sheet to all of the past IPIS Approach articles, please write USAF IPIS (FT-IPIS-PS), Randolph AFB TX 78148. Your suggestions or questions for future articles are also welcomed. ★

REX RILEY'S CROSS COUNTRY NOTES

SPECTACLES IN THE COCKPIT. That's the title of an article in the June issue of *Medical Service Digest*. It was called to my attention by Col George Shafer, commander of the USAF School of Aerospace Medicine at Brooks AFB.

While the article, by Lt Colonels Thomas Tredici and Benjamin Kislin, is primarily for medical people, there's some good info in it for aircrews. Check with your flight surgeon. He will have a copy and will undoubtedly share it with you.

RF-4C. During go-around from a low approach the navigator in the back seat of an RF-4C inadvertently hit the canopy switch with his elbow. The switch worked. The canopy raised, left the aircraft and landed in the grass near the runway.

According to the report, the switch guard is shorter than the switch. This same thing (switch longer than the guard) cost the USAF an F-86 a couple of years ago when the pilot accidentally shut off the fuel on final approach.

Note to RF-4C crews: There was no noticeable wind blast. In fact, the pilot didn't know the canopy was gone until he was told by the navigator.

INFLIGHT WEATHER INFORMATION. Where do you get inflight weather information? Not from an ARTCC although the FAA types are quite helpful whenever time permits. METRO, Flight Service Stations, or Transcribed Weather Broadcasts on VOR frequency are your sources. This brief was generated by a recent incident in which three aircraft in a flight of four ran into weather that caused compressor stalls and flameouts. Thunderstorms were forecast but were expected to be north of course. Shortly after departure the formation entered light cirrus which remained smooth until they ran into the cumulous clouds buried in the cirrus. Trouble then showed up in the form of flameouts, lightning strikes, rain and turbulence. The flight leader asked the Center if they were painting thunderstorms in the vicinity and the Center informed him that the flight had apparently flown into the middle of a cell. Eventually all aircraft recovered safely, although slightly scorched in places from lightning strikes.

This is not the first time aircraft have run into severe weather without warning from ARTC. Should you expect such a warning? If there were a SIGMET out, yes. ARTCCs are required to broadcast a SIGMET alert once on all frequencies on which they have active traffic which could be affected by the SIGMET. They do not broadcast the complete text of the SIGMET but issue an alert for aircraft to monitor the VOR frequency for this information. FAA Flight Service Stations, upon receipt of a SIGMET or AIRMET pertaining to an area within 150 nautical miles of the FSS or a broadcast facility controlled by the FSS, are required to broadcast such advisories once upon receipt and SIGMETs at 15 minute intervals at H+00, 15, 30 and 45 for the first hour; AIRMETs at H+15 and H+45 for the first hour; and SIGMETs and AIRMETs at H+15 and H+45 for the second hour.

If no SIGMET or AIRMET is current, no advisory will be given by ARTCC because FAA is in the air traffic control business, not the weather business. They may give you some help but that would depend on how busy the controllers are. In addition, they normally do not have their radar on a mode for storm identification. However, if you need vectors around the storm and the center is not saturated, this is the place to get them. More often than not they offer this service without your asking. The sources for weather information are METRO, Transcribed Weather Broadcasts and Flight Service Stations. This is what the Pilot to Forecaster Service and other facilities specified are for. They cannot provide vectors however, only information such as where and how much weather.

GROUND EJECTION. Following a combat mission the F-4C crew had taxied to the de-arming area and was running through their postflight checklist. The front canopy was open. Suddenly there was a bang and the pilot in front saw a flashlight fly by. Then the rear canopy left the aircraft and the rear seat man was ejected. His trajectory height is unknown because witness testimony varied considerably. The ejection system apparently worked as advertised but there was not enough time for the full sequence, and the man was killed.

This fatal accident was caused by a flashlight that lodged between the aft seat primary initiator assembly and the canopy actuator assembly. When the canopy was opened the canopy actuator and cam-follower assembly forced the flashlight against the firing pin with enough force to fire the initiator.

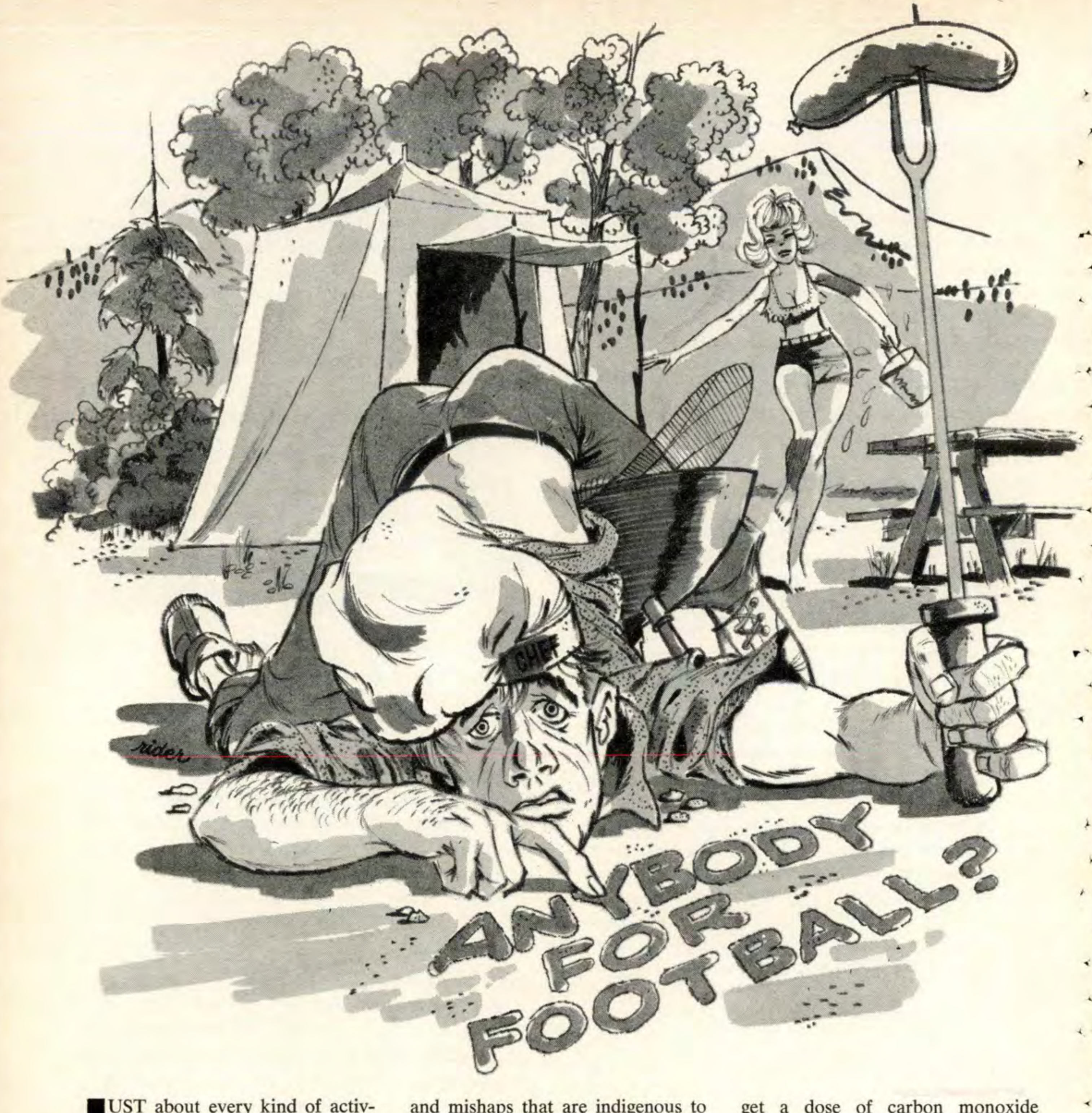
This, then, means that all you Phantom drivers will have to account for all items introduced into the cockpit prior to canopy opening after flights where these items may have floated into this critical area. Make a good accounting of such things as flashlights, checklists, water bottles.

