aerospace

SAFETY MAY 1977

From a drawing by R. Mahoney.
Courtesy Air and Space Museum.

MAY 1977

UNITED STATES AIR FORCE

aerospace SAFETY

THE MISSION - - - - - - SAFELY!

SPECIAL FEATURES

REGULAR FEATURES

NAME THAT PLANE

THE KEYSTONE B-3

This aircraft had a wingspan of 74 feet 8 inches and a gross weight of more than 12,950 pounds. It was powered by two 525 hp air cooled radial engines.

DEPARTMENT OF THE AIR FORCE • THE INSPECTOR GENERAL, USAF

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MAY 1977 AFRP 127-2 VOLUME 33 NUMBER 5

The Heritage of Lindbergh

Fifty years ago—on 20 May 1927, a slim, boyish young man took off from Roosevelt Field, New York, in a single-engine monoplane with no radio, without a parachute, and only the most elementary of navigation instruments to fly the Atlantic Ocean solo. Covering some 3600 miles, he landed 33½ hours later at Le Bourget Field, Paris, France, to a wild celebration and fame that changed the rest of his life.

The young man was Charles A. Lindbergh. His accomplishment opened an era of growth in aviation that has resulted in supersonic flight and men on the moon. Technology and engineering have taken giant steps forward. Engines and air vehicles today routinely accomplish missions that were unthought of 50 years ago. Complex navigation equipment and highly sophisticated computer techniques have permitted us to fly a space probe for almost a year and, having reached Mars, to selectively and with great care choose a precise place and effect a safe landing. The vision, dedication, devotion and sacrifice of many have made these unbelievable happenings come true.

In the military we have seen the airplane become one of the most flexible and powerful tools. But as with any evolving system, there were losses due to accidents. In 1947, the year the Air Force became a separate service, we experienced 2282 aircraft accidents which accounted for 584 fatalities. Contrasted to that experience, in 1976, the USAF had 108 accidents and 118 fatalities.

Technology and engineering played a role in these achievements, but the most significant factor has been man himself. Our commanders, operators, supervisors and maintenance personnel have teamed with the engineers, program managers, logisticians and the safety staffs to make Air Force operations the most effective, ready and safe in the world today.

As we continue that era opened by Charles A. Lindbergh some 50 years ago, I commend each one of you for your dedicated service and hard work and urge you to even greater heights of achievement, that this great land of ours may continue to remain free and strong. ★

William V. McBride

WILLIAM V. McBRIDE, General, USAF
Vice Chief of Staff

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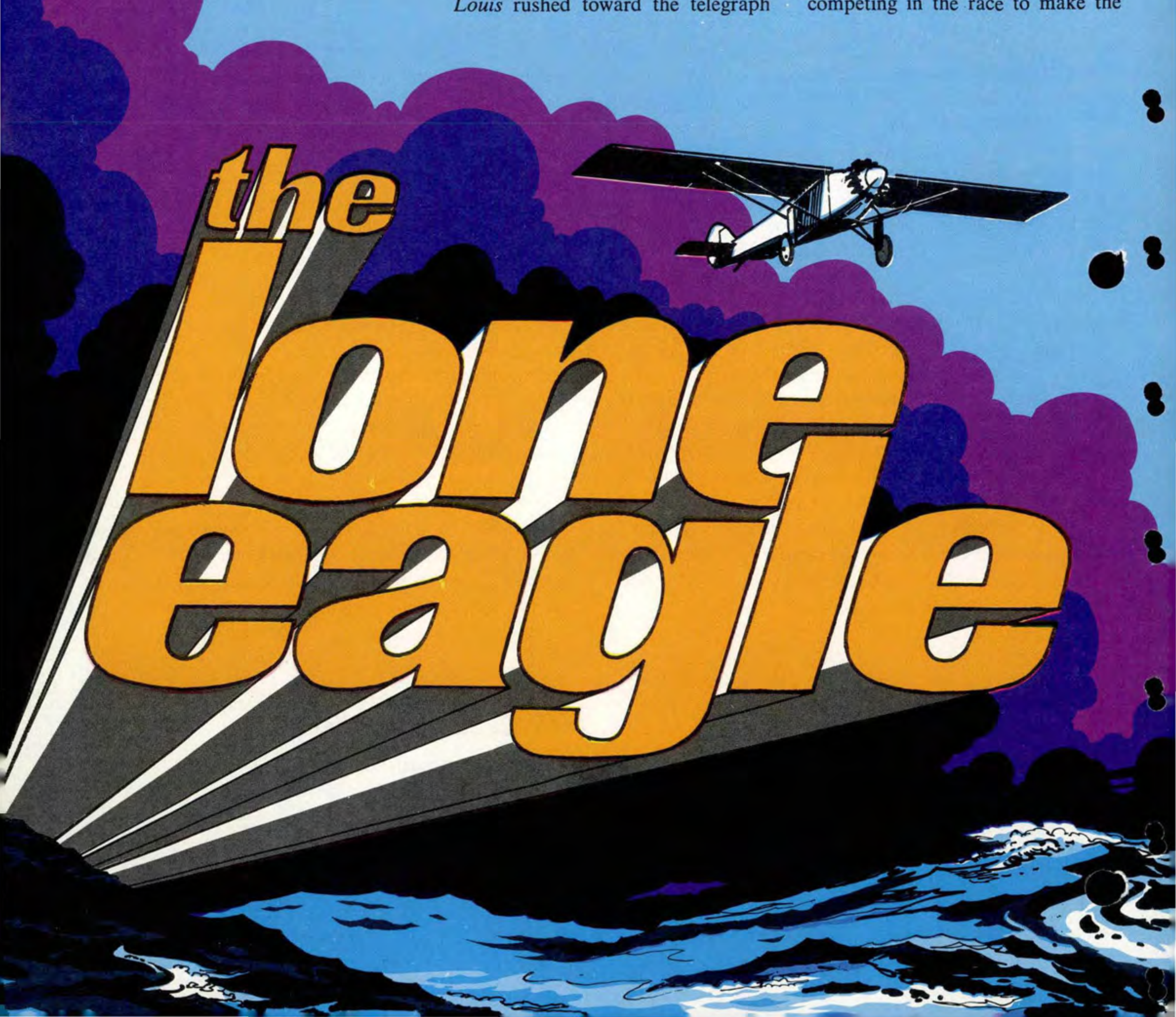
the lone eagle

What would become of him? The odds were certainly against him. At least four previous attempts at the transatlantic, non-stop record had ended in disaster and death. Now it was his turn. The weather was bad and in mid-ocean it would be worse. His Ryan monoplane was as yet unproven and the engine was not performing well at altitude.

After a little uncertainty at engine start, he strapped himself into his wicker seat. Once the engine had smoothed out, he signaled for the blocks to be kicked away and guided the lumbering plane down the sod runway of Roosevelt Field. Gathering speed, the *Spirit of St. Louis* rushed toward the telegraph lines and trees at the end of the field. She bounced several times and shuddered into the air. Lindbergh was on his way. In the next 33 hours, the world would leap ahead 50 years or more.

Behind him lay the world of the barnstormer . . . the wing-walkers, parachutists and county fair spectacles that had given Lindy his beginning. Behind him lay American air power starving for money and pilots and planes—so strangled that, although he showed great promise and had graduated first in his class of 108 cadets, he could not be granted a regular commission.

Some of the greatest airmen who had survived the world war were competing in the race to make the



first non-stop flight across the Atlantic Ocean.

French ace Captain Rene Fonck had crashed on takeoff killing two of the four crewmen aboard in a September 1926 attempt. In April, two more attempts ended in disaster. First, Commander Richard Byrd, who planned the navigation of the Navy's transatlantic flight of 1919 and who would later gain greater fame as an explorer, crashed on takeoff injuring all of the crew except the plane's designer, Anthony Fokker. Ten days later, Lt Commander Noel Davis and his copilot drowned when their Martin "Keystone" bomber flipped over in a marsh.

On May 8, 1927 another great French ace, Charles Nungesser and his navigator, Francis Coli were last seen passing the Irish coast on a Paris to New York bid. They died in, or above, the black green waters of the North Atlantic.

If these great men in their proven machines could not conquer the air, what would become of the tall, young and serious looking airmail pilot in his unconventional Ryan monoplane?

Neither an idealist nor a military strategist, Charles A. Lindbergh was putting it all on the line for the fame and the prize money. ($25,000 being offered by a New York hotelman for the first non-stop flight between France and New York.) Others were watching though. Some for the thrill of adventure, some from morbid curiosity, and a few, the "sons of the prophet," watched for vindication of air power.

It was only a year or so earlier, on December 17, 1925, that Colonel William L. Mitchell had been found guilty by a General Courts Martial. Guilty as charged, he had made public statements that were disrespectful, insubordinate and prejudicial to good order and military discipline.

Mitchell had watched as the Air Service was slashed in manpower and appropriations as soon as the first World War ended. Men died in the crashes of their obsolete and unsafe airplanes. Most galling, Mitchell believed that the US was open to attack by enemies who understood and used the air power that he was trying to develop for our own defense.

Photo courtesy 1361 AVS.

Capt Charles Lindbergh just before the take off from San Diego on the only test flight prior to his transatlantic attempt.

The American Air Service in the great war had flown in French and British airplanes. America's personal contributions to the air war, besides her pilots, were little more than 150 American built—British designed DeHaviland-4s which had been branded "flaming coffins."

Years after the war, American pilots still flew without parachutes and even had to buy their helmets, goggles and flying togs out of their own pockets. America, the inventor of the airplane was ignoring the lessons learned in France and pinning her entire defense on the surface ships of the United States Navy.

On April 28, 1941, the same day that the German Army marched into Athens and just seven short months before Pearl Harbor, Charles A. Lindbergh, Jr., resigned his commission as a Colonel in the Army Air Corps Reserve.

The United States appeared on a collision course with war. Lindbergh believed it was a European

Lindy in the Philippines with sample of the national nut (coconut).

Photo courtesy 1361 AVS.

Above, Charles A. Lindbergh and Col Harry Graham before takeoff from Rockwell Field. Below, Rockwell Field, 10 May 1927. Photographed by Mrs. Laura May McGuirk, Rockwell employee.

Photos courtesy AF Air Museum.

The Lone Eagle

matter and that we were unprepared, in any case. A totally honest man, he accepted what he had been told and what he had seen with his own eyes. The storm clouds of a European war were gathering, everyone knew that . . . but Lindbergh had been there and to him the outcome was already decided.

At the invitation of Hermann Goering, Lindbergh toured Germany and met with its aviation leaders, including Generals Udet and Milch, and with the designer Willy Messerschmitt. He flew over and toured many of the 500 pilot training centers at a time when the British had a mere 12 and the United States only three.

During the European visit, he was told personally by the French Air Minister that the French Air Force was obsolete and capable of producing only 45 new planes each month and the British, 70 or so. When told this, Lindbergh was already aware that Germany was producing 800 new warplanes every month. In fact, on the day the sixth British "Spitfire" rolled off the Vickers-Armstrong assembly line, there already were 2,000 Messerschmitt 109s operational in the Luftwaffe.

Not a Nazi, but awed by what he had seen of German technical skill and infuriated by what he perceived to be British indifference and French incompetence toward the threat, Lindbergh joined a movement called "Defend America First." He made public appearances pleading for America to stay out of the coming "European" war.

Diametrically opposed, President Franklin D. Roosevelt publicly accused Lindbergh of "defeatism" and characterized him at best a "sunshine patriot" and at worst a "Copperhead." Lindbergh's sense of personal honor and integrity left him no alternative but to resign his commission.

