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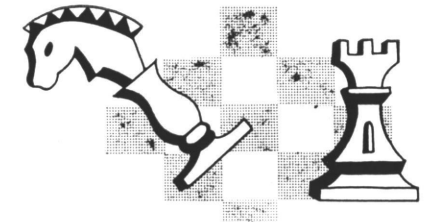
HIGH  LOW

WHAT'S THE GAME?

Lieutenant James M. Knowlton, CE

WITH THE ADVENT of greater mobility, larger dispersion of forces, and nuclear capabilities by our Army, a great deal of thought has been given to the role of Army Aviation on the battlefield of the future. This role includes not only the type of missions, but also the methods we will use to accomplish these missions.

One of the most pressing problems is the determination of the altitudes that we will use in the accomplishment of missions. Articles have been written concerning the pros and cons of flying at our high and low altitudes. The purpose of this article is to examine the advantages and disadvantages of high and low altitudes with emphasis that selection of one or the other should have a direct bearing on our training of pilots and observers. Whether it be a surveillance, observation, or fire adjustment mission, different methods must be used to train personnel for high or nap-of-the-earth altitudes. This determination will also provide Research and Development with a direction in which to work towards devices that will aid in the accomplishment of these missions, as well as to give certain performance considerations to keep in mind when planning for future Army aircraft.

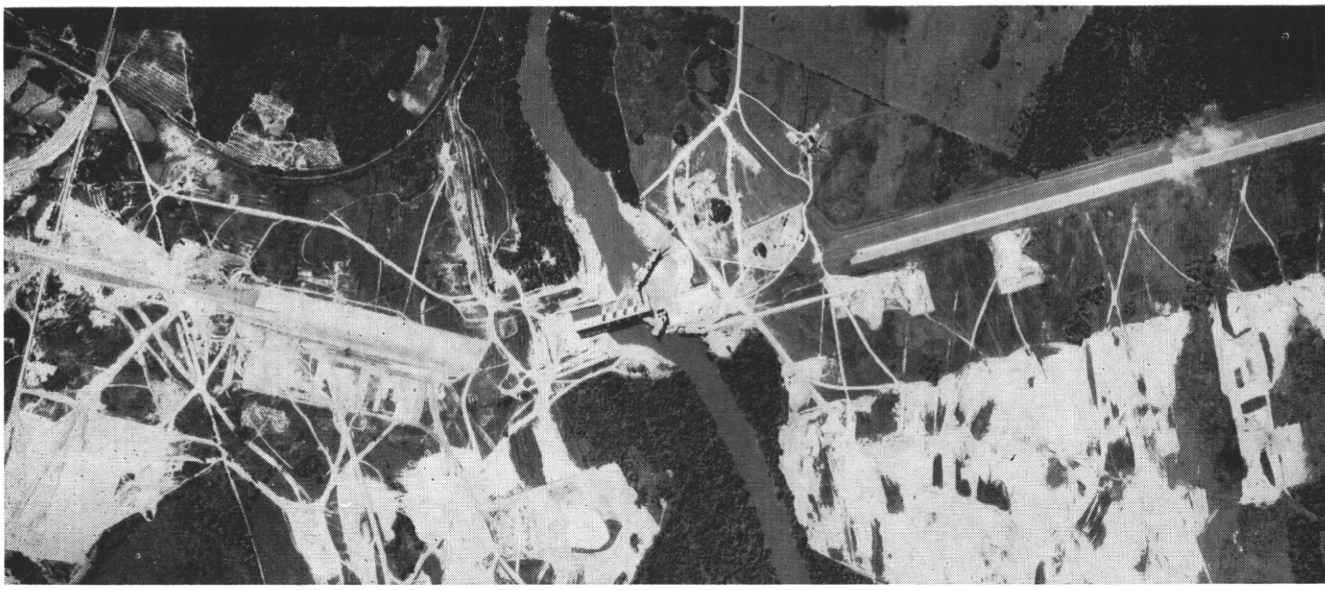
I would like to examine the advantages and disadvantages of both types of flying in terms of five general areas: pilot endurance; navigation; radio communication; detection, recognition, and location of targets; and vulnerability. There are other factors, but these are the main areas and deserve the most consideration.

Lt Knowlton is with the Forms and Records Branch of the Department of Maintenance. He is fixed wing qualified and instrument rated.

PILOT ENDURANCE

The first area is that of pilot endurance. At high altitudes, let's say over 5,000 feet above the terrain, this endurance could be as high as 6 or 7 hours a day per pilot. It would depend partly on the physical condition and training of the pilots, but would be governed more by aircraft endurance, maintenance capabilities, and logistical support.