Contributed by
Maj George C. Braue
7AF Life Support Officer

F-105 EGRESS SYSTEM. Modification of the F-105 egress system to provide zero-zero capability should be well underway by now. Concurrently we've had reports that some crews are "nervous" about this system. Perhaps they recall the rash of inadvertent firings of the slug deployed chute in the F-106 when that system was first installed. However, there is no record of anyone being injured. Most of those firings occurred when the pilot stood up in the cockpit without first actuating the ditching handle. That was because of the design of the disconnect. This was corrected and cured the problem.

According to the manufacturer, the disconnect in the system being installed in the F-105 has been designed so that inadvertent firing will be nearly impossible. Nevertheless, if this should occur the most exposed person would probably be a maintenance man servicing the pilot from the right side. The gun is mounted on a 45-degree angle on the right side because the pilot is normally serviced from the left. If normal practice is followed, there shouldn't be a problem.

This new system in the '105 offers so many advantages that the jocks should welcome it. It's capability is even better than that in the '106 because it has a one-second drogue compared to a two-second drogue in the F-106. This is the capability we need in all our fighters and we're glad to see the '105 will soon have it. ★



JUST about every kind of activity we call fun, or recreation, seems to have its own built-in hazards. Most of us most of the time either take the proper precautions or manage, somehow, to avoid these hazards. But the files are fat with the names of those who didn't.

Summer is funtime and we are in the midst of it right now, so all of us are exposed to the various ills and mishaps that are indigenous to this season. Almost all of us, for example, will get through the summer without getting a serious burn from a barbecue fire. But there will be a few who:

- Give a reluctant fire a shot of gasoline and land in the hospital with third degree burns.
- Move the operation into the garage or house because of rain and get a dose of carbon monoxide poisoning.

Let's hope there won't be a repeat of the sergeant who was going to make a *real* firecracker. He packed some black powder into a piece of pipe capped on one end. He had drilled a small hole in the pipe into which he planned to insert a fuse. But when he began pounding a plug into the end through which he'd poured the powder, the thing blew up and he lost a hand.

We'd like to know we aren't going to have any more drownings this summer, but there will be some. To keep the number to a minimum here are some suggestions based on bitter experience:

- When boating, fishing, water skiing, swimming, cut the horseplay.
- If you don't know how to swim, learn—or stay away from the water—or wear appropriate life saving equipment.
- Never swim alone even if you are a good swimmer.

Sun is fun but you can get too much of it. An overdose on the golf course can be just as damaging as too much on the ramp. And you'd better believe it can be serious. Most of us have experienced that painful, lobster-red condition. But in the exuberance of the moment we forget that an overdose can:

- Mean a stay in the hospital.
- Cause loss of duty time.
- Ruin your vacation.

Inevitably, of course, the subject of automobiles comes up. Add motorcycles, dune buggies, bikes—anything with wheels. First, cars. If you plan to take a long trip make sure the thing's in good shape. There are some long stretches of nothing in this country where a breakdown can be serious. Even the best cared for auto can get something wrong with it, but the odds are a lot better if:

- Your tires are good enough for what you are trying to do.
- The hoses and belts are in good shape.
- The machine is mechanically fit for the trip.
- The cooling system is capable of handling high temperatures and high elevations.

If you are the adventurous type who likes to make the scene in a dune buggy or a motorcycle, fine

but you don't have to do it like an idiot. Again, the condition of the vehicle is important. A breakdown in the desert can put you in deep trouble in a hurry. No use going into a lot of detail here. If you like this sort of thing, you know what to do. So use some of your savvy to make sure you don't get into an untenable situation like:

- A broken chain on your bike with no spare and no help.
- A breakdown in the boondocks with no water.
- Overdoing it in the sun.

Quite a few of us are flying light airplanes, either aero club owned, or privately owned or rented from a dealer. This is fine, but there will be a few who bust it. Past experience tells us that some will get in trouble with the weather. This is thunderstorm season as well as travel season. Sometimes the two don't mix. Gethomeitis has cost the Air Force a lot of pros over the years, and there have been several aero club types whose names are on that list.

Another little problem that crops up in summer is high density altitude. This is primarily a hot weather phenomenon that follows fixed natural laws. The pros compute and recompute performance with a whole raft of charts in the back of the aircraft Dash One. But light aircraft are subject to the same laws and the pilot won't have quite such an elaborate set of charts. In addition to higher than standard temperatures, there is another factor that we have to plug in. A lot of those fishing and vacation spots are at relatively high elevations and many of them have short runways.

Add high temperature, high elevation, stir in a short runway, season with a pilot that is relatively inexperienced and you have a mixture that is potentially lethal.

So all this talk about summer hazards is old hat. You've heard it before. But before you blithely take off for that well deserved leave, or a weekend of fun in the sun, remember: We're not telling you not to do any of these things. Barbecue every day, drive from coast to coast, scoot up into the hills on your motorbike or get the most out of that dune buggy. Fly to Lake Whatchamacallit for trout. Do it! You need the change of pace. But just use a bit of the common sense you've all got and you'll be around for football next fall. ★

LIFE

The Civil Air Patrol is an Auxiliary of the U. S. Air Force Aerospace Rescue and Recovery Service and, along with the U. S. Coast Guard, represents the only nationally organized, trained and ready search organization in the United States. The 83,000 CAP members are directed in their search efforts through the three SAR (Search and Rescue) Centers at Robins AFB, Georgia, Richards-Gebaur AFB, Missouri, and Hamilton AFB, California. During 1967, these centers coordinated over 316 inland search missions with the Civil Air Patrol.

CAP members train and search on their own time, without pay. Only during actual search missions does the USAF reimburse the CAP members by providing funds for the gas, oil and lubricants used during the search.

Left, Cadet Capt Dennis Bright records tail number of arriving aircraft. Visual checks were made several times daily by CAP cadets at the four airports where visitors landed during operation. Below, all available parking space was used by visitors to the Daytona 500.