Pearl Harbor settled the isolation vs. involvement issue. Lindbergh

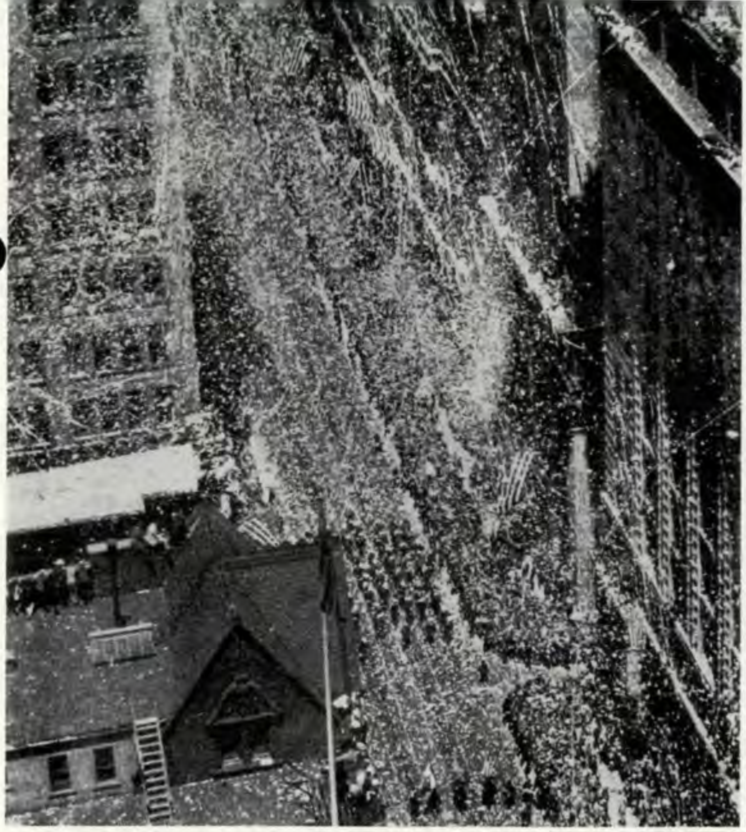


Photo courtesy AF Air Museum.

New York City—June ticker tape parade in honor of Lindy, one of the biggest in New York's history.

still believing that we were in the wrong war, but wanting to do his part, offered his services to the Army Air Corps. Although encouraged by "Hap" Arnold to press the issue, Lindbergh was given little encouragement by the Secretary of War. Secretary Stimson said that Lindbergh might assist as an advisor but ruled out any position of command. President Roosevelt would have to personally approve any appointment and feelings of ill-will still existed between the flyer and the president.

Fearing that he would be shunted into a meaningless, sideline job, Lindbergh withdrew his offer and returned to civilian aviation. He was a civilian (with his country at war) but he was far from the sidelines.

Working out of Ford's Willow Run plant near Detroit, he was as deeply involved in the war as anyone could be. He flew the Army acceptance tests of Consolidated's B-24 *Liberator*, and nearly killed himself flying the high altitude tests of Republic's magnificent jug, the P-47 *Thunderbolt*. Then, fate gave the nod to Lucky Lindy. In a new job as chief test pilot for Chance Vought on the F4U *Corsair* project, he worked a deal with the Navy to go to the southwest Pacific as a technical representative for his company. His job would be to offer assistance and advice, to look into problem areas (one of which was the Corsair's occasional but nasty habit of folding its wings on takeoff) and to get consumer views on ways to improve the design.

Three years to the day after Lindbergh resigned his commission, he was passing through Hickam Field, Hawaii on his way to war. While on that "inspection tour" Lindbergh flew 178 combat hours racking up 50 missions over some of the worst targets in the war zone including Rabaul, the worst of all. The missions were as varied as a pilot could hope for. Bomber escort, strafing, bombing, RESCAP (Rescue Combat Air Patrol), and some honest-to-God air-to-air combat with zeroes.

Although sent out by Chance Vought, with both War and Navy Department blessing to see what could be done to improve the Corsair's performance under combat conditions, Lindbergh changed his plans enough to get in some combat time in the Lockheed P-38 *Lightning* with Kenney's Kids out of Hollandia, New Guinea. He flew as an element leader in the 475th Fighter Group on missions with Tommy McGuire and Charlie MacDonald. While he was at it he managed to get a kill and, almost by accident, stretched the range of the P-38.

Like any of the pilots who had flown the airmail, Lindy was fuel conscious and had just automatically adjusted his settings. By decreasing the rpm and increasing the manifold pressure, he was able to maintain speed with the formation. They came back to base, he with tanks half full while the others were sucking fumes. He shared this bit of knowledge with his friends and, in doing so, practically created a new airplane.

A civilian? Definitely! But on the sidelines? Absolutely not! Regardless of his pre-war views, Lindbergh had come to his country's defense in his own way . . . in the best way he could have. As a civilian Tech Rep he enjoyed freedom of movement and freedom of decision. As a respected flyer he lent his name, his stature, and most importantly,

"We" arrives at France Field. Canal Zone.
Photo courtesy AF Air Museum.

Lindbergh appears to be the epitome of confidence in this photo during visit to a military base. Contrast this with the shy appearing young flyer ready to challenge the Atlantic.

Photo courtesy 1361 AVS

Photo courtesy AF Air Museum.

While in the Pacific Theatre Lindbergh's flying skill earned the respect of aces like Mayor Thomas McGuire.

Lindbergh, left, with Brig Gen Robin Olds.

Photo courtesy 1361 AVS.

his skills to the American war effort.

Lindbergh. The name was magic to young pilots who were waging the air war in the Southwest Pacific. And why not? America's "Lone Eagle" was probably the most adored and admired hero of his time. Just 17 years had passed since he had won immortality as the first man to fly non-stop from New York to Paris.

The immortality was not earned by being first to do it. The glory of Lindbergh's flight was that he had done it alone. Others in competition for the honor and the $25,000 prize had planned their flights with supporting crews and multi-engine planes. Lindy flew alone in a single-engine plane of unproven design.

Thirty-three and a half hours after taking off, at nearly 10:30 p.m. on the 21st of May, 1927, the *Spirit of St. Louis* slipped in to land at Le Bourget airport in Paris. Flying alone for a day and a half, Lindbergh made the 3,600 mile trip with fuel to spare. He had flown 1,000 miles in the ugliest weather of the North Atlantic. Like Columbus before him and Neil Armstrong 40 years after him, he changed the map of man's world. More than that, Lindbergh changed the mind of man.

Mitchell and the other prophets of airpower were vindicated. The airplane was not a novelty, either in the civilian or in the military sense. The oceans were not the barriers they had been, either to international culture or to aggression.

From the Lindbergh flight onward, even the most fundamental thinkers would have to admit, however grudgingly, that airpower was a force to be reckoned with. After the flight, requests for appropriations for research and development of the Air Corps would not be rejected out of hand.

It did not happen overnight. There would still be years of frustration and sacrifice ahead for the men who were trying to give this country an Air Force. Because of what Lindbergh did, though, our entire concept of national defense would be altered.

In return for his life-long gift of accomplishment, inventiveness, support and advice to American air power, President Dwight D. Eisenhower appointed, and the Senate confirmed, Charles A. Lindbergh a Brigadier General in the United States Air Force Reserve.

Lindbergh's achievements inspired a nation and helped to weave the fabric of today's Air Force. ★

HEADS UP

Midair collision prevention, of major concern to all in the aviation community, is creating a large, sophisticated effort. This article deals with an effective but simpler method for use in VMC.

CAPTAIN RICHARD P. MARTIN
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A recently published National Transportation Safety Board (NTSB) summary of recommendations on midair collision prevention reminded us that each year the risk of midair collision increases. Reviewing their recommendations as listed in the 28 January 1977 *TIG Brief*, it is apparent that perhaps much of the emphasis in the way we fly may be in the wrong direction. For example, one recommendation reads, "Develop and publish standards for visual search techniques to be used when pilots are operating in visual meteorological conditions." Many pilots feign clearing, but we should reevaluate how really serious we are about it.

We all know that it is easy to become preoccupied with correcting minor flight parameter deviations (altitude, airspeed) when in visual conditions (ants) and ignore the very real dangers that exist such as small VFR aircraft in close proximity (elephants).

Chapter 8 of AFR 60-16, *Instrument Flight Rules (IFR)*, begins with, "THE AIR FORCE GOAL IS MAXIMUM AIR OPERATIONS UNDER IFR. MAJCOMs will establish procedures to insure that all flights are conducted under IFR to the maximum extent possible without unacceptable mission derogation." Notice that it does not say, "FLY THE GAUGES TO THE MAXIMUM EXTENT POSSIBLE." The discussion continues with, "Pilots operating in visual conditions under IFR should be aware that they are in a 'see and avoid' environment. Separation is provided only from other *known* aircraft operating within CONTROLLED airspace."

When we are flying for instrument proficiency, an instructor or other observer is generally clearing for us. However, too many of us during normal, everyday, operational flying probably spend too much of our time "in the cockpit" when in VFR conditions. No doubt many aircraft fatalities have been the result of such a practice. It seems to be getting harder and harder to break the instrument yoke.

In the Stone Age, before attitude indicators were invented, pilots maintained their position in the air by what they saw outside. I doubt if too many of them unknowingly flew into their neighbor's chicken coops. How many of today's pilots consciously use outside visual references, except perhaps in the VFR traffic pattern? How many think about using outside references for maintaining altitude, heading and bank or are even remotely interested in knowing how? If the answer is few, it may be due to the common misconception that instrument flying is "where it's at," prevalent among large aircraft aircrews, or may be due to the checkride syndrome.

Generally, too many crew members and evaluators are overly concerned about flying within "X" knots of airspeed, "X" degrees of heading, and "X" feet of altitude while being observed. They feel that the best way to impress whoever is looking over their shoulder is to be as close to all flight parameters as possible. Unfortunately, in many cases they are correct. Many people are impressed by this type of performance and place little emphasis on a pilot's awareness of how close he is to all other traffic in his area of operations.

Yet, how many aircraft and/or lives have been lost because a pilot was 10 knots off his airspeed or 100 feet off his enroute altitude? How many have been lost due to midair collision? How many have ALMOST been lost due to midair collision? How many pilots have flown a sound aircraft into the ground in VFR conditions? If you don't think this is a problem, check the NTSB statistics on "controlled collisions with ground/water."

If we are to change the emphasis from "precise maintenance of all flight parameters" to "total professionalism in all flight conditions," priorities will have to be rearranged in three areas: flight examination, flight instruction, and plain, garden variety flying. It is vital for flight examiners to emphasize collision potential awareness, whether it be collision with airplanes or civic auditoriums, and deemphasize the measurement of a pilot's abilities by how well he nails down his flight instruments on a flight check in visual conditions. What we need is more "pilotage." And pilotage, as an art, probably needs more emphasis in all our flying programs.

Next, instructors must be able to teach pilots to operate comfortably in an "outside reference" environment, and make sure they know when the situation calls for such techniques. Last, the pilot, in the operational environment, must take the responsibility and initiative to become involved in the airspace in which he is operating. Review of terminal area graphic notices published in the Airman's Information Manual (AIM) will provide insight to the terminal traffic flow.

Air Traffic Control does not guarantee separation between IFR and VFR aircraft (except in positive control airspace) or even aircraft and mother Earth. (Editor's note: FAA has started installation of a low-altitude warning system at their ARTS III terminal radar locations. Approach Controls at Los Angeles, Dulles, Detroit, Denver, Houston and St. Louis have automatic alerts when aircraft descend below a safe altitude—price of admission is a transponder, with altitude reporting, squawking an appropriate discreet code. All ARTS III sites are scheduled to be equipped by mid-1977.)

FAA Handbook 7110.65, Air Traffic Control, states that the controller has complete discretion for determining if he is able to provide or continue to provide an additional service such as traffic advisories in a particular case. The controller's reason not to provide or continue to provide such service in a particular case is not subject to question by the pilot and need not be made known to him. In short, the pilot must use some VFR composite flight techniques anytime flight conditions are VFR, even while using an autopilot.

VFR and IFR flight use similar concepts. Maintaining IFR means adhering to IFR altitudes and airspeeds, while remaining within defined airspace, such as the enroute structure or terminal area and making the most of any traffic separation service available. When VFR, we still remain within certain airspeed, altitude and area parameters, such as in the traffic pattern. On a VFR flight plan, we are expected to adhere to VFR hemispheric altitudes. They are different from IFR hemispheric altitudes but are to be maintained nonetheless.

For specific aircraft, instrument approaches are flown at specific altitudes, airspeeds and bank angles. VFR traffic patterns are flown within similar parameters. The difference is that VFR control parameters are maintained primarily with outside references, or at least should be. The reason that they should be is to keep aircraft clear of other aircraft, condors and tall pine trees. In the VFR traffic pattern, most pilots position themselves with a visual relationship to the runway, both horizontally and vertically. If anyone can think of any reason why we shouldn't maintain our position visually, when possible, on an IFR clearance, let's hear it. The kicker is that we are better off looking outside than inside when it comes to maintaining flight parameters.

The horizon, our main visual reference, has two significant advantages over any attitude indicator. It is quite large and it has never precessed, although sloping cloud banks may present the illusion that it has. Because of the horizon's size, a one degree change in pitch will appear quite large when made against it.