On the other hand, the low level nap-of-the-earth flying, where the pilot is following the contours of the terrain, over or around hills and high trees and down through gullies, necessitates a higher degree of concentration and reflex action. He must be ready for a steep turn, a climb, or a letdown instantaneously. A pilot who has flown an hour of this type of flying will be ready for a cigarette and a chance to catch his breath. His mission or flying time per day, depending also on preparation time, might only be 2 hours a day! From a standpoint of continuous reconnaissance or surveillance



While flying high the trained observer can obtain much information about the enemy . . .

missions, this type of flying would require ultra efficient coordination between aircraft and commanders involved.

NAVIGATION

How about the navigational problems involved with each type of flight? The high altitude flight encounters problems similar to those encountered on a VFR cross-country flight. Checkpoints such as lakes, rivers, towns, roads, and their relationship to one another are used — probably coming from recent aerial photos of the area. This is not so with nap-of-the-earth flying; normally used checkpoints can be easily missed by being 200 or 300 yards off a desired flight path. Relationships to other objects are not readily apparent, and there is not time for inflight photo study; hence, disorientation is very easy. Thus, one pilot flying such a low-level mission would have to spend several hours studying recent aerial photos, maps if available, and plotting courses and measuring distances.

RADIO COMMUNICATIONS

The third area is that of radio communications. At higher altitudes the problems are those of range, governed by transmitter power, atmospheric disturbances, and the normal line-of-sight limitations of higher-frequency radios. Pilots become familiar with these communication problems in their local and cross-country flying. Low altitude flying renders the higher-frequency radio useless because of its line-of-sight limitation. Present lower-frequency radios are more favorable, but have undesirable background disturbances and unsuitable reception distances.

OBSERVATION PROBLEMS

The fourth problem area is in the detection, identification, and location of aggressor targets. It has been proved, both in tests and in combat, that a trained observer, flying a surveillance or target type mission at high altitudes, is able to obtain much information about the enemy. This is especially true when the enemy is moving on roads or across open country. Such indications as smoke, dust, flash, or anything suspicious attract his attention. The observer is also helped by the offensive or defensive patterns of targets, which are much more apparent from high altitudes. The aircraft usually then goes lower or orbits until negative or positive information is obtained.

At high altitudes it is easy to locate the position by coordination or reference to natural landmarks. The pilot can report it immediately, call in artillery fire, or report it at the completion of the mission, depending on particular mission, type target, or aggressor situation. But will he be able to detect targets such as machine-gun emplacements, personnel, vehicles in the woods, or even equipment with minimum camouflage? We know our most likely aggressors are masters at all types of concealment, and CONARC testing indicates that even the well trained ob-

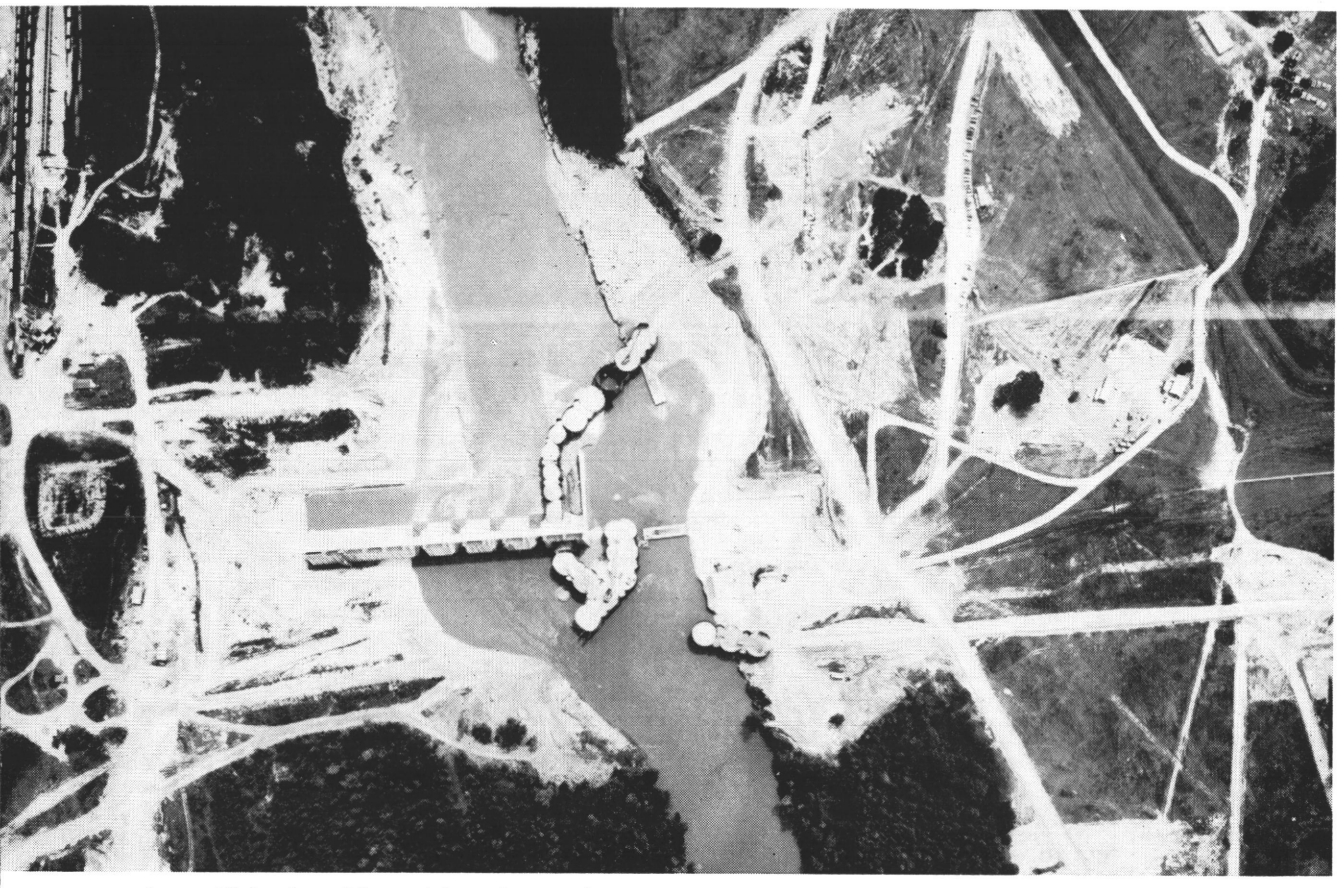
server will see only a very small percentage of targets at high altitudes. Then he will not be able to make positive identification between, for instance, a 155 self-propelled and a medium tank.