IN February 1965, the new Daytona race track at Daytona Beach, Florida, held its first annual "Daytona 500" stock car race. National publicity attracted people from all over the United States, Canada and Mexico for the two day event. And general aviation pilots were there, too. They converged on the Daytona area in such numbers that it was impossible for Flight Service to monitor or control all their arrivals and departures.

SAVERS

A few of the hundreds of aircraft at Daytona before the race.

Maj. S. J. Templeton, Eastern ARRC, Robins AFB, GA

Of the four local airports, only one had a control tower, and it was swamped with a constant stream of arrivals and departures. Several crashes and many aircraft unaccounted for caused a tremendous number of manhours and flying hours to be expended in search and rescue missions.

After this experience, the Eastern Aerospace Rescue and Recovery Center at Robins AFB, Georgia, coordinated with FAA's Flight Service and devised OPERATION LIFE SAVER, a *preventive* search and rescue mission which would be operated by the Civil Air Patrol during sporting events like the Daytona 500. When 1967 came along, the Florida Civil Air Patrol was ready with over 70 CAP members stationed at the Daytona local airports to record the arrival and departure of every plane, from the 90 mph Cub to 500 mph Jets.

An operations plan based on last year's experience was developed by the Eastern Rescue Center to cope with the expected increase in air traffic this year.

On Friday evening before the race weekend, the Florida CAP personnel moved into place at four airports: Daytona, Ormand, New Smyrna Beach and Deland. They were under the direction of CAP Captain Leroy E. Barnett as Mission Commander. During the next 48 hours, Captain Barnett and his CAP volunteers were on constant duty recording every flight in and out of the Daytona area. In addition to providing ramp checks for missing planes, watching every movement and carefully recording every arrival and departure, an effort was made to "sell" filing flight plans to the visiting pilots and to make sure that they had weather information available for their entire route of flight. During the two day period, 3150 separate airplane movements were recorded and 45 incidents of lost or overdue aircraft were processed. The CAP members, who served without pay or other benefit, did an outstanding job in insuring a safe "Fly in."

The sports-loving, air-minded Americans flying into Atlanta, Georgia, for the "Atlanta 500" on 30-31 March found the Georgia Wing of the Civil Air Patrol on duty there for another LIFE SAVER mission. This preventive SAR effort was of invaluable assistance to Atlanta Flight Service personnel in the safe and efficient handling of the great influx of air traffic.

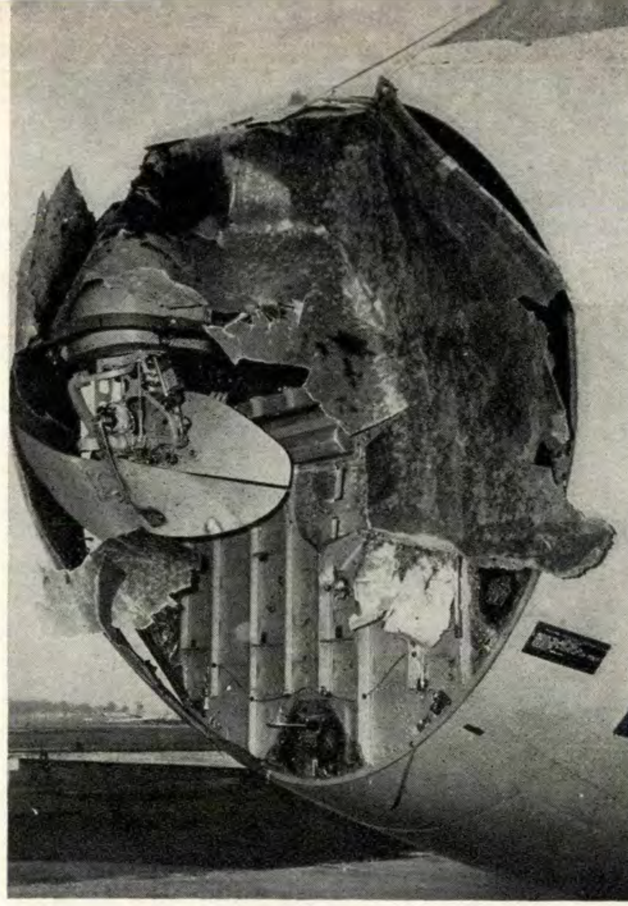
Impressed by the success of these missions, the Commander of Eastern Rescue, Colonel Walter F. Derck, pointed out that, "Our rescue center personnel had no missions during the Daytona and Atlanta 500, which is the first time we have experienced complete success with such high density air traffic into an uncontrolled area. The Civil Air Patrol was of immeasurable help. We look forward to future LIFE SAVER missions in other areas such as the Indianapolis 500 and anywhere a large influx of general aviation aircraft is expected." ★

LIFE SAVER staff discuss plans for coordinating CAP activities. L-R, are EARRC's Maj S. J. Templeton, USAF; CAP Capt L. E. Barnett, CAP Mission Commander, and CAP Lt Col W. E. Ewin, Deputy Mission Coordinator.

All aircraft movements involved in operation were recorded by CAP members. Cadets check aircraft on ground at Ormond Airport.

Two-way radio contact between CAP Mission Hqs and mobile team at end of runway was maintained on 24-hour schedule. L-R, CAP WO John Dees and Cadet MSgt David Crack keep in touch.

T-Storm KEEP OUT!



Maj Everett E. Ruble, Directorate of Aerospace Safety

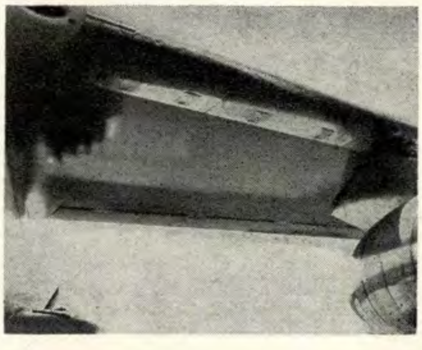
THE first warning about T-storms by an instructor pilot to a student is said to have been made 'way back in 1904, when Orville said, "See that thing over there. That's a thunderstorm. It's dangerous. Stay as far from it as possible!"

That was good advice then, and it is just as good today. Nevertheless, we still have trouble with T-Storms. For example:

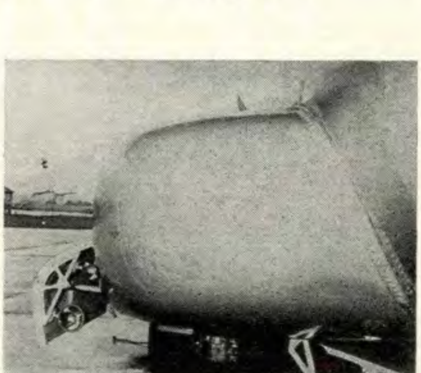
- A jet transport with a weak radar set took off from an overseas base into an area of forecast thunderstorms. Ten minutes after takeoff while climbing through 21,000-22,000 feet, light turbulence and rain were encountered. The navigator was unable to paint returns on radar. Shortly afterwards, the aircraft entered a storm cell and encountered severe turbulence, rain and hail. The radome disintegrated as a result of impact with hail. Number Two engine was damaged as a result of ingesting parts of the radome. Engine nose cowls, wing and stabilizer leading edges were dented to varying degrees.