As an exercise, pick any reference in the cockpit which aligns with the horizon when in level flight such as the magnetic compass, or a mark on the windscreen. Make a pitch change which changes that reference by one inch. The change on the attitude indicator will be almost imperceptible. A change of reference against the horizon can be made more precisely than a change of reference against most attitude indicators. The net result of more precise pitch is "smoothness" and a resultant airspeed stabilization. A result of smoothness is a tendency to relax. When aircraft control smooths out, so do nerves.

Students enrolled in the Instrument Pilot Instructor School have found that, while making pitch changes using this technique, altitude can be easily maintained, usually within ±20 feet with virtually no effort. Another result of making pitch changes on the original "Earth" attitude indicator is that trim becomes natural almost to the point of being subconscious. With so large a reference, a precise pitch can be maintained while the control pressure is trimmed off to zero. With pitch oscillations held to a minimum, required power changes become fewer. With fewer pitch and power changes, trim changes almost disappear. Sound too good to be true? Try it.

A technique for maintaining heading is to pick a point on the ground and simply fly to it. Nothing new here. We've all heard that technique before, but how many of us use it now? If a radar controller assigns a heading 60 degrees to the left of present heading, simply pick a point on the horizon about 60 degrees from present flight path and turn to it. You will more than likely find some easy cockpit reference for 60° left or right. Pilots who try this may be surprised at how close they can come to the correct heading. If they are consistently rolling out past the desired heading, then an occasional cross-check of the heading indicator should assure the desired heading is not missed.

The point is that nothing constructive is accomplished by staring at the heading indicator while it passes through 60 to 90 degrees of heading change. If the urge to stare cannot be overcome, try staring at the sky. Perhaps a flock of geese won't need to terminate their mission because your aircraft has intruded on their airspace.

Bank angle can also be easily maintained. Set 30 degrees of bank, or whatever bank suits your mission, establish level flight and find a good cockpit reference which meets the horizon. If the same seat height can't be assured on every flight, pick new references each flight. They won't be that different. The end result is relaxation and a new awareness of what is happening outside.

There are many attendant visual scanning techniques which make it easy to spend a great deal of time looking out for whatever dangers may be there. Air Training Command publishes several in their instructor study guides, such as performing in-flight checks, one item at a time with a glance outside between each, and scanning appropriate flight instruments and interpreting what is seen while looking out. Perhaps some of you out in the field have similar techniques. If so, put out the word.

As was pointed out in the 28 January 1977 *TIG Brief,* all of our crewmembers must be trained to time share between cockpit duties and visual scanning for targets, airborne or otherwise. They also must be convinced that they won't get hammered for small flight parameter deviations in the meantime. If they are taught to fly *outside,* they won't deviate that much, anyway. The time to get started is now. Some techniques have been mentioned here. There must be more. Perhaps some of the best ones are in your home squadron. Think of what we are really trying to do. We are flying airplanes. We want to fly them safely. We don't want to bend our sheetmetal or anyone else's.

When in the clouds, we need the gauges. That's all there is. When out of the clouds, the best gauge is outside. As a simile, if you are floating in the middle of the ocean, a good life preserver is great. When you get picked up, it isn't needed anymore. You may hang on to it, though. That boat that picked you up might sink. Instrument proficiency is inherent in the wings we wear as pilots. It is a valuable aid when we need it. It may be an unnecessary encumbrance when we don't. Heads up. ★

IMPROVE THE ODDS

MAJOR PHILIP M. McATEE
Directorate of Aerospace Safety

What would you say if you could reduce one category of mishaps by 25%? Think that is impossible? Well there **is** a category—landing mishaps—where we could do it!

The AFISC mishap forecast for CY 1977 predicts 12 pilot induced landing mishaps during the year. As writer/philosopher George Santayana said, "Those who cannot remember the past are condemned to repeat it." In order for us not to repeat ourselves, we must look to the past for clues to guide our effort to meet our reduction goal.

A review of all pilot induced landing mishaps during the period June 1975 to February 1977 has yielded some interesting statistics. In our sample period there were 31 mishaps that fit our pilot-induced damage over $50,000 category. Now in order for the number 31 to have meaning, we must consider that there were more than 4 million Air Force landings (exact landing figures are not available) during the same time frame. ATC alone makes over 100,000 landings per month.

That means AF-wide there was less than one landing mishap per 100,000 landings. Now that looks like we are doing pretty well. If we are doing that well, how can we expect to achieve a 25% reduction in our 12 predicted landing mishaps? To see what is necessary for us to do to achieve this, let's review some mishaps over the past two years to see what they have in common:

• A T-33 was practicing a simulated flameout pattern. Shortly before rolling out on final, the pilot selected full flaps. Then the IP requested full throttle. At approximately 50 feet above the ground, the IP raised the flaps in an attempt to stretch the glide. The aircraft struck the ground 630 feet before the runway. CAUSE. The instructor pilot did not make a go-around before the pilot got the aircraft into a position from which recovery was questionable!

• A T-33 was on a student transition flight. After practicing simulated flameout approaches, the pilot entered downwind for a no flap touch and go. The pattern was normal until the T-33 was approximately 3700 feet from the runway. The aircraft struck the ground 156 feet short of the runway. CAUSE. The instructor pilot failed to closely monitor airspeed and failed to take command in time or initiate a go-around when low airspeed and high sink rate were established.

• An F-106 was practicing approaches, after completing night intercepts, when the pilot noticed a fuel imbalance and requested a full stop. His wingman was flying

a loose formation when, at two miles on final, he went around. The mishap pilot was distracted, and misread VASI indications. The aircraft hit short or struck a 9½ foot mound on the end of the runway. Although the pilot immediately executed a missed approach, the aircraft landing gear was badly damaged and he ejected. CAUSE. The pilot failed to execute a missed approach in time when his concentration was broken for the approach.

• An RF-4 was on a formation landings sortie for a student due to a previous unsatisfactory ride. The mission was normal until a formation GCA approach with the IP in the back seat demonstrating a formation landing. As the two aircraft came over the overrun, the mishap aircraft drifted to the right and touched down off the right side of the runway. CAUSE. The front seat pilot failed to take action to call for a go-around when he realized the aircraft would not touch down on the runway.

• An IP was demonstrating to a student a circling approach in a T-38. The IP rolled the aircraft out on final ½-¾ mile from the runway at 600-800 feet. The final approach was steeper than normal with a high rate of descent. The IP tried to add power to extend the touchdown point and slow the rate of descent but it was too late. The right main and nose gear failed immediately upon touchdown. CAUSE. The IP failed to initiate a go-around when the aircraft got too close in and too high on final to permit a safe landing.

The preceding mishaps have one thing in common: **a go-around when the approach did not go as planned probably would have averted the mishap.**

Let's go back to our prediction of 12 pilot induced landing mishaps for 1977. At least **three** could have been prevented if **all** pilots would **always** make a missed approach and try it again if, at any point, the approach or landing is not going as planned. Don't try to stretch that touchdown point! Don't try to recover that bad approach.

Any pilot can end up with an unstable approach for a multitude of reasons—wind shear, unstable speed, too high a sink rate, distractions, weather, etc! The reasons are many but the solution is the same. Take it around and try again.

Let's all try and make our prediction of 12 landing mishaps be wrong on the pessimistic side.

Whenever the approach is not going to your liking, taking it around and trying again can improve **your** odds of not having a landing mishap.

Now how can you pass up a deal like that? ★

DETOUR T-STORMS

T-39 (above) and B-52 show damage sustained in hail encounters. Hail, ice, water, intensive up and down drafts are characteristic of well developed T-storms.

The most powerful engine we have is as but a speck of salt in the ocean when compared to the greatest engine on this earth —the thunderstorm. An awesome package of violent winds, ice, hail and rain, at the height of its power it is capable of destroying any aircraft whose crew is imprudent enough to penerate it.

Long ago pilots learned to respect severe weather simply because they had to. They didn't have airplanes that could routinely fly above most weather. They didn't have radar to help avoid danger areas. They didn't have the weather and air traffic support we take for granted today. In fact, we have so much going for us that we must guard against becoming complacent and fail to respect—and fear—those giant engines in the sky.

For the past three years we have averaged six weather related accidents per year. Very few of these have involved thunderstorms, but one which did resulted in a catastrophe. A C-141 disintegrated in the air after penetrating a thunderstorm. The aircraft was in an area of several thunderstorms and its airborne radar had failed. The air traffic controller had told the pilot that there was a solid wall of severe weather between the aircraft and its destination and that he couldn't see any way around it. Shortly afterward, the aircraft evidently encountered extreme turbulence and broke up in flight.

That was the only accident of that type that the Air Force has experienced in recent years, but there have been several air carrier accidents. In 1975 an Eastern Airlines B-727, driven downward by the force of a violent downdraft, struck the approach lights, 2400 feet short of the runway, at Kennedy Airport, New York.

The aircraft was one of 14 which landed or attempted to land within a 25 minute period during the busiest time of the day—1545 to 1610. The other flights experienced from none to serious problems. Most reported some windshear and rain. All of the aircraft passed through a portion of a small but extremely violent thunderstorm cell. The accident aircraft's misfortune was to fly through the center of the cell at an altitude and landing configuration that made it most vulnerable.

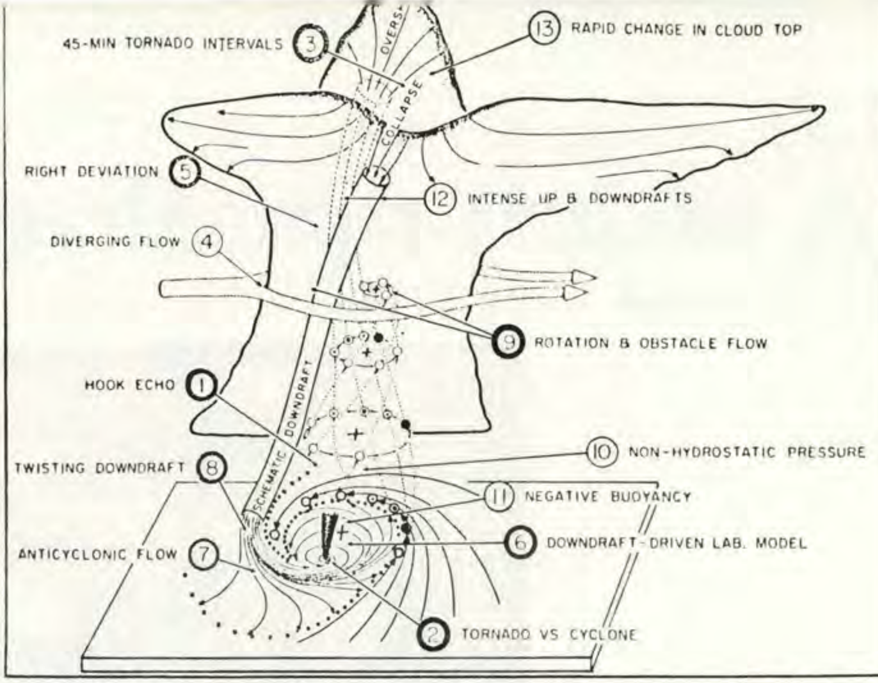
Other aircraft experienced similar difficulties but circumstances were enough different that they were able to avoid an accident. The airspeed of one aircraft dropped 25 knots another 20 knots. Airspeed of the accident aircraft decreased from 138 to 122 kts in seven seconds. The loss of speed and the tremendous downdraft made a go-around impossible.

On August 7, 1975, Continental Flight 426 took off at 1610 from Stapleton International Airport at Denver. At approximately 100 feet above the runway, airspeed dropped from 158 kts to 116 in five seconds and the aircraft descended to the ground. Another victim of a severe downdraft cell.

In the foregoing two cases. small but extremely violent cells known as down bursts caused the accidents. This is a recently discovered phenomenon, which indicates that we still do not fully understand the thunderstorm mechanism.

So far we have discussed only the shear and associated turbulence resulting from the tremendous downrush of air and rain in thunderstorm cells. But there are other dangers which can be just as bad. Lightning is one of the most common things associated with thunderstorms. Lightning occurs within the cloud, from cloud-to-cloud, cloud-to-ground and can travel several miles. Aircraft apparently trigger lightning by building up a charge from friction with particles in the air. When an aircraft enters a cloud it can trigger a strike. Generally, strikes cause little damage, but occasionally they cause severe problems such as loss of a radome and, in a few cases, structural damage to components such as the vertical stabilizer.