The low flying observer has many advantages in recognition of targets. It is almost impossible to hide or camouflage guns, vehicles, or even personnel from an observer flying 100 feet over the ground. Detection is instantaneous; it must be, due to the rapid passage over the ground. This information is also much more complete and accurate, but observers must be trained in low-level scanning methods and split-second recognition of targets. Only smaller areas can be surveyed, but missions can be planned to include most likely target areas. Target location and fire adjustment will be difficult, but some possible solutions will be discussed later.

VULNERABILITY

The last area is that of aircraft vulnerability, perhaps the most important consideration. The aircraft flying its mission high in the air will not only have to cope with machinegun and antiaircraft fire but also with guided rockets, heat-seeking rockets, noise-seeking rockets, radar-controlled fire, and probably other weapons still under development. The aggressor will attempt to destroy any aircraft that is keeping them under observation or calling in fire missions.

Slow flying, relatively speaking, Army aircraft are also vulnerable to any high-performance aggressor aircraft that the pilot does not see. The nap-of-the-earth aircraft will encounter only small arms manned and fired by aggressor personnel. They may hear an aircraft coming, but "localization of sound" will prevent their telling exactly from what direction. Then they must raise, aim, and fire their weapons in the 2 or 3 seconds that the aircraft is visible. Radar controlled guns will be ineffective against it due to interference by the ground. Heat-



but will he be able to identify machinegun emplacements, camouflage equipment, etc.?

seeking missiles will be dangerous to the aggressor because of the danger of their homing in on his own tanks or sterno stoves. Noise-seeking missiles will be confused by the echoes and reverberations of the engine exhaust from the ground. Of course in the event of engine trouble or damage caused by enemy fire, the pilot will just about have time to set up an approach to an area almost immediately ahead. There will be no gliding back behind friendly lines by damaged low flying aircraft.

These are some of the problems associated with high or low altitude flying. What are some of the techniques or developments that would aid the Army Aviator in the performance of his mission?

PERFORMANCE TECHNIQUES

The only way to increase pilot endurance is to train aviators to fly and navigate at low altitudes. This would decrease his reaction time, his uneasiness, and the time required to plot, plan and memorize a low-altitude mission. He may use a combination of a planned course with a combination of headings, ETAs, and checkpoints, or perhaps a system of directions given by high altitude aircraft. Improvements in radar or a drone-carried TV might enable persons miles to the rear to follow and issue directions to a low flying aircraft. This control of the preplanned course will also enable battlefield air control to anticipate his departure and return and make the necessary clearances and alerts.