- Another jet transport on an air evacuation mission was inbound to an overseas station at Flight Level 330. The weather ahead appeared to be nothing but cirrus clouds and no returns were present on radar. The aircraft commander elected to continue although the clouds could have been circumnavigated. After entering the clouds, turbulence was encountered. Two flight nurses were injured from being thrown around in the aircraft. Some litters split from the "G" forces allowing the patients to fall through.

Thunderstorm flying is usually a subject that is covered in flying safety meetings as a seasonal type briefing. With the world-wide missions the Air Force is flying today, this subject should receive attention the year around. ★



Hail and jets don't mix well. These photos show results of one such encounter between hail, C-141.



Missilanea

SAFETY EDUCATION. Safety education for all levels of management and for the work level airman is a vital ingredient for any successful safety program. Education in this context concerns the development of proper perspective and attitudes toward safety. It deals with basic fundamentals and the reasons why. Training is more concerned with immediate job knowledge, skills and work methods.

The Wing Chief of Safety and his staff must undertake to provide extensive education and training for first-line supervisors. The supervisors must understand their key role in the safety effort, namely that they are primarily responsible for preventing accidents (assuming they have adequate support from above). Each supervisor must conduct his own safety training for his airmen. This takes the form of both individual on-the-job training and periodic safety meetings held right in the work areas. Experience has shown that the supervisors should learn how to give safety instruction, and then do their own teaching. This practice strengthens the bond between supervisor and airman and aligns what a line supervisor teaches by his day-to-day actions in dealing with them with what a staff safety chief might teach.

At the airman worker level there are two principal objectives: (1) to develop safety consciousness and favorable attitudes toward safety, and (2) to achieve safe work performance for each airman on his job. To achieve these goals a number of things must be done. At the time an airman is assigned, orientation by both the OIC and the man's immediate supervisor should cover several areas, including the need for safe work performance, the hazards in his work area and job, the necessity for prompt reporting of personal injuries or unsafe conditions to the supervisor, and the general causes of accidents. Instruction in safe working procedures must be integrated with instruction designed to achieve acceptable output and quality performance.

In addition to individual on-the-job training, successful safety practice in many organizations has demonstrated the value of periodic safety meetings conducted by the supervisor. Among the topics that may be covered are: how to prevent accidents, accident causes, importance of good housekeeping, handling materials safely, first aid, equipment hazards, fire prevention, use of hand tools, and protecting the eyes.

In summary, a healthy safety education environment is a necessary ingredient of a successful and meaningful safety program.

Maj Nat A. Stater
Directorate of Aerospace Safety

YOU CAN'T BEAT SUCCESS. The statistics on primary accident cause factors for surface launched missiles during 1967 show that maintenance errors, operator errors, and supervisory errors have decreased to zero. A look at the 1966 statistics shows quite a different set of figures—maintenance error, 18 per cent; operator error, 4 per cent; and supervisory error, 2 per cent. These three areas (maintenance, operator, and supervisory) can be categorized as personnel error. The old human factor really gets into the act here, and borrowing from an old cliche, "You Can't Beat Success," our accident prevention programs aimed at personnel error prevention must be paying off.

Materiel failure accounted for 80 per cent of our 1967 missile accidents and this is the area which now requires additional attention. "Better mouse traps" must be designed and built. As this is accomplished, our people (human factor) must continue to maintain their zero accident cause factor rate.

The over-all breakdown by cause, number of occurrences, and percentage of all accidents in surface-launched missiles for 1967 is as follows:

CAUSE	NUMBER	PER CENT
Operator	0	0
Supervisory	0	0
Maintenance	0	0
Materiel Failure	8	80
Weather	0	0
Undetermined	2	20
TOTAL	10	100

The 20 per cent figure in the "Undetermined" category stands for only two accidents, so our investigation procedures and techniques are improving through training and experience.

The designers and engineers are improving our present missiles and building new ones to give us that "better mouse trap." Everyone else in the missile business must make maximum use of the Missile Hazard Report (MHR), Emergency Unsatisfactory Report (EUR), Air Force Forms 22, etc., to identify real and potential hazards. With a combination of these efforts, our missile accident rate WILL continue to DECREASE. ★

Maj Warren C. Hoflich, Jr
Directorate of Aerospace Safety

STABILITY & CONTROL

Vernet V. Poupitch, Directorate of Aerospace Safety

STABILITY and control of an aircraft are what the nervous system and muscles are to a human body. So it follows that the Stability Augmentation System is an extremely important, sensitive and precise system without which any space vehicle, missile or modern aircraft would be useless. The following general explanation of such a system with the assistance of material from articles in Lockheed's Fighter Maintenance magazine and their avionics engineers, will augment the T.O. It is hoped that this article may explain a typical system to the pilot and thereby assist him and the debriefing crews in writing up irregularities or malfunctions more precisely. This in turn helps the system maintenance crews pinpoint and correct the discrepancies earlier.

Every champion athlete throws his weight around. He must, for his timing and coordination come to focus in those split-second shifts of weight—some call it "body English"—that ensure the precise control of attitude and direction he needs to win over a competitor.

Like fine-tuned athletes, early aviators used weight-shifting for control. But they weren't all champions, and the pioneer aeronauts soon were divided into two classes—the quick and the dead. The quick survived because they were better at the game of center-of-gravity shifting, scampering around the flimsy frames of their gas-bag airships or gliders.

My first experience with buoyancy and C.G. was when I was invited to ride in a "rubber cow" at Scott Field where I was stationed as a heavier-than-air pilot. As we cruised along, the crew invited me to take the controls of the dirigible and I, of course, jumped at the opportunity. Just to show up the wise heavier-than-air pilot, the crew compressed the gas in the rear bags, which raised the nose up to a steep angle, then throttled the engines (J-5s) back and watched me sweat—which I did. I gyrated the controls (which felt as flabby as a wet sponge) all over the cockpit of the gondola when everything else failed, such as normal *airplane* recovery procedures. But there I hung, embarrassed as a young bride on her first night, while the airship floated steeply inclined and inert as an oyster on the beach in August. Some ships just don't stall or spin, I learned!

The evolution of movable flight controls changed the pilot from an airborne athlete into a stationary sensing device. Now he could sit in one spot and let the weight-shifts work on him. The feel of flight forces surging deep in his body blended with sight and sound to create that unique, mystical and indispensable piloting technique known as the "seat-of-the-pants" method. To this day, it remains the basic skill every student pilot must develop and demonstrate before he opens the throttle for his first solo takeoff.