There are very few documented cases in which lightning triggered an explosion in an aircraft but it has happened. The correct mixture of fuel vapor and air in a tank at the right temperature results in a very explosive mixture that lightning theoretically, at least, could detonate. Lightning seems to like a temperature of about +5°C to −5°C.



A model of a tornado cyclone, which was presented before the Subcommittee on Space Science and Applications, Washington, D.C.. November 6, 1973.

Hail is another feature the T-storm serves up. Usually hail is found in the center of the storm, but a good, strong updraft can lift it and throw it out the sides and top. Winds carry hail as much as 20 miles away, where an unsuspecting pilot, flying in crystal clear, calm air, can suddenly hear the pinging of hailstones on the skin of his aircraft. Hail is bad news. It damages composite materials such as radomes, peens leading edges and tears up antennas. It can also damage inlet guide vanes and other engine components. Hail accompanied by a large volume of water can cause compressor stall and even engine failure. Witnesses aboard a DC-9 that crashed near Atlanta in April said that prior to engine failure there was intense hail and a lightning strike on an engine nacelle.

Almost always present in the vicinity of T-storms is turbulence—from light to medium chop to extreme turbulence in the storm. It is a product of shear and is most severe in the heaviest moisture area. Radar is the best weapon available for avoiding severe thunderstorm turbulence, but there are limits. It can't "see" turbulence; rather it sees the moisture in the air. The ISO-ECHO feature better defines the area of high moisture. Recently, RCA announced a new multicolor radar. The area of heaviest rain—maximum turbulence—shows red. Around it—less moisture and less turbulence—the picture is yellow. Beyond that in the clear, the picture is green. But don't look for it in your aircraft anytime soon.

With airborne radar, you're in good shape. If you don't have it, your air traffic controller may help out. However, he may not be able to provide weather radar service at all times.

All thunderstorms are potentially dangerous and should be avoided. When penetration is unavoidable, the aircraft should be configured in accordance with the Dash One. A request for controller assistance should be made as early as possible.

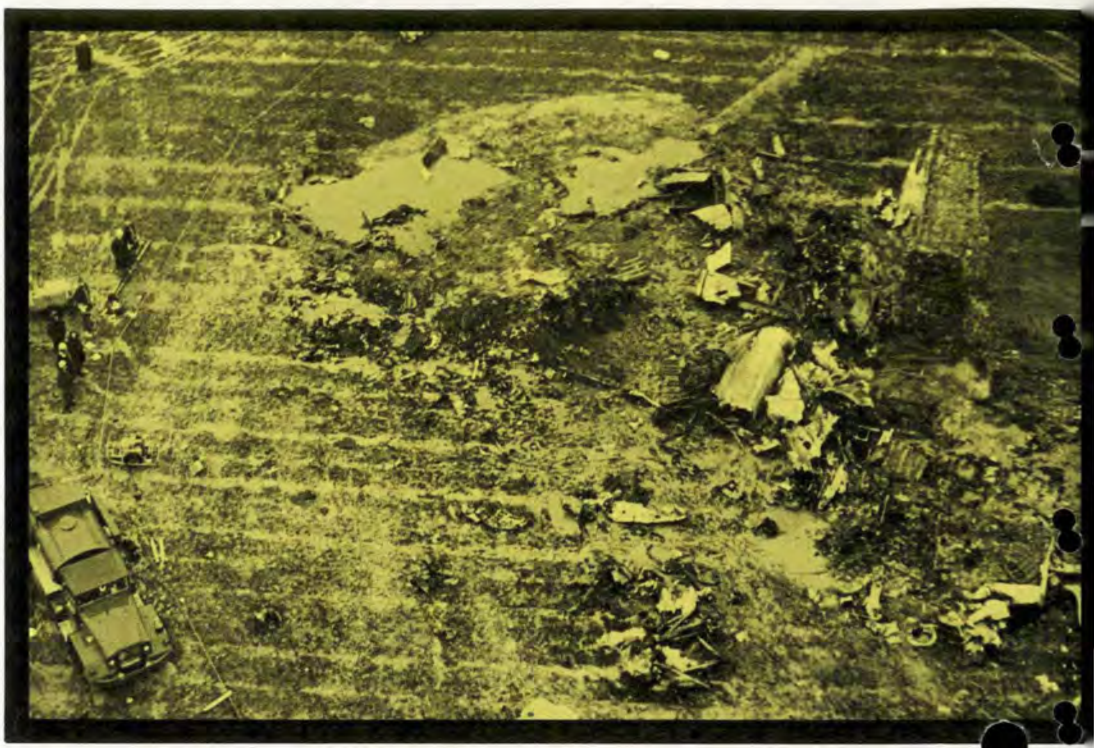
Pilot reports can be especially helpful, particularly in areas of high traffic density when weather is rapidly changing.

Areas of severe weather can often be avoided by careful planning. However, keep in mind that forecasters cannot predict with required accuracy thunderstorms that have not yet formed, time and place of extreme turbulence, when freezing rain will occur. ★

Addressing "Collision With The Ground" Accidents

A MULTI-PRONGED ATTACK

MAJOR THOMAS R. ALLOCCA, Directorate of Aerospace Safety



The aircraft, the aircrew members and the operating environment are three aspects of the aircraft safety problem. We've come a very long way with the aircraft, although we've yet to produce an accident-proof airplane. The other two have far more unpredictable variables, especially the aircrew members. They, in general, pose the knottiest problems for those concerned with aircraft accident prevention. The aircrew successfully completes a mission on one day and then collides with the ground on the next. Why?

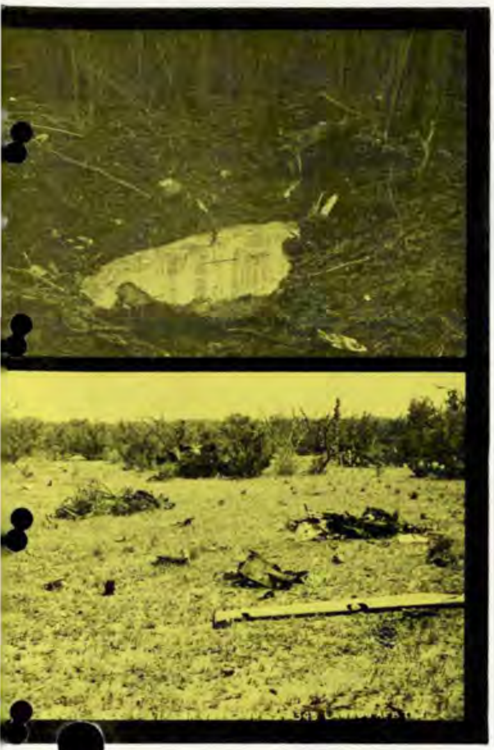
The accident narrative stated ". . . the aircraft was flown into a mountain and was totally destroyed . . . the crew members received fatal injuries . . ." The total cost of the mishap exceeded 13 million dollars.

Another narrative reads: ". . . the aircrew accepted a clearance and descended to an altitude lower than the minimum sector altitude in mountainous terrain. The aircraft struck a mountain, was totally destroyed, killing all aboard." The total cost of this mishap exceeded 7 million dollars.

A third accident occurred when "the pilot at the controls descended below minimum approach segment altitude." This mishap, involving seven fatalities, cost well in excess of 3 million dollars.

The accident board report on accidents of those types generally concludes with causal factors such as "descended below minimums" or "descended below safe terrain clearance altitude." While such statements are totally true, they don't address the nagging question: Why? Why does a competent, trained pilot descend below a safe terrain clearance altitude until he hits the ground? Why does an experienced aircrew, which have been briefed about the hazards of flight in mountainous terrain, descend below minimum terrain clearance altitudes? In many, perhaps most, cases the accident investigators simply "don't know." Perhaps the most significant aspect of such findings—from the accident prevention viewpoint—is that they leave little, if any, foundation upon which to build a program of remedial action. Consequently, various schools of advocacy arise, each seeking to correct the problem.

One approach attempts to solve the "collision-with-ground" problem by instituting a piece of "warning equipment," whose function would be to alert the crew of im-



pending disaster. Similar devices have traditionally been incorporated—with success—into the fleet as a result of an alarming number of mishaps. For example, the jet engine overheat warning systems, common to Air Force aircraft, were incorporated to alert the crew of potential engine problems. A ground collision warning device, the equipment enthusiasts assert, would function much the same way, alerting the crew of a flight condition which must be corrected to prevent ground impact. They also cite, as supporting rationale, that the Air Force has opted to outfit a small portion of its fleet with a ground proximity warning system. We should be cautious, however, of jumping on the warning systems bandwagon since they may not prove to be a panacea.

There are several ways in which a crew may become aware of a potentially dangerous situation. Our experiences with a variety of audio and visual warning devices, and various combinations, indicate none have met our expectations. Mishaps still occur, many even though the devices functioned properly. Why is it then, that, in spite of such systems, accidents still occur due to incorrect crew actions following a warning indication?

Some safety experts believe that present-day warning systems are unsatisfactory and that the addition of still more colors, bells or buzzers may not lead to significant safety improvements. These specialists do not discount the utility of warning systems; they believe, rather, that if such devices are to be truly effective, what may be needed is a basic change in the philosophy on which such a system is based. They maintain that these systems will always contain a basic shortcoming—that of not prioritizing the relative urgency of the warning—and that until this basic deficiency is rectified, alerting systems will not be totally effective.

A second approach to addressing the "collision with the ground" mishap problem would have Air Force make a broad-scale review of training strategies and tactics. This approach assumes that the problem can best be addressed by evaluating the training concepts and procedures used to prepare aircrews for low level* flight operations.

However, devising a training strategy which will minimize the kinds of mishaps described above is a difficult undertaking. Learning and human behavior theories have undergone great changes in recent years and the resulting kaleidoscopic effect has tended to fragment, rather than simplify, training strategies. Nevertheless, the training advocates insist that we need to continually review such things as curricula development, student/instructor selection criteria and training aid selection/use to ensure that we are using sound rationale to develop and implement training strategy.

In the final analysis, we really do not know "why" these mishaps occur and can't readily choose one approach over another. Or at least not with any real conviction. Our investigations in the past have been material failure oriented. We now need to really address the nagging question of "why" by improving the quality of our mishap investigation. Accident investigators have spent many hours trying to puzzle out the "why" of these kinds of accidents. In some cases they have been able to suggest, if not absolutely prove, one or more reasons for the departure from a normal flight path. When these reasons are suggested, however, they more often appear to be strokes of brilliant intuition on the part of a single investigator rather than the result of an established, proven, deductive, investigatory process.

Proponents of the need to "improve the quality of the investigation" argue—with considerable vehemence—that we have become expert at reconstructing the wreckage of an aircraft mishap to determine

*Low-level operations include "terrain following/low level flight," penetrations, approaches and landings.

what "mechanically" caused the accident. What we are not able to do, they contend, is to dig into the human factor elements which must be the underlying cause of an accident when mechanical, support and procedural cause factors have been eliminated. Advocates of this approach suggest that we must first master this ability before we can effectively answer the "why?".

However, this course is also not easily achieved. Delving into an accident to uncover the deep psychological, or perhaps, psycho-physiological, reasons for human deviation is difficult at best, impossible at worst. It would be foolhardy to suggest that a USAF mishap investigation board would ordinarily possess the necessary expertise to address such issues. Moreover, the human factors aviation communities have not provided the accident investigator with the basic research from which he can construct an effective, deductive "checklist."

How should USAF prevent recurring "collision-with-ground" accidents? Equipment modifications? Enhanced training? The proponents of each of these approaches do not deny the validity of the others, but believe, rather, that the area of their particular interest offers especially significant opportunities for enhanced safety. I submit, however, that while each approach contains an essential kernel of effectiveness, the answer may lie in a combined effort.

First, we must improve the quality of our investigations of people-caused mishaps. Such improvement will likely lead to valid, effective recommendations. Many, if not most of these recommendations, will involve the areas of equipment improvement, procedural changes, training improvement, and other relevant activities. We must then ensure that we implement, as expeditiously as possible, the agreed-to recommendations.