Radio communication by high altitude aircraft would be improved by automatic coding and decoding radios. The low altitude aircraft could relay information that necessitates immediate countermeasures by the commander to a high altitude relay aircraft. Perhaps a helicopter with exceptional acceleration might climb to sufficient altitudes to transmit on a high-frequency radio and drop back on the deck. The development of an improved low-frequency radio that is not rendered useless by the maskings of the earth, or adversely affected by range and atmospheric limitations, would be advantageous.

Observation at high altitudes would be improved by the development of a magnifying face plate that would not restrict the observer's field of vision as binoculars do. A recording device would enable the observer, whether at high or low altitudes, to gather information without stopping his scanning. A camera mounted on the low flying observer's head and controlled to take pictures when he pushes his microphone button to describe detected targets would save the time and expense of studying pictures that contain no targets.

Training in flying a definite low altitude flight path at a constant airspeed might help in target location. The flight path would be known to the artillery or be tracked by radar. By knowing the time lapse since passing a certain checkpoint, a call, "tanks 250 yards to left," would enable the fire support to plot the target in relation to the aircraft path. Fire adjustment by the helicopter with exceptional acceleration that could climb up and observe the round just as it falls, each time from a different direction, might be a solution. Fixed wing aircraft flying at low altitudes might have to call in fire and then return later to observe damage or the lack of it.

What can be done to decrease the vulnerability of an aircraft at a high altitude. Not much except to increase its speed, and then missiles, rockets, and high performance enemy aircraft will always be faster. Added armor protection for pilot and observer would be effective at high and low altitudes. The low flying aircraft must fly right over the treetops and be exposed to ground fire for as short a period as possible. Increased maneuverability would enable the pilot to have a greater safety factor in case objects such as trees or wires come up unexpectedly.

From the different problems and possible solutions associated with high or nap-of-the-earth flying, it is apparent that these are two different, distinct types of flying and have two definite indications. Pilots and observers must be trained with emphasis on the problems associated with the high- or low-altitude flying. This decision as to what type of flying will be done on the modern battlefield must be made to aid Research and Development, Tactics, and training in establishing a direction towards which to work. Pilots and observers must be trained differently in at least these five areas; aircraft and devices will also vary according to the height above the ground at which they will be used. Tests and studies indicate that it will be necessary to fly both high and low altitudes, depending on the situation. Training and research should be directed towards these distinct problems encountered in both types of flights.

Learn and Live

Insufficient room to turn

THE TECHNIQUES of Army flying are not difficult to learn. Procedures, however, must be followed slavishly. Good judgment and experience are necessary, especially when flying in hilly or mountainous terrain.

The factors of downdrafts and air turbulence in mountain operations are complicated and very important. The best advice is to forego mountain flight until you have made a special study of the hazards or been thoroughly indoctrinated in the techniques.

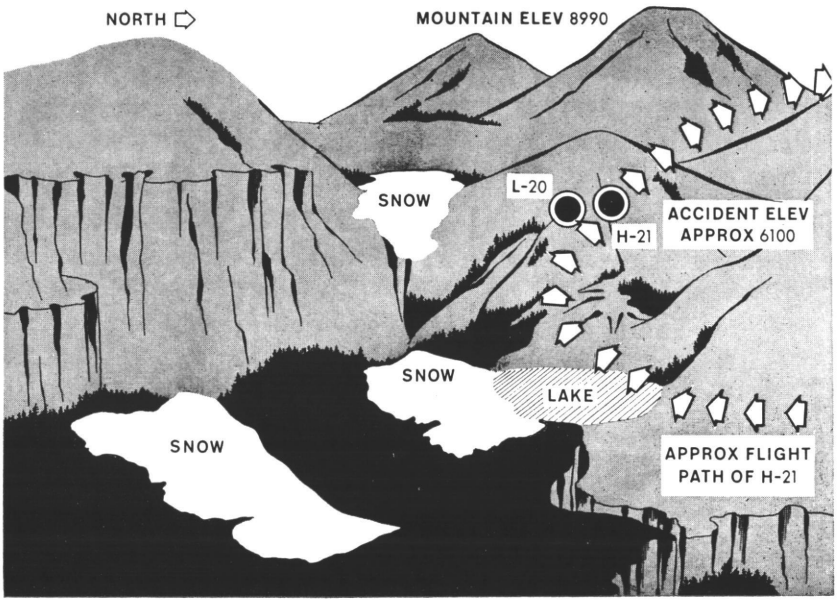
Complete mastery of an aircraft in the flatland will not provide insurance for safe operation in mountain flying. Consider this Shawnee (H-21) pilot whose mission was to photograph a Beaver that had crashed in rugged, wooded mountain country. He had a total of more than 700 hours and was considered exceptionally proficient in the Shawnee. Let the pilot tell his story:

"We circled the wreck clockwise, with the Beaver on our left so the photographer could take pictures from the air . . .