But in this day of supersonic fighter aircraft, seat-of-the-pants feel can often be too little, too late, or divergent. The best pilot's capabilities to sense and react aren't up to the job of correcting the transient instabilities that can occur in an aircraft at or above the speed of sound. Our designers had to look beyond human limitations, to the realm of automation, to get the rapid, fine increments of control surface movement needed for this task, i.e., the Stability Augmentation System (SAS). My goal is to acquaint you with the key elements of an SAS and their operation in order to emphasize, through understanding, the importance to flight safety of reporting flight control system discrepancies combined with timely and proper maintenance activity.

LAYOUT AND FUNCTION

In the pitch, roll and yaw axes of an airplane the units listed below perform the functions described.

The *instantaneous rate gyro* (unit

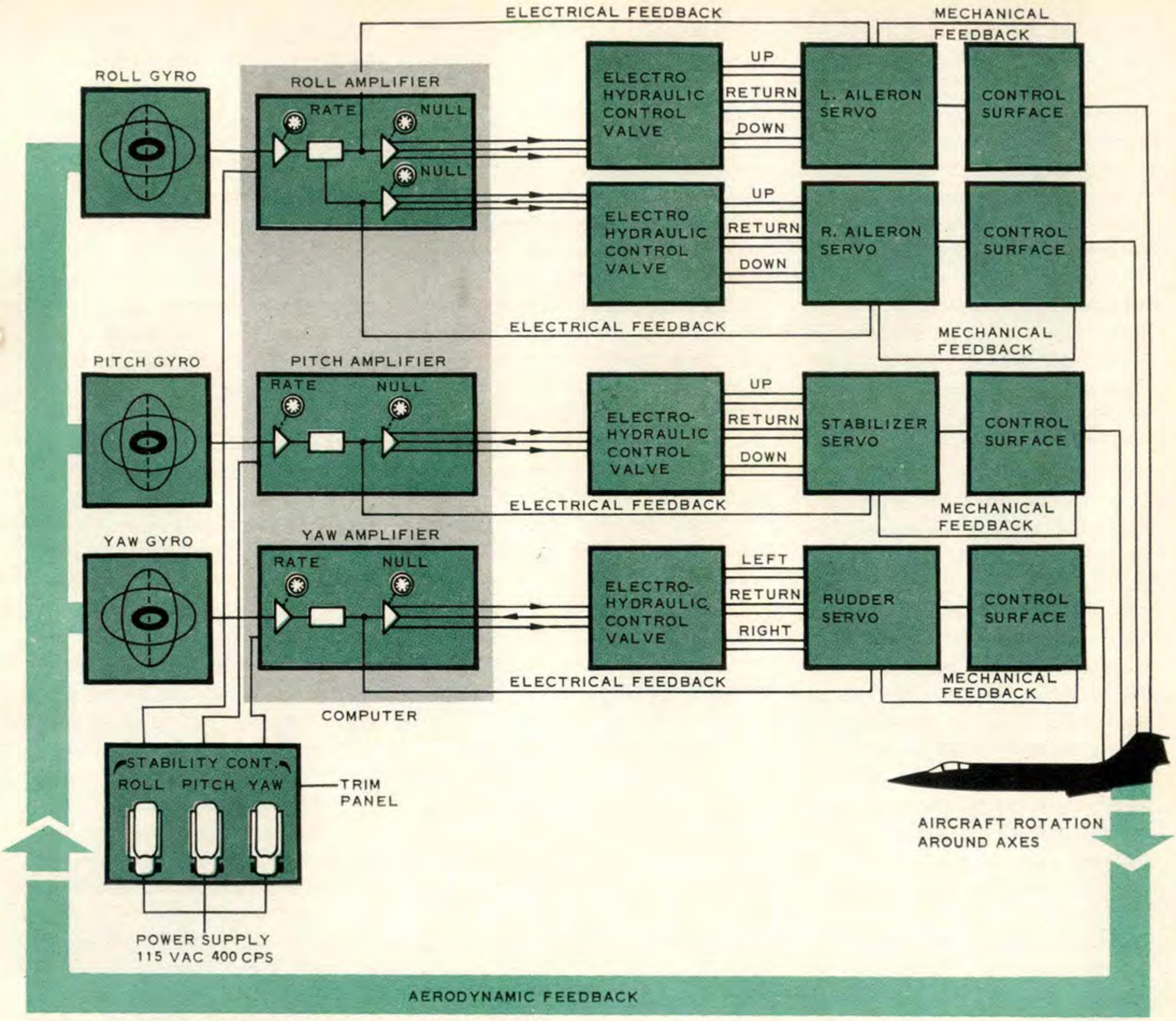


Figure 1 Block diagram of typical stability augmentation system

identified as rate in Figure 1) senses the direction and measures the rate of any transient instability. (For discussion, let us define momentary undesired motions about any axis as transient instability.) It also transmits this information to the computer.

The *computer* compares and sums the incoming signals from rate gyro and feedback sources, and transmits the resultant signal in amplified form as an instruction to the electro-hydraulic flow control valve mounted on each servo assembly.

The *electro-hydraulic flow control valve* translates the electrical signal input into a proportional hydraulic command to its related servo assembly.

The *servo unit* moves the control surface in the direction and to the degree (at the rate) dictated by the electro-hydraulic flow control valve, at the same time transmitting electrical and mechanical feedback information so that control surface movement will cease at the proper point.

Control surface movement (from the trimmed condition) damps out the transient instability and the aircraft returns to stable trimmed flight.

Should an "overshoot" occur causing undesirable rotation of the aircraft about any axis, movement of the airframe (aerodynamic feedback) will be detected by the rate gyro, and a new cycle in the opposite direction will be initiated to correct the condition.

THE RATE GYRO

Now for more details on these elements. The first in the chain of command in the three-axis damper system are the rate gyros, one for each of the three airplane axes, as shown in Figure 2. Each gyro's rotor spin axis is oriented so that it senses only the transient inputs in its related plane of movement, as illustrated. But it should be remembered that the spin axis of any particular gyro is not aligned with the airplane axis it serves. This is because the rate gyro is a "one-degree-of-freedom" type (mounted in a single gimbal ring) which exploits the principle of gyro precession to produce its output signals to the computer. Let's look at Figure 3 to see how this works.

When the gyro rotor is running at normal speed, tilting its spin axis by means of external input (applied force) results in rotation of the gimbal ring in its bearings (resultant movement or precession) at a rate proportional to the input force rate. This happens because the precession characteristic of the gyroscope always tends to align the direction of rotor rotation with the direction of the input force. Check the four arrows in Figure 3 to prove this, step by step. Applied forces tilt gyro case, gimbal ring and rotor spin axis all together; the resultant movement (precession) tends to rotate the gimbal ring 90 degrees until the direction of the arrow on the spinning rotor parallels that of the applied force arrows.

The gimbal ring, however, is spring-restrained to a limited movement. The electrical induction coil pickoff sends to the computer an AC signal which reports the gimbal movement as proportional voltage changes and its direction by phase relation.