I believe that the synergism resulting from a coordinated attack, equipment modifications, better training and improved mishap investigations, will go a long way to not only answering the "why?" but —more importantly—to ensuring that the question is not asked time and time again. ★

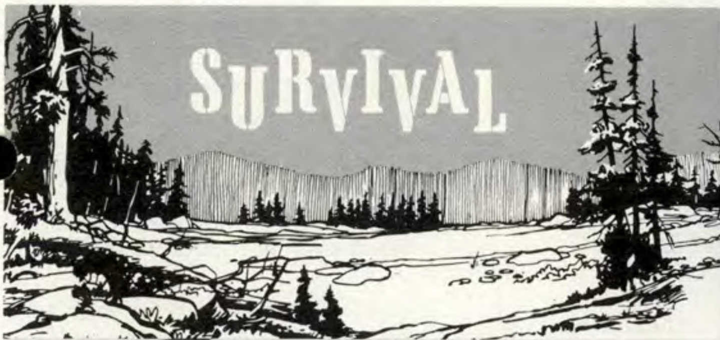
The Pilot Walked Away

A student pilot was following his instructor in close trail formation through combat maneuvers in F-84F's. The instructor made a sharp turn and the student was unable to follow. He lost his leader, applied power, climbed and collided with Lead and went into a steep spiral or spin. The student was unable to recover, so at 5,000 feet, 500 knots, he ejected successfully and without injury. The aircraft exploded on ground impact and was destroyed.

The entire nose section of the instructor's aircraft (555) was torn off as a result of the collision; but the pilot was unaware of it. He felt some vibration at 89%, so he reduced throttle to 35% and returned to base. Unable to operate the landing gear with either the normal or emergency system, the pilot elected to land wheels up on the runway. Damage from the collision plus the skid on the runway was such that the aircraft was considered a wreck. The pilot was unhurt.

Photo and narrative courtesy of the Fairchild Republic Co.

This event occurred in the 1950's and involved a Belgian aircraft. ★



THE SDU-5 NRS, ELF AND YOU

CAPTAIN RONALD E. VIVION and TSgt CHUCK MORROW
Operations and Requirements Branch, 3636th Combat Crew Training Wing, Fairchild AFB, WA

ITEM—SDU-5/E DISTRESS MARKER LIGHT

Flashing strobe beacon carried by aircrews for use in facilitating rescue or alerting forces to position on ground. Includes a blue flash guard to prevent mistaking flash for ground fire and an infrared (IR) hood for use with selected recovery systems (see Fig. 1).

ITEM—NRS—NIGHT RECOVERY SYSTEM

Consists of on-board equipment carried on selected HH-53 "Super Jolly Green Giant" rescue helicopters. Combines visual and electronic emissions from ground personnel to facilitate rescue of downed crew members at night.

ITEM—ELF—ELECTRONIC LOCATION FINDER

Consists of on-board equipment carried on selected HH-53s. Utilizes electronic emissions from crew member on ground to precisely locate survivor position and aid in approach and recovery for pickup.

ITEM—YOU.

The survivor on the ground, or water, having specific responsibilities to help the rescue forces in recovery, under any conditions.

SDU-5 strobe. Light must be visible and stationary for successful rescue.

The problems associated with the rescue of a downed crew member have multiplied greatly with the growth of rescue and survival possibilities. We may not have air superiority in the next "go-around"; nor may we be able to soften up an area sufficiently to insert a gaggle of rotorwings. On the plus side though, there are some newer pieces of gear in the inventory which will allow a helicopter to insert into an area, grab you, and run.

Let's assume that you have been shot down in a medium-threat area and survived to the point of making contact with the SAR Forces. With the state of the art of point defense increasing in quantum leaps, that medium-threat area could quickly turn into an extreme threat if a full-blown SAR is initiated. So, covert SAR may be the only answer.

The right side of an HH-53 cockpit showing the NRS equipment installation.

Covert SAR implies that "don't nobody know about it, 'cept them that's doing it?", and that's the meat of this discussion—get a rescue craft into the area, locate the survivor, and rescue him/her without the enemy being aware of the activity. One means of doing this is to utilize natural masks: namely, darkness, weather, terrain, and small forces (hard to detect). That is what the ELF and NRS systems are all about. They are designed to allow a helicopter to E&E into a defended area in normally adverse conditions. I'll briefly discuss each of these systems and your responsibilities.

The ELF system depends on radio transmissions from the survivor on either 243.0 or 282.8 and only these frequencies. These signals are converted into guidance directions to the crew. The approach is flown manually, and the hover can be done automatically or with good old hands-on talent. Whichever method is used, the survivor must follow directions explicitly. If a 15-second hold-down is requested, that's exactly what is needed. The pilot may request you to turn on your beacon, leave it on, make a short transmission on your survival radio, or a combination of these tasks. Do what he says . . . but a little human cross-check will help matters considerably. If you hear or see the aircraft, say so, and keep the pilot informed of his progress. This is where sound vectors and your compass can be extremely valuable. Line-of-sight transmissions will be critical when using this equipment, so rescue will be aided if your hiding spot uses available terrain to enhance your transmissions.

As the name implies, NRS is used to make night pickups. NRS-equipped aircraft use visual navaids, or sensors, and possibly the ELF system, to do this. As a survivor, you must know that it is vitally important to follow directions. You must have the SDU-5 strobe light ready with its IR hood attached. If the hood is not in place, the high-intensity strobe light will zap the sensors when you turn it on. Also, the strobe must be stationary since it is used as a hover reference. If you move it around while the chopper is in a hover, the aircraft will make a corresponding shift. Place your strobe in an open area. Keeping it with you in a bush will confuse the issue, since the leaves diffuse the light. We can think of few things worse than an HH-53 trying to use a leaf for a hover reference. Remember that when you are on the hoist, the chopper is still using that hover reference; so if you don't want to go swinging through that bush or tree several times on your way up, pick a nice, open clearing and set the strobe there.

There has been a great deal of discussion in the past about the noise that the SDU-5 makes when activated. The clicking sound as the strobe discharges and the small whine associated with the charge build-up are noticeable when all is quiet. With a "53" clattering around in your neighborhood, you shouldn't have much fear of the sound giving away your location. If it bothers you greatly, you can muffle the sound by cupping your hands around the sides of the beacon. Unmuffled, the sound of the strobe still can't be heard even at moderate distances.

All of this activity in your area will certainly draw some attention from opposing forces. The primary factors to keep in mind are to be careful, use your head, and have a little faith in your own abilities. Don't hesitate to take charge of your SAR if you see the situation requires it; but you still must follow directions explicitly and avoid those small errors that can be costly.

To improve night recovery capabilities, the new PAVE LOW III system is coming into the inventory. As test results become available, we'll update you on both its characteristics and your responsibilities concerning its use.

Now . . . here's a short quiz. Without conferring with anyone, answer these questions:

1. Do I have a strobe light (SDU-5) in my survival gear?

2. Where is it located?

3. Does it come equipped with both hoods (blue flash-suppressor and IR)?

4. Can I operate it in the dark?

If your answer was "no" or "I don't know" to one or more of these questions, we highly recommend that you get with your Life Support Survival training folks and find out all of the answers.

Comments and questions concerning the information contained in this article may be forwarded to 3636th Combat Crew Training Wing/DOTO, Fairchild AFB WA 99011, AUTOVON 352-5470. ★

The excellent article which first appeared in the Digest of U.S. Naval Aviation Weapons Systems, *Aeronautics Edition, April 1969, on the generation of static electricity in aircraft fuel systems was presented at the Lightning and Static Electricity Conference in December 1972, sponsored by the Air Force Avionics Laboratory, Air Force Systems Command. Recently, the Air Force has experienced fires in the F-105, A-10 and UH-1 fuel tanks which occurred during aircraft fueling operations. Therefore, this article is not only timely but also provides the technical information as to why this hazardous condition exists. Action has been initiated by AFSC to provide the solution to reduce or eliminate the electrostatic hazard during aircraft fueling.*

ELECTROSTATICS IN JET FUELS

DR. JOSEPH T. LEONARD

A hydrocarbon liquid such as jet fuel develops an electrostatic charge as it flows over another surface. Although the exact nature of the mechanism involved is not completely understood, the charge is generally thought to be caused by ionic impurities in the liquid in parts-per-million or parts-per-billion quantities. These impurities, though inactive when the fuel is at rest, can contribute sufficient charge to the fuel in motion to produce fires or explosions at the point of discharge. Thus, electrostatic activity can be hazardous in jet fueling operations.

CHARGE MECHANISM

When the fuel is at rest, the impurities are absorbed at the interface between the fuel and the walls of the container, with one part of the ionic material showing a strong attachment for either the fuel or the metal surface. The negative portion of the molecule, more strongly attached to the wall, and the positive part, remaining in the liquid, form a sort of double layer along the wall. When the liquid is at rest, the numbers of both positive and negative charges are equal and hence there is no net charge on the fuel.

However, when this same fuel begins to flow, the charges separate, and positive ions are swept along with the fuel while the negative ions migrate to the wall of the pipe. In this manner, the fuel acquires a net positive charge as it moves through the system.

When the charged fuel is loaded into a tank, either of two possibilities will occur: (1) the charge will relax naturally and harmlessly to the walls of the container or, (2) if the conductivity of the fuel is sufficiently low, the charge may accumulate and give rise to high potentials on the fuel surface. If conditions are right for local potentials to exceed the breakdown value of the vapor space, electrical discharges will take place. Whether or not the vapor ignites then depends on the composition of the vapor and the nature of the discharge.

Charge Relaxation

Aircraft fuels in general, and jet fuels in particular, are susceptible to electrostatic charge generation primarily because of their low conductivity. The rate at which the charge on a fuel relaxes depends on its conductivity, as shown in the equation:

$$Q = Q_{\sigma}\varepsilon^{-tK/\varepsilon\varepsilon_{\sigma}}$$

where

Q_{σ} = initial charge

Q = charge at time

ε = dielectric of free space

ε_{σ} = permittivity of free space

K = conductivity of the fuel

Since charge decay is an exponential process, the charge never goes completely to zero. Therefore, in discussing charge decay, it is more convenient to speak of the relaxation time constant, T, which is the time required for the charge to decrease to 37% of its original value. For, when $Q/Q\sigma = 0.37$,

$tK/\varepsilon\varepsilon\sigma = 1$

and

$r = \varepsilon\varepsilon\sigma/K.$

Thus the relaxation time constant is similar in concept to the RC time of an electrical circuit. The relaxation time constants for fuels of various conductivities are shown in Table I.

If the conductivity of the fuel is less than 10^{-14} mho/cm, the charge may relax faster than predicted by this equation. However, most jet fuels have conductivities in the range of 10^{-14} to 10^{-13} mho/cm (see Figure 3). Since the relaxation time constants for fuels in this range may be as long as 18 seconds, it is possible for such fuels to build up dangerous potentials during fuel-handling operations.

Charge Increase

The generation of charge on fuels flowing through pipes sharply increases with the introduction of a filter system into the line, as shown in Figure 1. A typical aircraft refueling operation is depicted at the top of the figure. Fuel from a hydrant line passes through a dispenser cart containing a filter/separator unit and then on to the aircraft wing tank. The graph at the bottom of the figure plots the level of charge on the fuel as it passes through the various pieces of equipment shown directly above. When the fuel passes through the filter/separator unit, there is a tremendous increase in the level of charge on the fuel.

TABLE I.
Relaxation Time Constants For Fuels.

Conductivity (mho/cm)*	*Relaxation Time Constant (Sec.)*
10^{-15}	180
10^{-14}	18
10^{-13}	1.8
10^{-12}	0.18
10^{-11}	0.018

*mho - Conductance of a body having a resistance of one ohm per centimeter.

Thus, fuel enters the aircraft in a much more (10 to 15 times more) highly charged condition than if it had not been filtered. The reason for this increase is that the filter provides a large amount of surface area on which the charge separation process can take place within a comparatively short time. And, since there is little opportunity for charge relaxation to occur, the fuel emerges from the filter/separator and enters the aircraft in a more highly charged condition. How hazardous is this charge to the fueling operation?