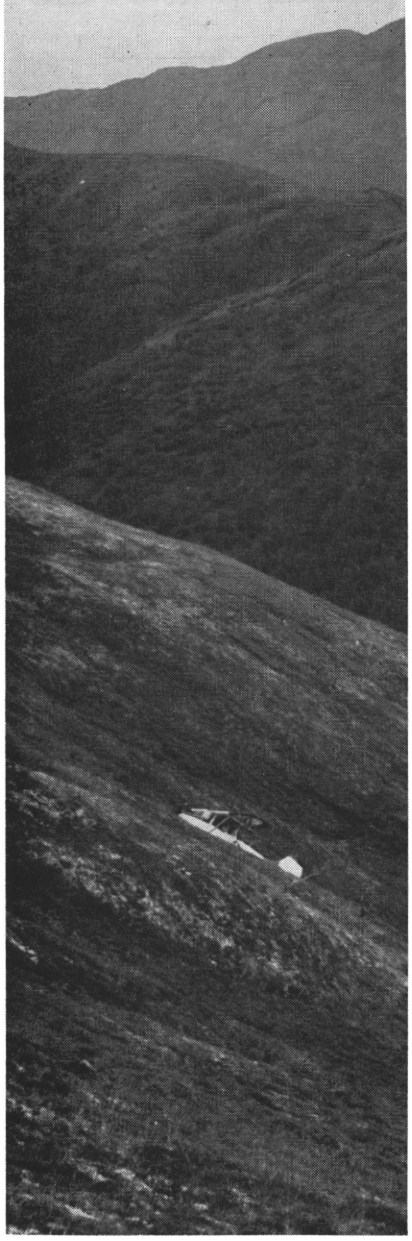
"We were making our second low reconnaissance of the area at approximately 35 knots when the aircraft started to settle.

"I increased rpm to 2700 and manifold pressure to 45.5 inches of Hg (maximum) and dived

Theme song for mountain fliers: "Don't Box Me In!"



This article was prepared by the U. S. Army Board for Aviation Accident Research.



Mountains ever fence you in?

the aircraft to regain flying speed but the ship continued to fall through. There was not enough room in the box canyon to regain effective lift, so at the last moment I executed a flare and landed on the steep slope with a near zero airspeed. The ship slid backwards shearing the right main gear. It then rolled on the right side, shearing the blades, and slid approximately 100 feet down the mountain where rocks brought it to a halt."

Flight path prior to the crash was from east to west into a box canyon surrounded by high jagged mountain peaks. The wreckage of the aircraft being photographed was about 6,100 feet above sea level. The pilot had judged the wind to be light and variable, generally from the west southwest.

The first low reconnaissance was successfully completed. The climbout was made over the canyon rim and a peak that circled to the north. The crash occurred on the second low pass.

Downdrafts and turbulence are caused by air-mass movements against the mountain range. In general, moderate, smooth updrafts will be on the windward side of the range. On the leeward side, very turbulent air and strong downdrafts will exist below the level of the mountain crest. In some cases this area can get so violent that an aircraft becomes unmanageable.

In this case the pilot made a serious error in judgment. He had two safe courses open to him and chose neither. He could have made the low pass at an altitude high enough to keep out of the box canyon. If he felt he had to descend below the canyon rim, he should have made the pass in the opposite direction, toward the open end of the canyon.

Even under ideal weather reporting conditions, forecasts are notoriously unreliable in mountainous terrain. Wind conditions may vary unpredictably. Knowledge of this should keep an aviator vigilant and, more important, sharpen his planning.

Undoubtedly the type of mission affects the probability of an accident. Hazards are incurred under a variety of conditions such as instrument, formation, and low-level flying, particularly low-level flying in mountainous terrain. This type of flying demands mastery of certain techniques. Appraising a situation in low-level operations is something for the pilot's judgment. Descriptions in an article cannot begin to provide adequate substitutions for practical experience.

EXPECT THE UNEXPECTED

Two first lieutenants in two L-19As were on an authorized VFR flight to resupply an infantry patrol. Weather had been marginal all morning but by noon had cleared sufficiently to make the scheduled drop. Here's what happened as viewed through the eyes of the participants:

COMPANY COMMANDER (of infantry patrol): "My company was in column on the south slope of the mountain at approximately 1,500 feet elevation. The aircraft made a dry run over the drop zone to determine the best spot to drop the rations. I was in radio contact with the passenger of the first plane. After the dry run, it was determined the best position for the drop was at the tail of the column, because of clouds higher up the slope. Both planes then circled in preparation for the final run and the ration drop. The lead plane made an accurate drop in the marked area. After the drop the plane turned left in an attempt to get over the mountain. The area available for climbing in relation to the elevation of the mountain was very small and the plane crashed into the side of the slope."