COMPUTER

The computer is the "brain" of the system, containing separate channels for yaw, pitch and roll. Rate gyro signals to their respective channels in the computer are processed and summed with the electrical feedback signals (proportional to surface rates) to produce an output (command) signal to the electro-hydraulic flow control valve at the related servo. The computer contains failure-monitoring circuitry so that a specific malfunction in any channel can result in removal of the electrical current which normally flows through the coils of the related flow control valve. Without the trimming effect of this current, the mechanical bias of the valve results in a "one-way" hydraulic signal to the affected servo. Since the damper system has only limited authority over control surface movement, this predetermined surface deflection develops slight aerodynamic forces which are easily corrected by the pilot until he turns off the affected channel and retrims the control surface. The other two channels, being independent, remain unaffected in their operation.

FLOW CONTROL VALVE

The *electro-hydraulic flow control valve* is the point where electrical signals become proportional hydraulic signals. Each servo unit provides its related control valve. The flow control valve is an electro-hydraulic unit which receives an Automatic Flight Control System (AFCS) or the SAS generated electrical signal. Under the dominant influence of the electro-magnetic field in one of two coils in the torque motor, the armature motion varies an orifice which, through a hydraulic pressure differential, moves the hydraulic control valve. This valve, when it opens in one direction, ultimately ports 3000 psi hydraulic fluid to extend a flight control surface actuator in one direction. Conversely, if the electrical input signal predominates in the opposite coil, the movement of the control valve in the opposite direction retracts the flight control surface actuator.

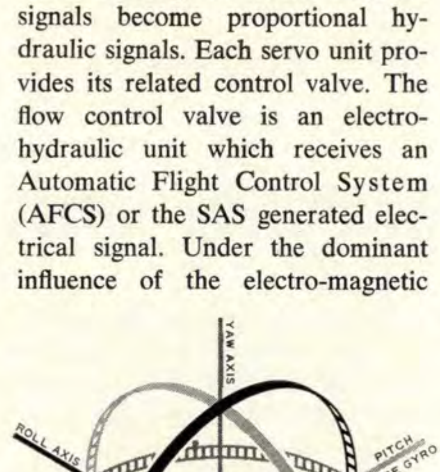


Figure 2

We now know generally how transient instabilities in the flight of the aircraft are detected and measured, and how the corrective electrical signals are converted to hydraulic commands which can be utilized by the servo assemblies.

If we had been describing the functioning of the human nervous system, our words would have been much the same. But nerves without muscles are only disconnected wires. The "nerve" elements of the stability augmentation system do the first part of the job—sensing, judging, and transmitting commands.

The flight control assemblies are like muscles, powerful yet capable of minute incremental movements of great rapidity, when properly adjusted and maintained.

As an actuator control assembly moves, the attached servo follow up lever works through the servo valve input linkage to move the dual spool valve back towards its neutral position. When this position is attained, flow to the actuator is cut off. Thus the flight control surface stops at the deflected position required to correct the original transient instability.

RETURN TO TRIMMED CONDITION

Return to trimmed condition is automatic and follows immediately upon correction of the initiating transient. Here is how it happens.

When the rate gyro and synchro

feedback signals are equal and opposite in the computer, the computer will cease transmitting command signals to the flow control valve. The flight control elements of the system then cease to move, causing the control surface to remain hydraulically positioned to hold in an untrimmed position. This sort of "status quo" condition would persist for the duration of the nulled signal condition.

The nulled signal condition in the computer can be altered in two ways:

1. When the transient is corrected, the rate gyro centers itself and thus cuts off its signal to the computer.

2. In the roll and yaw functions of the system, a steady state (angular velocity) gyro signal may be eliminated by washout circuitry in the appropriate channel of the computer. This ensures that only rate changes (angular accelerations) are processed by the roll and yaw channels. The pitch channel, however, in some aircraft, does not employ washout circuitry, in order to add a desirable amount of "stiffening" to the pitch response.

When the gyro signal is cut off, the feedback signal from the synchro remains unopposed in the computer. This causes the computer to initiate a repetition of the actions but in the opposed direction, so that the stabilizer moves toward its trimmed position. As it does, it causes movement of the attached servo valve input linkage and modulating piston in such a direction as to return the synchro to the zero output position. At this point, of course, the feedback signals cease, and with trim established, the cycle ends.

SYSTEM AUTHORITY

The stability augmentation system has only limited authority over control surface movement, so commands from the pilot's control stick on some aircraft can override com-

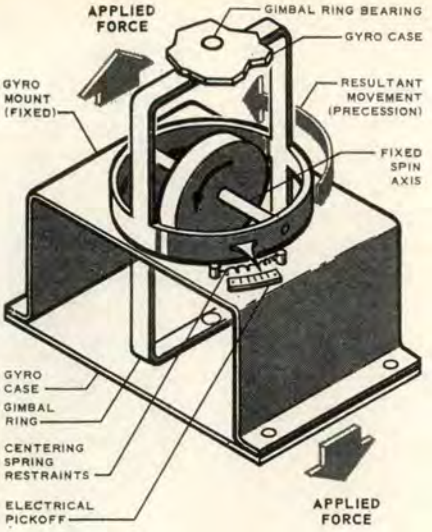


Figure 3 Schematic diagram of typical rate gyro

mands from the SAS. The functions of the control stick/servo loop and the stability augmentation loop differ in the following major particular:

- A control stick command obtains a proportional control surface displacement which remains as long as the stick remains displaced.
- A damper system command produces proportional control surface displacements (differential servo) to remove the transient instability, after which the command is automatically eliminated and the surface returned to the trimmed position.

Although these servo system functions differ, they can be achieved simultaneously and differentially through functional servo mechanization of the common control surface actuator.

A WORD OF WISDOM

The SAS makes use of aerodynamic, electrical, hydraulic and mechanical devices to perform its function. One of the peculiarities associated with such a loop system is that a malfunction in any one of these system elements may be difficult to readily identify. For example, an oscillation around an axis may be caused by an incorrect gain setting at the computer, or by air in the hydraulic system, or by a defective mechanical element in a servo unit.

Therefore, as a pilot, do not hesitate to list after each flight *all* the flight control system malfunctions or irregularities. This will aid the crew chief and the maintenance personnel in diagnosing and pinpointing the bad unit.

Checking and trouble shooting the pilot's report is both an art and a science. And one thing we have learned from the earliest great aeronauts and engineers, men such as Lilienthal, Langley, the Wrights, Sikorsky, to our contemporaries is: *Any* change or rework of an aircraft flight control system or aerodynamic change to structure or powerplant must be flight checked. The functional check flight is important and necessary. From my experience as an active engineer and pilot for nearly 40 years, I can appreciate how true the axiom of aviation's great pioneers that, no aircraft change affecting performance would be taken as a matter of fact without flight test.