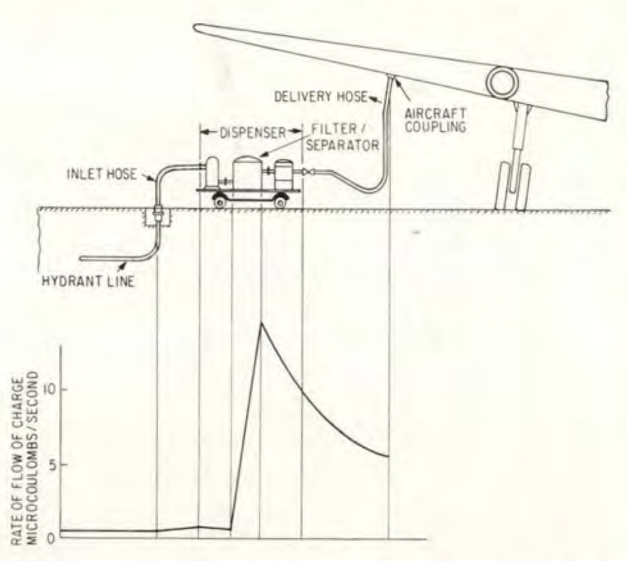


Figure 1. Effect of Filtration on Fuel Charging in an Aircraft Refueling System. Reproduced from Winter. E.F., Roy.Aero.Soc.66 429(1962)

IGNITION HAZARD

In comparison with the thousands of safe fuel-handling operations conducted daily all over the world, there have been very few fires or explosions resulting from static electricity generated by the fuel. Yet, during one winter in Canada, the RCAF experienced several electrostatically ignited fires while refueling jet aircraft with JP-4 fuel. This means that, given the proper set of circumstances, electrostatic charging of fuels can constitute a real hazard. The conditions necessary to produce this hazard are: the presence of a flammable fuel/air mixture in the vapor space of the tank and a discharge of sufficient energy and duration.

Flammability

As suggested in Figure 2, not all fuel/air mixtures can be ignited. Instead there is a definite concentration range over which mixtures of each hydrocarbon in air will burn. This is called the flammable range. For a material such as n-octane, a hydrocarbon found in jet fuels, the flammable range extends from 0.92 to 6.5 percent of n-octane in air. If the upper limit of this range is exceeded, the mixture becomes too rich in hydrocarbon to be ignited. Likewise, if the fuel vapor concentration falls below the lower limit, insufficient hydrocarbon is present in the vapor space to sustain combustion.

Using temperature limits rather than concentrations, Figure 3 presents the flammable range of several common fuels. The areas described by the double-headed arrows represent the flammable ranges for the individual fuels. Avgas, for example, is seen to be in the flammable range from −40 to 20°F. Above 20°F, equilibrium mixtures of Avgas in air are too vapor-rich to be ignited. For JP-4, the flammable range extends from −35 to aproximately 75°F. Above 75°F, JP-4 passes into the vapor-rich region. For kerosene, the lower flammability limit corresponds to about 110°F, and for JP-5, it is 140°F.

The temperature-flammability limit concept applies only to situations in which the liquid fuel is in equilibrium with its vapor. Consequently these limits should be used only to estimate the composition of a fuel/air mixture in a quiescent tank. At best, they can serve only as a rough guideline in describing the situation that exists inside an aircraft wing tank during refueling. In practice, these conditions may vary widely from ideality.

With kerosene, for example, "flammable" fuel/air mixtures can be produced, during refueling, at temperatures far below the lower flammability limit for that fuel. In this case, however, the flammable mixtures consist of foams or mists generated by the splashing action of the fuel rather than equilibrium fuel-vapor/air mixtures. Such foams and mists can be ignited at temperatures below the lower flammability limit of the particular fuel in question if sufficient energy is supplied. There is one case on record in which an electrostatic ignition occurred while a commercial aircraft was being refueled with an aviation kerosene that had a flash point of 95°F. At the time of the ignition, the fuel temperature was 55° (40° below its flash point). Thus, the flammability of mixtures depends not only on fuel temperatures but also on the circumstances prevailing inside the tank during fueling.

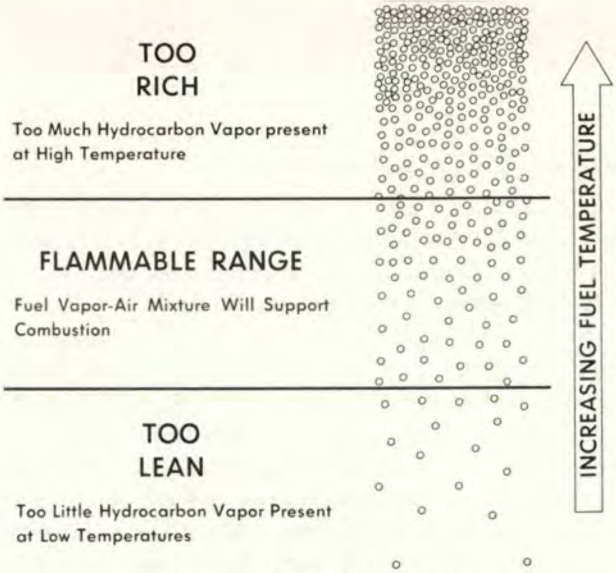


Figure 2. Flammability Concept.

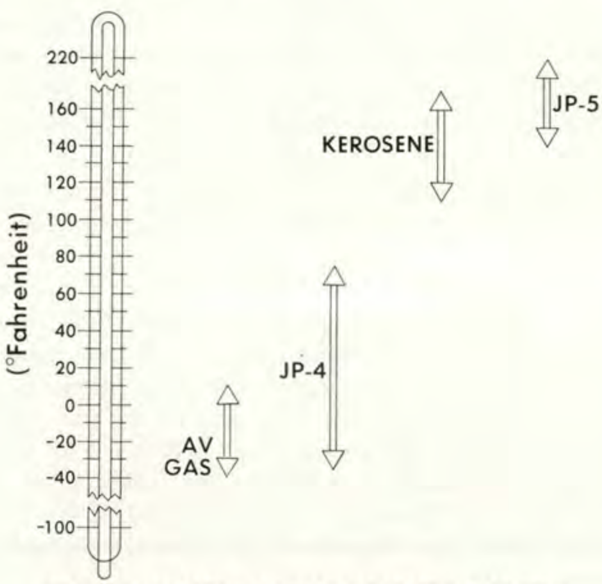


Figure 3. Temperature-Flammability Limits for Common Fuels.

ELECTROSTATICS IN JET FUELS continued

the remaining columns indicate the types of discharge obtained from the fuel surface and the metal-plate electrodes. When the needle and 60-degree point electrodes were used, the usual type of discharge from the fuel surface and the metal plate was a corona. At very small gaps (2.5 cm or less), however, the 60-degree point electrode produced spark discharges from both fuel surfaces and metal plates. Since spark discharges are more energetic and more likely to cause ignitions than corona discharges, they are considered to be more hazardous. Consequently, pointed electrodes cannot be used within aircraft fuel tanks to bleed off charges harmlessly from fuel surfaces, as is occasionally suggested.

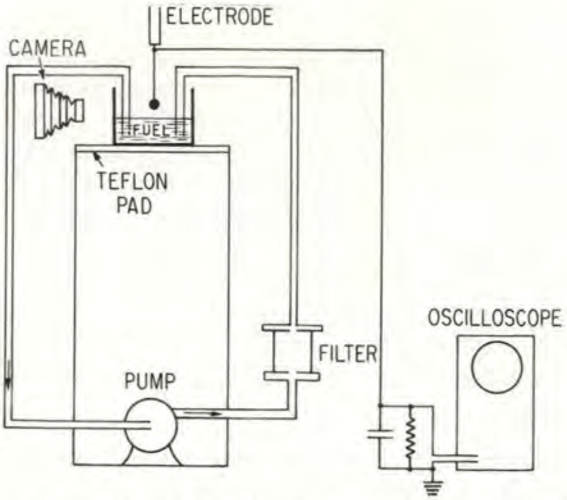


Figure 4. Apparatus Used to Study Discharges from Fuel Surfaces.

Discharge Energy and Duration

The amount of energy required for a spark to ignite a fuel/air mixture under ideal conditions is very small—a mere 0.2 millijoule. Ideal conditions are:

(a) An optimum fuel/air mixture and

(b) A spark discharge taking place between two metal electrodes at a gap of 0.2 inch. Sparks having energies considerably in excess of 0.2 millijoule can occur in the vapor space of fuel tanks during the course of aircraft refueling operations. Yet, despite the frequency of these discharges and the fact that, at least part of the time, the vapor/air mixture above the fuel is in the flammable zone, there have been relatively few explosions during refueling that can be attributed to electrostatic ignitions.

The big question is: Why? What is so distinctive about discharges from a charged fuel surface that they seldom produce explosions? To find answers to these questions, scientists at the Naval Research Laboratory have developed an apparatus (Figure 4) capable of producing sufficient charge on a fuel surface to break down spark gaps of up to 15 centimeters. Fuel (in this case JP-5) was circulated through a filter and into an insulated polyethylene tank, where discharges from the fuel surface to a grounded electrode could take place. The discharges were photographed through a window at the side of the tank and the quantity of charge transferred was measured with an appropriate circuit.

Because the nature of the discharge (corona or spark) depends on the configuration of the electrodes, a wide variety of electrodes (including a needle point, spheres of diameters varying from 9/32 inch to 2½ inches, and a metal plate) were used in this study. Discharges between a charged fuel surface and these grounded probes were compared with similar discharges between a metal plate used to simulate the fuel surface and the same grounded probes. The object of the comparisons was to determine what distinctive properties of discharges from fuel surfaces make them less incendiary than discharges from an all-metal electrode system.

TYPE OF DISCHARGE

Table II summarizes these discharge measurements. The first column lists the various grounded electrodes;

The usual type of discharge from the metal-plate spherical-electrode system was a spark. The energy of these discharges increased with the larger diameter of the sphere and the gap width. Another type of discharge, a prebreakdown streamer, was also found with the quarter-inch and half-inch spherical electrodes at larger gaps. In an all-metal electrode system, these streamers play an important part in the development of filamentary sparks. With such a system, streamers start at the anode as separate filaments or as a trunk and combine to form a treelike configuration with multiple branches. The majority of these streamers stop halfway across the gap and are referred to as secondary streamers. However, some streamers manage to traverse the entire gap and, in so doing, pave the way for the main stroke (spark), which follows the most vigorous primary branch. In this study, most of the prebreakdown streamers obtained with the quarter-inch and half-inch sphere-to-plate electrode systems were followed by spark discharges. It was also shown that the streamers could be produced without spark discharges merely by placing the proper resistor in series with the gap.

When the half-inch and one-inch spherical electrodes were used opposite the charged fuel surface, prebreakdown streamers were the only type of discharge obtained over the entire gap range studies (2.5 to 15.0 cm). Unlike the streamer discharges from the metal plate, the prebreakdown streamers from the fuel surface were never followed by spark discharges. Other differences in the behavior of the two electrode systems (fuel surface and metal plate) are apparent in the various types of discharges illustrated in Figures 5 through 8.

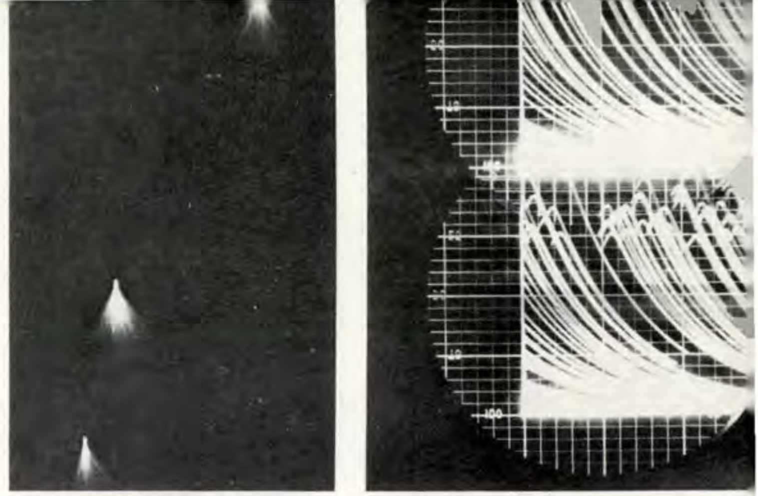
Figure 5 shows the type of discharges obtained with the 60-degree point opposite the metal-plate electrode. In the photograph, the discharges exhibit the paintbrush-like form which is typical of corona discharges at electrodes with high positive potential. The accompanying oscillographs show that the corona discharges were composed of many individual low-level discharges per unit length of time. From time-exposure oscillographs, it was determined that the frequency of these discharges increased from 100 to 900 discharges per second over the gap range of 1 to 8 centimeters. The energy of the individual discharges increased from four to 11 microjoules over the same gap range.

The 60-degree point electrode opposite the fuel surface gave the typical paintbrush-like structure of the corona discharges (Figure 6). The energy of the individual discharges in this photograph are of the same order as those from the metal plate. However, the frequency of the discharges (approximately 80 discharges per second) was not only less than that for the all-metal electrode system, but it also remained constant over the gap range investigated.