ENLISTED MAN (passen-

ger in lead plane): "We made a good ration drop and it appeared that everything was normal; however, the pilot told me we were in trouble and going to crash. He made a left turn, raised the nose of the aircraft and touched down on a steep incline to the left of our original path."

PILOT OF SECOND PLANE: "As we both entered the canyon I was at 1,500 feet indicated, and the lead plane slightly lower. I climbed to 2,000 feet to check the cloud height, and at this altitude I was just at the bottom of the clouds. From this I estimated we had about 500 feet to work in.

"We made one dry run over the troop area, and on this first pass neither I nor my observer spotted the troops; however, on the second trip up the canyon we saw them. I again tried to make radio contact but couldn't, so I tried to cut inside him. Because of the turbulence I was forced to make a shallow turn; however, I gained on him and was 200 to 300 yards to his rear, and maybe 200 feet higher. He dropped his bundles and started a left turn toward the ridge line, then his right wing dropped, and I thought he was going to turn away from the hill. Almost immediately the aircraft turned left again and struck the mountain.

"I dropped my bundles from about 200 feet and switched to emergency frequency and started calling MAY DAY . . ."

PILOT: "At about 1300 hours I started my descent toward the west in order to pass across the ridge on which the drop was to be made.

"When approaching the area I noticed that slightly to my left it appeared that the terrain was much more suitable for the drop so I swung left to pass directly over it. I was at an altitude of about 75 feet above terrain when I released the rations. I applied power and started to make a climbing turn to the right and at the same time realized I could not maintain a steep enough climb to clear the ridge to the west of the drop area. I elected to turn left in order to crash land going directly uphill . . . I maintained as steep a climb as possible and told my passenger we were going to crash. Just prior to impact I pulled the nose of the aircraft up to slow my forward speed as much as possible and to touch down in a three-point attitude."

Just prior to impact the pilot pulled the nose up

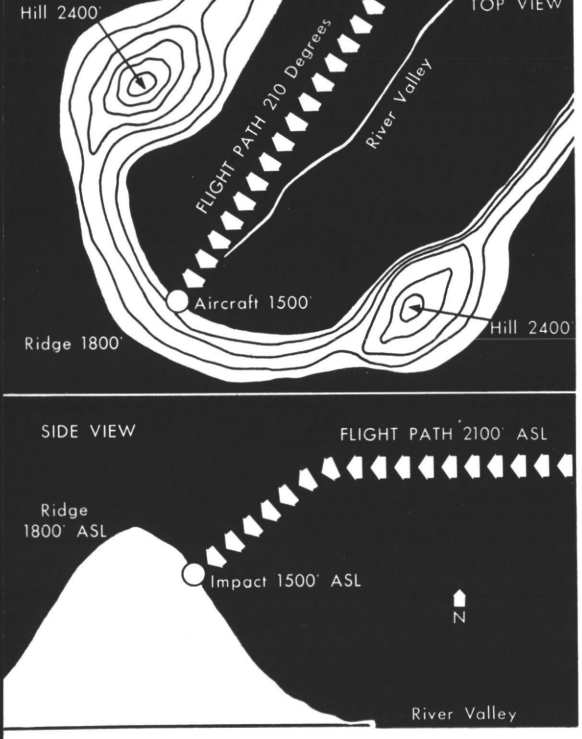
OPERATIONS OFFICER: "I am the operations officer for the Aviation Company and, as such, my office accepts and evaluates missions and assigns pilots and aircraft to the mission.

"Even though relatively new to the area, this aviator had made four flights into the same general area of the proposed air drop.

"I had no qualms about assigning him to this resupply mission. The only alternative would have been to cancel out the resupply mission. This mission had already been delayed for one day because of weather and the patrol needed the rations. Aerial resupply was the only method to supply them.

"The Army Aviation School provides for and formally teaches all phases of Army Aviation operations. Resupply by aircraft (including parachute supply drops) is one of the phases of the school. It was the opinion of the company commander and mine that officers awarded the MOS of Army Aviator were trained in all phases . . ."

ACCIDENT INVESTIGATION BOARD: ". . . having carefully considered the evi-



Flight path that failed

dence finds that the accident was due to pilot error."

What do you think?

FLIGHT PATH THAT FAILED

Admittedly, Army Aviators are well-trained and upon graduation are equipped for almost any eventuality — except for judgment and experience. One derives from the other. These desirable traits come only in time, with painstaking observation, self-development, unit training, and analysis.