There is no wind tunnel in existence that will give this data. New aircraft are subjected to rigorous contractor flight test and demonstration before the customer's acceptance. If the aircraft is destined for civilian or commercial use, Civilian Aeronautics Board flight test personnel reverify the performance data jointly with the contractor. If the aircraft is destined for the military, the respective military agency subjects the aircraft at its flight test center to a completely independent and thorough performance demonstration flight test before assignment for operational use. During the demonstration not only is general airplane performance checked, but integration of all systems is verified, particularly those systems which affect flight control or accomplishment of the mission. ★

(Our thanks to the Lockheed Aircraft Corporation for permission to use certain copyrighted material.)

"LOOK YOU GUYS, IT'S ME," the pilot thought to himself as he made a low pass on the base golf course. Yes, it's true; we still have pilots in the Air Force who feel the urge to show off for their buddies. I guess all of us get the old, "Look, Maw, I'm dancing" urge once in a while. Next time you feel that way, think about this fellow who very recently recognized some friends on the golf course and profited from his sad, but very lucky, experience. He clipped the top off a utility pole, cut some power lines, and damaged his aircraft. However, the damage was sufficiently light to allow a safe recovery. You might not be so lucky.

FOR THE SECOND TIME IN THE PAST TWO MONTHS railroad tracks have ruined a big jet engine. The first occurred just after engine start; the latest was after landing.

The wind was gusty and strong as the pilot taxied off the runway in his big century series fighter. Shortly after reaching the taxiway, the captain opened the canopy and the swirling winds carried his blue flight cap from the shelf above the instrument panel into the right hand air intake duct. Although the throttle was immediately stopcocked from the idle position, the damage was done: cracks on three vanes of the engine inlet case; dents on five compressor blades of the first stage rotor; one blade twisted; nicks and dents as far back as the fifth stage rotor. Come on men, secure all loose items in the cockpit. Add it to your checklist if necessary, but let's stop destroying engines with personal FOD.

T-BIRD—INADEQUATE PREFLIGHT—Recently a T-33 landed at a western base with the right half of the plenum chamber access doors open. Closer observation revealed that this half of the doors had been secured by only one dzus fastener which failed on the final approach allowing the door to open. Not one other dzus on that side had been fastened. The crew said they had had work done on the oil pressure transmitter at an enroute base. They were in a hurry and did not adequately preflight the aircraft. Luckily for these boys that the door did not come off in flight. Had this occurred, as with previous incidents of this type, the results could have been disastrous. PERFORM A CHECKLIST PREFLIGHT AS CONTAINED IN THE EXPANDED CHECKLIST IN Section 2, of TO 1T-33A-1.

Maj Archie B. Clark, Jr
Chief, Safety Div., 3575 PTWg
Vance AFB, Oklahoma 73701

AFR 55-14 VIOLATIONS. AFR 55-14 prescribes operational procedures for aircraft carrying dangerous materials as cargo. Although this regulation is only six pages long and easy to comprehend, its provisions are routinely violated.

One source of violations is the aircraft commander's failure to correctly complete the "dangerous cargo" portion of his military flight plan (DD Form 175) as directed by para 4a, AFR 55-14. An associated violation is the failure of the major command or the aircraft commander to insure that destination and departure bases are cognizant of the estimated arrival/departure times and other load information of aircraft carrying dangerous material. (Ref paras 3a(1) and 4b, AFR 55-14.)

Still another discrepancy is violation of para 5, AFR 55-14, which explicitly illustrates and prescribes worldwide inflight emergency notification procedures for aircraft carrying dangerous materials.

Perhaps the greatest number of violations result from inaccurate or incomplete dangerous materials load messages to the control tower/approach control. In some cases, aircraft commanders have denied having dangerous cargo aboard, although subsequent checks of the aircraft revealed the presence of dangerous material. Whenever the control tower/approach control has not received prior notification of arrival of the aircraft, the aircraft commander should transmit the load message as prescribed by para 4c(1), AFR 55-14.

These intolerable situations must be immediately rectified. However trite these violations may seem, strict adherence to the provisions of AFR 55-14 is mandatory.

- Too much information may constitute a communications security violation.
- Not enough information will jeopardize effective fire-fighting and rescue operations.
- False information negates the intent and provisions of AFR 55-14.

It is imperative that all affected personnel become intimately familiar with the provisions and implementation of AFR 55-14. Associated directives to consult are T.O. 11N-20-11 and AFM 71-4. Cargo identifying terms in para 3-3, T.O. 11N-20-11 (5 Jan 1966, Change 3, 1 Mar 1967) that are in conflict with AFR 55-14 (30 Oct 1967) should be disregarded pending T.O. 11N-20-11 revision. (Ref TAC message R-242144Z (25 Nov 1967) which quotes a message from the Director of Special Weapons, Kelly AFB, Texas.)

2d Lt Danny Ray Sheppard
474 TFW Nuclear Safety Officer
Nellis AFB, NV

THIS TRIP ISN'T NECESSARY. Some adventurous types might be tempted to try LSD—just once, just to see what it's like.

Our advice is *don't!* Here's why:

A "trip" lasts from six to twelve hours but can last for weeks, even months. A small dose of LSD has been known to induce severe psychotic reactions, including hallucinations and acute panic with suicidal and homicidal states. But more insidious, perhaps, is the "flashback," a recurrence of the psychotic reaction after a single use, weeks, months or even years later. While there's still a lot to be learned about this drug, there is evidence of other serious changes in body chemistry.

Known users of LSD in the Air Force are to be:

- Grounded—disqualified for flying,
- Disqualified for air traffic control duties,
- Disqualified for duties under the Human Reliability program.

Furthermore, use of LSD resulting in a disabling condition could possibly lead to separation from military service with loss of all medical rights after discharge.

Don't be lulled into trying this stuff. The experts know beyond any doubt that LSD is extremely dangerous and very unpredictable.

WRONG WAY CORRIGAN. A recent minor accident involving an approach end engagement in an F-4 points out once again that the jock has just got to know a little about arresting systems. The old rationalization that sez, "I don't know what kind it is—but if it's there, I'll take it—if I'm going too fast it'll probably fail—but it'll slow me down some—maybe" is just not professional enough to be acceptable.

For your information: An MA-1A modified is the main gear arresting system altered to have a hook capability but retains the anchor chain energy absorber. This modified MA-1A is not multi-directional and is not the same system as an MA-1A connected to a BAK-9, which is multi-directional. For the pilots who haven't been around so long, in a normal engagement with the MA-1A, you pick up the cable with the main landing gear or the tailhook and start progressively picking up chain links. If an approach end is attempted with a tailhook, after engaging the cable you'll instantaneously pick up enough chain to hold a battle ship in berth. In this case the cable broke, and the flailing end of the cable damaged the F-4. The airplane stopped with emergency brakes on the runway. ★

Maj David L. Elliott
Directorate of Aerospace Safety

EVERY MAN AN FSO

The article "Flying Safety is Fun" (March 68) recommends that every man be an FSO. In response, I submit this letter.

The Rex Riley column, page 15, has an item explaining Hz. While a frequency (audio) may be expressed as 336.5 Hz, it is more likely to be 336.5 MHz (megahertz). A *mega* is a million.