Only spark discharges were found in the one-inch sphere-to-metal plate electrode system (Figure 7). In this photograph, the spark discharge appears as a continuously luminous channel spanning the gap between the sphere and the plate. The oscillograph shows the spark as a discrete discharge, quite different from the multiple-discharge patterns found for the corona discharges with the smaller electrodes.

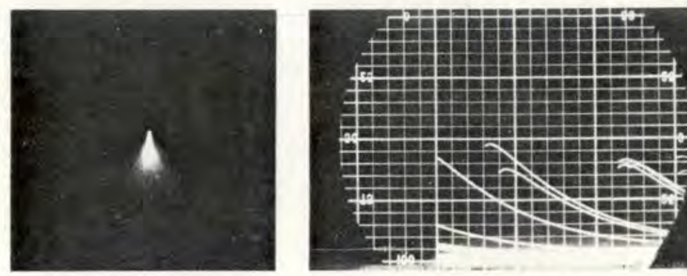
The one-inch spherical electrode opposite the fuel surface produced prebreakdown streamer discharges (Figure 8) characterized by a brightly luminous channel extending approximately one to two centimeters from the spherical electrode. Beyond this point, the structure of the discharge became so highly branched that it was difficult to detect photographically, even with long exposures such as were necessary to produce this illustration. The streamers appeared on the oscillograph as single discrete discharges.

The frequency of formation of prebreakdown streamers depends on the charging tendency of the fuel. In



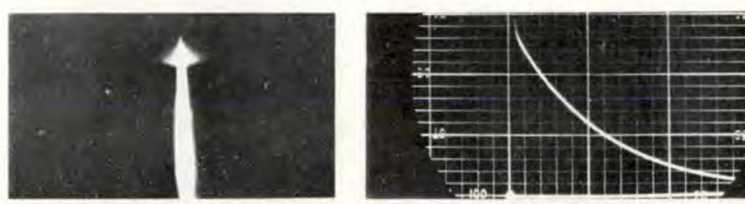
DISCHARGES 1-SECOND EXPOSURE | OSCILLOGRAPH 1-SECOND EXPOSURE

Figure 5. Sixty-Degree Point Versus Metal Plate Discharge.



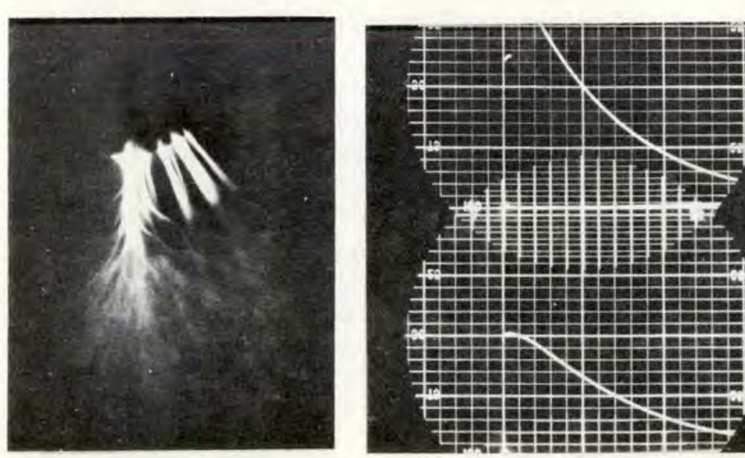
DISCHARGES 60-SECOND EXPOSURE | OSCILLOGRAPH 1/10-SECOND EXPOSURE

Figure 6. Sixty-Degree Point Versus Fuel Surface Discharge.



SINGLE DISCHARGE | OSCILLOGRAPH

Figure 7. One-inch Sphere Versus Metal Plate Discharge.



20 SUCCESSIVE DISCHARGES GAP 10cm | OSCILLOGRAPH

Figure 8. One-Inch Sphere Versus Fuel Surface Discharge.

TABLE II.
Comparison Of Discharges From Fuel Surface To Grounded Probes Of Various Configurations With Discharges From Metal Plate.

	DISCHARGES FROM FUEL SURFACE		*DISCHARGES FROM PLATE*	
Grounded Electrode	***Gap (Cm.)***	***Type of Discharge***	***Gap (Cm.)***	***Type of Discharge***
NEEDLE	1.0 - 5.0	CORONA	1.0 - 3.0	CORONA
60° POINT	2.5 2.5 - 15.0	SPARK CORONA	0.25 1.0 - 8.0	SPARK CORONA
1/4" SPHERE	2.5 - 15.0	CORONA	<0.9 >0.9	SPARK PREBREAKDOWN STREAMERS
1/2" SPHERE	2.5 - 12.5	PREBREAKDOWN STREAMERS	<1.0 >1.0	SPARK CORONA AND PREBREAK-DOWN STREAMERS
1" SPHERE	2.5 - 15.0	PREBREAKDOWN STREAMERS	0 - 1.6	SPARK

these experiments, conditions were adjusted to produce only two or three streamers per minute so that individual discharges could be measured. However, as many as 100 streamers per minute could be produced through the proper control of the conductivity of the fuel, the effectiveness of the filter, and the pumping rate of the discharge apparatus.

The prebreakdown streamers from the fuel surface resembled spark discharges in that they were audible as a single report, could be seen by the naked eye in a darkened room, and appeared on the oscilloscope as a single discharge. However, they were much less energetic than spark discharges, as indicated in Figure 9.

In this figure, the energies of the prebreakdown streamer discharges from the fuel surface are compared with those of the spark discharges from the metal plate (both opposite the one-inch spherical electrode). Although the energies increased with expanding gap widths for both systems, the energy of a spark discharge was much greater than that of a prebreakdown streamer for comparable gap widths. Extrapolation of both curves of the graph to a 2.0-centimeter gap width gives a ratio of approximately 37 to one.

Not only were the prebreakdown streamers less energetic than spark discharges, but also they released over a much longer period of time. In highspeed oscilloscope studies, the duration of the prebreakdown streamer discharge was up to seven times longer than that of a spark discharge at a comparable gap width. The increase is ascribed to the properties of the fuel itself that cause it to behave as a resistor in series with the gap.

The ability of prebreakdown streamer discharges from a fuel surface to produce an ignition was tested by substituting JP-4 fuel for the JP-5 fuel normally used in the fuel-charging apparatus. At temperatures ranging from 45 to 55°F, which are well within the flammability limits for JP-4 (Figure 3), repeated prebreakdown streamer discharges from the fuel surface failed to produce ignition, although spark discharges under the same conditions did ignite the fuel vapor.

CONTROL OF THE ELECTROSTATIC HAZARD

Outside the United States, and particularly in Canada and Great Britain, the use of a static disipator additive is generally accepted as the most practical solution to the problem of electrostatics in fuels. The additive, which is now included in the Canadian specificatio for jet fuel, is expected to be adopted by the British soon. In addition, over 80 airlines have agreed to pick up fuel containing the additive which is currently available throughout Canada and at a large number of international airports scattered throughout the world.

In the United States, a great deal of reliance has been placed on the concept of providing a 30-second relaxation time during fuel-handling operations. (In this case, relaxation time refers to the time required for a drop of fuel to travel from the filter to the receiving tank.) Tests have shown that, regardless of the conductivity of the fuel, most of the original charge on a fuel is dissipated after 30 seconds of relaxation. However, at a number of aircraft refueling installations in this country, considerably less than 30 seconds of relaxation time is allowed. Under these conditions, the hazards of electrostatic discharges may mount, particularly when faster flow rates are employed. Although these systems may have been afforded some measure of protection from electrostatic ignitions in the past by the production of prebreakdown streamers rather than spark discharges from fuel surfaces, this mechanism may not continue to provide protection under the anticipated high-speed refueling conditions. For example, it is known that the frequency of formation of streamer discharges increases sharply with flow rate. Consequently, at high flow rates, a fuel with a high charging tendency would be expected to produce many prebreakdown streamers in rapid succession. The incendiary nature of such rapidly occurring streamers cannot be predicted from our present knowledge about individual prebreakdown streamer discharges, nor can one say if, or under what conditions, these rapid streamers could lead to spark discharges. Without such information, we must regard the introduction of high-speed refueling in systems where considerably less than 30 seconds' relaxation time is provided as increasing the possibility of electrostatic ignition.

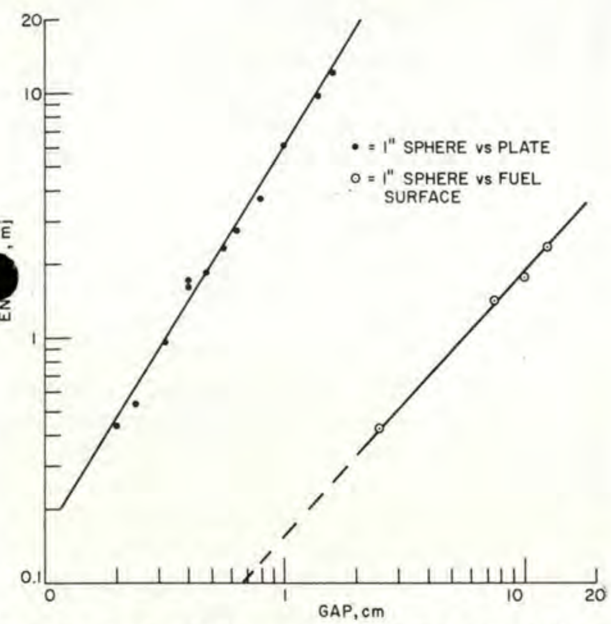


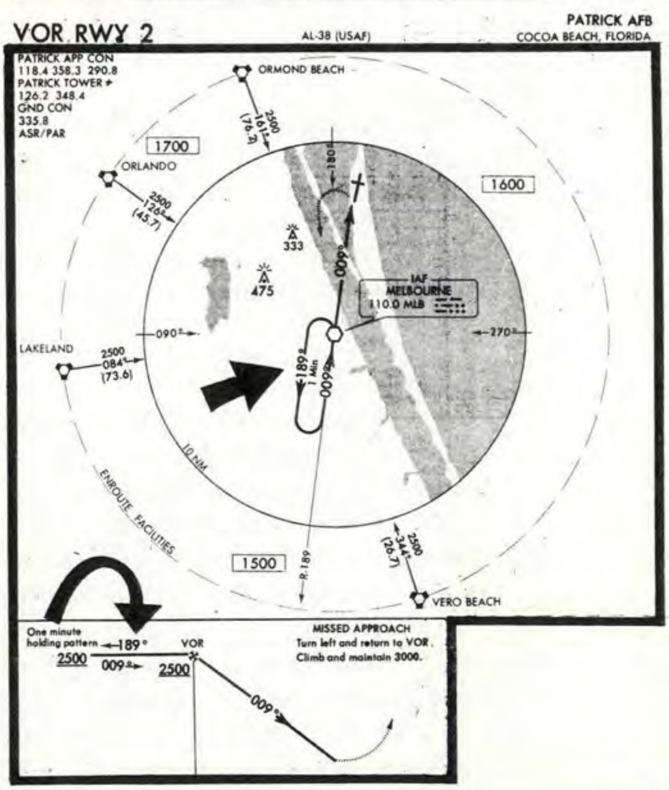
Figure 9. Energies of Discharges from Metal Plate to One-Inch Sphere Versus Discharges from Fuel Surface.

A device recently became available for reducing the level of charge on flowing petroleum products. Called the "Static Charge Reducer," it consists of a length of pipe containing an insulating liner through which a series of pointed electrodes protrude into the liquid flow. The highly charged fuel enters the reducer and produces an intense electrical field at the pointed electrodes, which then neutralize the fuel by the "lightning rod principle." The device is intended primarily for installation at loading racks and terminals. Its effectiveness for aircraft refueling has not yet been demonstrated.