Before that hoped-for level of experience is reached errors are made all the time. As judgment is developed with experience, the tendency to err lessens. But let's face it: perfection is never attained.

If you've never been subjected to a certain experience, you cannot have developed judgment in that area. If you have never flown in rugged terrain, you may find it difficult to believe the dangers really exist. But they do. Maybe this pilot's experience will help enlighten others.

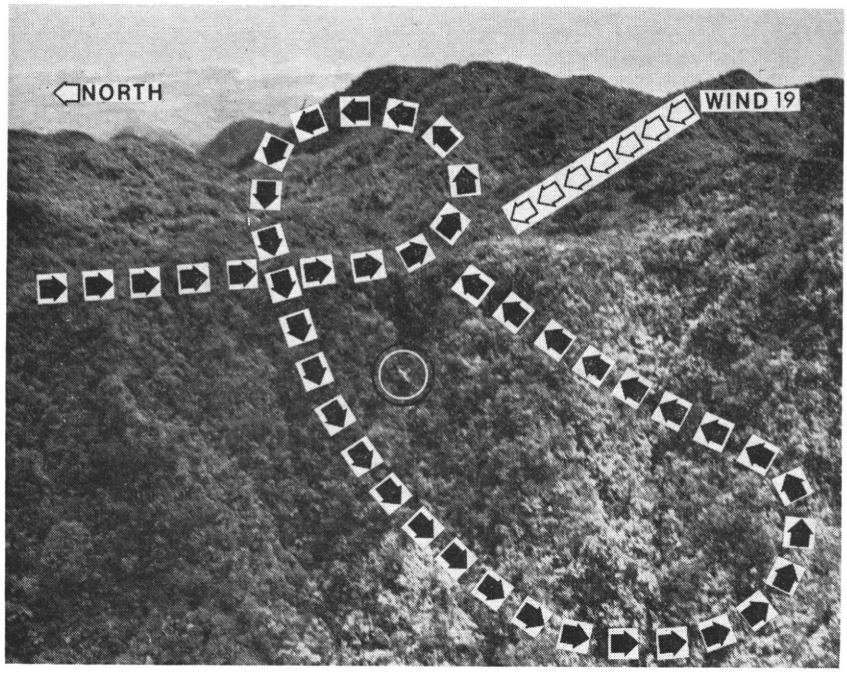
A civilian aircraft had been reported missing. An Army Aviator had been briefed for the air search mission. The Bird Dog had been preflighted carefully and the flight to the search area was uneventful. The pilot throttled back to slow cruise (70-75 mph), set 15-20° flaps while he and his observer began scanning the terrain from 1,000 feet above. The direction of search was generally upslope and altitude was gained as they flew inland.

"Proceeding up the river I noticed the cloud bases were 2,500 feet and I seemed to be about 200 to 300 feet below them. The fork of the river I was following ended in a dish-shaped valley and the mountains ahead and to the right were cloud covered. A ridge to the left was open and I saw that I was high enough to clear it by 200 to 300 feet. Approaching the ridge I added power, anticipating a downdraft. Approximately one-half mile or less from the ridge, I entered a downdraft and applied full power and made an effort to gain more altitude. Realizing the engine wasn't reacting fast enough and I was going in, I left the full power on and gained as much altitude as I could in a power-on stall. As stall speed was reached, I aimed at a large tree and started adding flaps. When I hit the tree, all forward speed stopped and vertical motion was small. We paused momentarily on the treetop and rolled over on the right wing. The aircraft pivoted 90° to the right in falling and struck the right wing and continued rolling over on its back."

It was the opinion of the accident investigation board that the pilot was dividing his time between searching and flying and was not conscious of losing altitude until it was too late to take action.

If the pilot had been flying to one side of the valley in the manner of mountain-wise aviators, it is possible he could have turned away from the ridge and avoided the crash. There are tricks to all trades. Trad-

The Bird Dog crashed in dense jungle and was never recovered



Flight path of H-19C prior to crash

ing punches with a mountain isn't the way to learn them.

DOWNWIND LANDING

If you're still not convinced of the hazards of mountain flying, consider the case of the 28-year-old aviator with more than 2,000 hours flying time in his log book. This age and experience level should have removed him from this type of accident, but the mountain hazard tripped him.