The article "Aero Club May Day," page 23, refers to a power setting of "2350 rpm and 2100 manifold pressure." Looks like linotype operator factor compounded by supervisory factor. He meant 21" (inches) of MP. The article would have been more informative if the cause of the loss of oil had been mentioned. His successful forced landing was outstanding.

"The Magnificent Dozen" was tremendous. The survivability of helicopters in hostile (bullets) environment is impressive. I recently completed a year flying Hueys. Our 30 ships were hit on 74 occasions in a nine month period. Only one was shot down. It went in inverted from a low altitude and airspeed. The crew survived and returned to flying status after a relatively short time.

The cooperation of the various services and wholehearted support and respect for each other and their contribution was heart warming. When men's lives are intertwined and each can help the other, a lot of good will and brotherhood makes itself very apparent.

Lt C Thomas W Wheat, Jr,
U. S. Army

AERO CLUB FACILITIES

Referring to your USAF Aero Club Directory on page 18 of the February issue, the members of the Olathe Navy Aero Club wish to know if they are permitted to land at Air Force bases where Air Force Aero Clubs are located.

We hope you can give us this information, along with any regulations we would need to know in order to land and tie down aboard an Air Force base. The Olathe Navy Aero Club flys out of the Naval Air Station, Olathe, Kansas, and all members are familiar with controlled fields. Any information you can give us will be appreciated.

Sylvia L. Jordan
Training Officer
Olathe Navy Aero Club
Olathe, Kansas 66061

Use of Air Force facilities by members of aero clubs "organized as a sundry fund activity and operated as an instrumentality of the U. S. Government" by our sister services is authorized by AFR 55-20, par 6c, (1) (c), quoted below, for your information:

"*Par 6 c.* Aircraft Exempt from Submitting AF Forms 180, 181 and 203. *In addition to foreign government aircraft, certain other aircraft are permitted to use Air Force installations without completing AF Forms 180, 181 and 203. They are:*

(1) Aircraft owned and operated by:

(c) Aero Clubs of the other military services which are organized as a sundry fund activity and operated as an instrumentality of the U. S. Government."

AUGUST 1967 COVER

Your excellent magazine has been a guide to me in many ways: as a maintenance safety code, of course, and now also as a literary guide for my new role as Information A1C. I have benefited from both content and format. Thank you for both.

Like many others, I too would love to have a print of that superb August 1967 cover pic to display. I'm heading out to Vietnam for my stint soon and the Thud is dear to my heart. Although the demand is high, I hope you can fulfill this one request. I shall continue to peruse your periodical in my hootch.

John E. Petroske, AIC, USAF
55th AEMS, AIC Information

Thanks for the kind words—your pic is in the mail. Good luck to you.

FLYING THE PHANTOM

Being an F-4 jock, I read with interest Major Lloyd G. Wayne's fine article "Flying the Phantom" in the April issue. The discussion on page 18 with reference to plus or minus G factor resulting in long or short drop of a bomb may be academically correct, but the way I read the sentences, if you have a plus G factor you hit long and a minus G factor you hit short. This is not the case in actual practice.

If an aircraft commander fails to maintain proper release G condition, the following paragraphs depict what will occur:

- Dive bombing ballistic tables are based on a release G force equal to the cosine of the dive angle (.866 G at 30 degrees, for example). Any deviation from planned G will result in two errors—release point range error, caused by a change in the aircraft angle of attack and dive angle, and bomb trajectory error. The two errors will be partially cancelling, but the release point range error will be the greater of the two.
- An increase in G-loading on an aircraft results in an increased angle of attack, which in effect decreases sight depression relative to the flight path. The result will be a short drop; conversely, a negative G-loading will decrease the aircraft angle of attack, thus producing a long drop.

I mention the above points not to detract from Major Wayne's fine article, but to point out that neophyte gunners could accept this as a rule and flail bombs and rockets over the countryside, never coming close to the target.

Maj Richard A. Housum
F-4 Flight Evaluator/Examiner
Directorate of Tactical Eval
Hq 12AF, Waco, Texas

Following are the author's comments:

"Thanks for taking the time to comment. From past experiences in the F-4, I certainly agree with your bombing error analysis. However, in writing the article I was primarily discussing the flight characteristics of the F-4 and used the bombing examples in an effort to bring a point home to the jock. I did not intend in any way to relate the plus G with a long hit and vice versa. The discussion was in a general sense, using plus and minus and long and short in a conventional manner.

"Your comments are appreciated and I hope this paragraph is not misunderstood by new jocks as a bombing error analysis."

U. S. GOVERNMENT PRINTING OFFICE 1968 301-220/11

WELL DONE

Lt Col Rufus Dye

388 TACTICAL FIGHTER WING, APO SAN FRANCISCO 96288

On 7 November 1967, Lt Col Dye, flying an F-105 Thunderchief, was a member of a 20 ship strike force assigned to attack an important target in North Vietnam. As the force was inbound to the target, deep in enemy territory, a MIG-21 interceptor succeeded in breaking through the force to fire an ALKALI air-to-air missile which impacted directly on Lt Col Dye's aircraft. Lt Col Dye immediately notified his flight leader that he had been hit and, maintaining control of his critically damaged aircraft, began a turn out of enemy territory under the escort of his fellow flight members.

Quickly analyzing the engine instruments and noting the performance of the aircraft, Lt Col Dye determined that it was still flying reasonably well, and he elected to attempt recovery at the nearest airfield some 200 miles distant. The other flight members inspected his aircraft and found that the missile had detonated just inside the tail, blowing away nearly all the speed brake petals and severely damaging the horizontal and vertical stabilizers. The body of the missile had then impacted and lodged between the aft fuselage structure and the engine tailpipe, tearing large holes in both. Forced to fly at full power to maintain airspeed, Lt Col Dye realized that a refueling would be required to reach his intended recovery base.

A unique problem faced him on this refueling: The loss of the hydraulic system would require a forced refueling, one in which he would have to hold the aircraft receptacle on the refueling nozzle by engine thrust since the system could not lock onto the boom—and his damaged engine was not putting out sufficient thrust to permit this. When he was in position behind the tanker, he called the tanker pilot to "toboggan," a maneuver in which the tanker and receiver make a shallow dive with the tanker's power pulled far back. This difficult maneuver gave Lt Col Dye the thrust advantage he needed to take on the fuel required to continue the flight.

On arrival at the recovery base, Lt Col Dye knew he would have to lower his landing gear by the emergency system, that he would be without leading edge flaps, speed brakes and normal wheel brakes, all due to the hydraulic loss, and that he would have at best marginal thrust for his approach. In addition, he anticipated correctly that the damage would most likely have destroyed his drag chute. He wisely chose to extend the gear and flaps at safe bailout altitude and proceeded to check the controllability and power capability of the aircraft. Finding these adequate, he then made a successful landing, using the emergency brake system to steer the aircraft and the tail hook for a barrier stop without further incident.

By his cool professionalism under these extremely stressing circumstances, Lt Col Dye not only effected his own safe recovery but also saved an extremely valuable aircraft. WELL DONE! ★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