CONCLUSION

The amount of charge on a fuel when it arrives in a tank depends on such factors as the diameter and length of the piping, the flow velocity and conductivity of the fuel, and the presence of auxiliary equipment such as relaxation tanks and filtration units. When as a result of optimum conditions of pumping and filtration, a fuel reaches the receiving tank in a very highly charged condition, one would expect true spark discharges to take place from the fuel surface. On the other hand, the discharges described in this study, being low-intensity streamers, are the type that would be expected from a somewhat less highly charged fuel. A 1965 survey of aircraft-fueling operations throughout the world indicated that, while the charge density on fuels entering aircraft fuel tanks varies over a wide range, in most cases it is comparatively low. Naval Research Laboratory studies showed that when the charge on the fuel surface was low, prebreakdown streamers were the common form of discharge if the grounded electrode was not pointed. Thus prebreakdown streamers might also be a common form of discharge inside aircraft fuel tanks, at least when the ground electrode, i.e., the structural member of the tank that serves as ground for a given discharge, is not a sharp point. If so, the lack of fires and explosions during aircraft-fueling operations might be explained in part by the fact that frequently the charge on the fuel surface is dissipated in the form of the less incendiary prebreakdown streamer rather than the spark discharge. ★

THE IFC APPROACH



POINTS TO PONDER

The USAFIFC has recently received several inquiries concerning holding patterns, descent within holding patterns when cleared for the approach, minimum reception altitudes and minimum crossing altitudes. The following questions and answers may clarify any confusion concerning these subjects.

HOLDING

Q. How can I determine the minimum holding altitude of an arrival holding pattern depicted on an instrument approach procedure?

A. Currently, the only means of depicting minimum holding altitude is a statement in the planview next to the holding pattern, as in Figure 1 or the depiction of a holding pattern in lieu of procedure turn, as shown in Figure 2.

Q. If I am established in the holding pattern shown in Figure 1 or 2 and I receive an approach clearance, when may I descend?

A. You may descend to the published minimum holding altitude immediately upon receiving the approach clearance in both cases. (Note: This would apply only to procedures which depict a minimum holding altitude as described in the answer to question no. 1.)

Q. What procedure should be used in a Lost Comm situation when no minimum holding altitude is published, as in Figure 3, and you have arrived at the IAF prior to your EAC/ETA?

A. Hold in the published arrival holding pattern at your arrival altitude until the EAC/ETA. If you must descend to a lower altitude in order to safely fly the approach, descent should be accomplished within the published holding p

By the USAF Instrument Flight Center
Randolph AFB, Texas 78148

tern. Since no minimum holding altitude is published, you may descend no lower than the published minimum or emergency safe altitude (whichever is applicable) and commence the approach from this altitude.

MINIMUM RECEPTION ALTITUDE

Q. What is Minimum Reception Altitude (MRA)?

A. MRA is the lowest altitude which assures reception of adequate navigational aid signals to determine a specific fix/intersection.

Q. In what instances may a pilot expect to find an MRA published on an enroute IFR chart?

A. Any time reception of signals from a navigational aid, which is located off the airway being flown, may be inadequate at the designated MEA of that airway. The need for an MRA is determined by a flight inspection, which must be conducted prior to the establishment of the airway.

Q. How is an MRA depicted on the enroute IFR chart?

A. The letters "MRA" and the appropriate minimum reception altitude will be positioned in close proximity to the fix to which the MRA applies. If the fix is also a designated reporting point, a "flag" symbol containing an "R" will be attached to the reporting point. This is shown in Figure 4 at the GAMMA fix.

Q. In what instance(s) must a pilot comply with an MRA?

A. You must comply with an MRA whenever it is necessary to utilize a crossing radial to identify a fix. However, a DME fix arrow ((15)→ or →) at a fix where an MRA is depicted, indicates that the fix may also be identified with DME. If DME is used to identify the fix, as shown in Figure 4 at GAMMA, REEDSPORT and SCOTY reporting points, the MRA will not apply since it is not necessary to receive the 295 radial from ROSEBURG VOR.

MIMIMUM CROSSING ALTITUDE

Q. What is a minimum crossing altitude (MCA)?

A. It is the lowest altitude at which an aircraft can cross a fix or navigational aid when proceeding in the direction of a higher minimum enroute IFR altitude (MEA).

Q. When should an aircraft climb to comply with an MCA?

A. Start your climb so as to cross the fix or facility, at which the MCA is depicted, at or above the published altitude.

Q. Where are MCA's depicted?

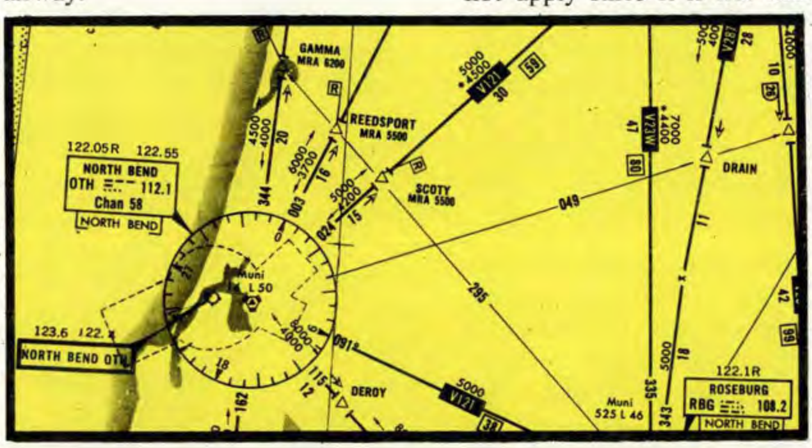
A. They are normally only depicted on low altitude enroute IFR charts.

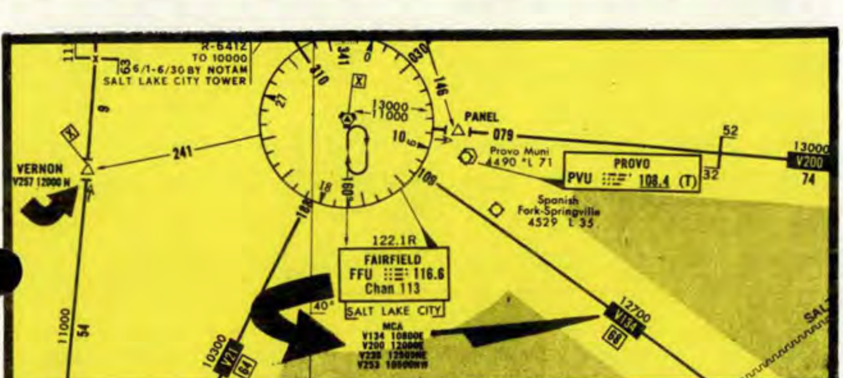
Q. How are the MCA's depicted?

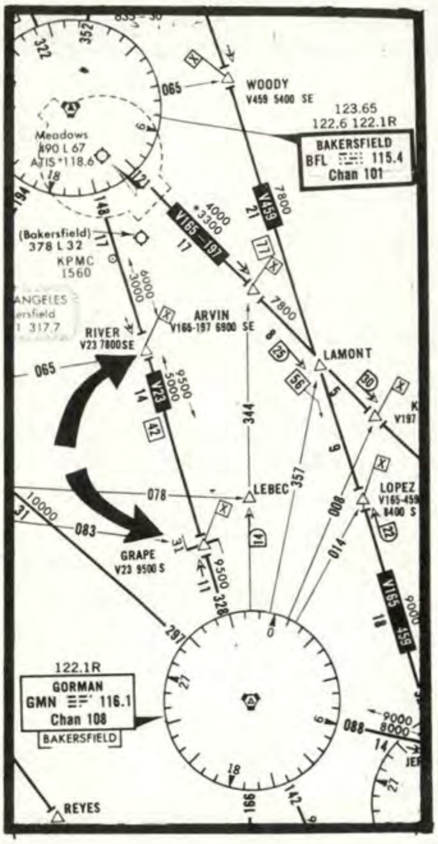
A. When an MCA is associated with a NAVAID or reporting point, it will be identified by a "flag" symbol containing an "X." In the case of a NAVAID such as the Fairfield VORTAC in Figure 5, the MCA will be identified by the letters MCA above the appropriate airway designation and number, the applicable altitude, and the direction of flight, e.g., V134 10800E. With reporting points, as shown at the Vernon fix in Figure 5, the letters "MCA" are not normally included and the other information is centered below the reporting point identification. If there are multiple minimum crossing altitudes associated with a fix or NAVAID, as is the case at the Fairfield VORTAC, the information may be consolidated under one listing.

Q. What criteria is used to determine when an MCA is needed?

A. An MCA is established when an obstruction would cause an aircraft to have less than minimum obstruction clearance during a climb







to a higher MEA. In order for the airway designer to determine if an MCA is required, he uses the following minimum climb rates versus flight altitude.

Sea Level through 5,000 feet	150 feet/NM
5,000 feet through 10,000 feet	120 feet/NM
10,000 feet and over	100 feet/NM

For an example of how the airway designer applies MCA criteria, refer to Figure 6. On V23 south of Bakersfield VORTAC, there is an MCA of 9500 feet at Grape intersection. The distance from Grape to River is 14 NM. The minimum flight altitude between the two points is between 5000 and 10,000 feet MSL so the minimum climb rate, from the preceding table, is 120 feet per NM.

To illustrate the computation, let's assume we need to determine the MCA at River for an aircraft flying SE on V23. To do this we multiply the minimum climb rate (120 feet per NM) by the distance from River to Grape (14 NM) and determine the minimum altitude change required (1680 feet). Then, subtract the minimum altitude change required (1680 feet) from the MCA at Grape (9500 feet MSL). This altitude (7820) is then rounded off to the nearest even hundred feet or 7800 feet MSL. When you see a route, or route segment, that has different MEAs for different directions of flight on that route, you should be aware that you are flying in an area of rapidly changing obstacle heights.

Q. Should a pilot maintain these climb rates when climbing to comply with an MCA?

A. Yes. These rates should be treated as a minimum. If you are unable to maintain at least these climb rates, then a climb to the higher altitude should be started earlier or a different routing requested from air traffic control.

Do you have a subject you would like to see addressed in "The USAFIFC Approach" article? Call us at AUTOVON 487-4276/4884. ★

Name That Plane

The first of the "B" category bombers, this early Army Air Corps twin-engine bi-wing bomber carried a crew of five. For answer see inside front cover.

366th Wins Daedalian Maintenance Award

Tactical Air Command's 366th Tactical Fighter Wing, Mountain Home AFB, Idaho, has won the 1976 Daedalian Maintenance Award. The trophy will be presented during the Order of Daedalians' annual meeting, 19-21 May in Denver, Colorado.

The Daedalian Maintenance Award was established in 1960 by the Daedalian Foundation to promote maintenance effectiveness and efficiency in the Air Force. The award, a large silver cup, was donated by Colonel Joseph A. Wilson, USAF Ret. The name of the winner and year of award are engraved on the base of the cup.

Lieutenant Colonel Joseph Sabin, Deputy Chief of Staff, Systems and Logistics project officer described this year's competition as "fierce." "All three contenders displayed an exceptionally high degree of professionalism, expertise and initiative in supporting their command missions. Strong leadership was evident at all levels," he said.

This year's winning maintenance complex is directed by Colonel Lee R. Wasmund, 366TFW Deputy Commander for Maintenance. The unit was cited for its high degree of professionalism and quality of maintenance.

During 1976 the 366th participated in and made a significant contribution to the success of several military exercises, including Jack Frost, Brave Shield XIV, Bold Eagle '76, Cope Train, Red Flag, Kangaroo II and the Korean Augmentation.

The 1975 award winner was the 436th Military Airlift Wing, Dover AFB, Delaware. ★

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UNITED STATES AIR FORCE

Well Done Award

Presented for outstanding airmanship and professional performance during a hazardous situation and for a significant contribution to the United States Air Force Accident Prevention Program.

First Lieutenant

MILTON J. P. MILLER

74th Tactical Fighter Squadron
23d Tactical Fighter Wing
England Air Force Base, Louisiana

Lieutenant Miller was on a night ground attack upgrade mission in an A-7D. The flight entered the range and rendezvoused with the O-2 forward air controller who illuminated the target area with a flare. As the flare lit, all ground references disappeared, and the target area was obscured by a white, milky haze. During turn to downwind, Lieutenant Miller's main attitude direction indicator and heads up display began tumbling. He quickly rolled to straight and level flight on the standby attitude direction indicator. A quick cross-check of his performance instruments indicated the aircraft was climbing in excess of 4,000 fpm and the airspeed was rapidly decreasing through 250 knots indicated. The standby attitude indicator had also failed. Lieutenant Miller was now totally disoriented with respect to outside references. He advanced the power to military and succeeded in stabilizing the aircraft in level flight. Focusing on the turn needle, altimeter and vertical velocity indicator, Lieutenant Miller began a slow turn to allow Lead to join with him. Once joined, the flight executed a formation recovery. Lieutenant Miller's timely and decisive actions during a critical phase of flight prevented possible injury or loss of life and resulted in the safe recovery of a valuable aircraft. WELL DONE! ★


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