He was assigned an H-19C resupply mission to a mountain outpost. Let him tell what happened:

"We followed the ridge line up to the pad. Passing over the pad at about 200 feet we made a climbing left turn and approached from the south for a low pass at 50-100 feet to check the feasibility of air dropping. The air was not very turbulent and the wind was blowing up the ridge from the north at approximately 10 knots. The low pass was started, descending to 50-100 feet over the drop zone for a low reconnaissance. Approach speed was 35-40 knots, leaving plenty of clearance for a left turn in case of a downdraft. Nearing the ridge line the aircraft started to settle and full left pedal and sufficient left cyclic was used for a left turn. Feeling no control response, full power was applied but the aircraft continued to settle and go straight ahead. The aircraft was then headed for a small draw in the ridge line and to the left of the drop zone. Noticing several people standing in the aircraft's flight path who would be hit if it crashed on the ridge line, we flared short of it and the initial point of impact was approximately 20-30 feet below the ridge line."

The aircraft turned to the right after crashing and hit on the right side and top, losing two blades and breaking the left windshield. It continued to roll to the right and came to rest about 100 feet below, with the nose pointing up the ridge.

The accident investigation board learned that actually the wind was opposite what the pilot had estimated. In making this error he brought the aircraft into the pad on the ridge in a downwind condition. The aircraft was loaded 400 pounds below gross. While the density altitude wasn't given in the accident report, the midsummer, midday temperature probably had some bearing on the aircraft settling with power.

But the big bugaboo here was topography. Mountain flying requires special alertness to avoid the hazard of terrain. If a thorough basic knowledge of mountain flying is lacking, even alertness won't help. Get the word. Learn and live.

(Editor's Note: See *Mountain Operations*, page 13.)

The aircraft hit below the ridge and rolled downslope

FUNDAMENTALS OF TWIN ENGINE FLIGHT

James R. Paul

WITH THE prospects of larger, faster, safer, and more efficient multiengine aircraft appearing on the Army Aviation horizon, it might be appropriate for single-engine pilots to start considering the many facets of safe multiengine flying in preparation for future training. Those who are presently twin-engine qualified may find it worthwhile to review basic safe operating procedures.

Modern twin-engine aircraft in the Army's present inventory deliver excellent flight performance, reliability, and safety, provided they are properly handled by pilots who know how to use them. It is generally felt that any reasonably proficient single-engine pilot in the Army can, in a few hours transition, take off, circle the field, and land any of the Army's multiengine aircraft. However, should an emergency occur, such as the loss of an engine on takeoff before attaining safe single engine speed, the aviator may find himself riding a completely unmanageable monster, with little recourse except to ride her down.

For safety in twin-engine aircraft, familiarity with two speeds is vital:

1. ENGINE-OUT MINIMUM CONTROL SPEED (V_{mc}) is defined as the minimum airspeed at which the aircraft is controllable when the critical engine is suddenly made inoperative, with the remaining engine at takeoff power. Since the power output increases at lower altitudes, the engine-out control loss is more critical on takeoff, especially from airports at low elevations. (The left engine is considered the critical engine, since all US built engines turn props clockwise, with the resultant torque to the left.)

In the event of a sudden engine failure at an airspeed below the engine-out minimum control speed, the operating engine must be throttled back immediately to achieve an airspeed at which flight control can be maintained. If this power will not prevent a loss of altitude, an immediate landing must be effected. Banking slightly (not more than 5°) toward the operating engine will assist in maintaining flight control without appreciable loss of lift.

Mr. Paul is a civilian instructor in the Instrument Division of the Dept of Advanced Fixed Wing Training. He is presently on TDY with the Caribou project at the Aviation Board.

After an engine failure at cruising, METO power should be applied immediately

2. ENGINE-OUT BEST CLIMB SPEED (V_y) is defined as the airspeed which delivers the best rate of climb, or slowest descent, with one engine out with the remaining engine at takeoff power. This may be very close to V_{mc}; V_{mc} and V_y speeds are published in the flight manual for each particular series of aircraft.

When operating an aircraft out of confined areas or over obstacles, the pilot will obviously obtain the steepest angle of climb possible. However, if an engine should fail under these conditions, 10 knots or below V_{mc}, and in a steep climbing attitude, he is immediately in serious trouble. The only recourse is to reduce power on the good engine, level off, and attempt to regain V_{mc} or land. Never attempt a takeoff over an obstruction without first considering and formulating a definite plan in the event an engine should fail.

When testing for an unknown minimum control speed, set the plane up at some relatively high speed, close the throttle on one engine with takeoff power on the other, and slow down to the speed at which you can just hold straight flight with full rudder. This speed is actually a little below V_{mc} for sudden and complete loss of power on the takeoff, since to have control of the aircraft the pilot should be able to turn into the good engine. Some aircraft can be controlled to the stall and recovered on one engine. In such cases the V_{mc} should be established at a safe speed above the stalling speed even though it can be controlled at a slower speed.

When testing for engine-out best climb speed, set up takeoff power on one engine, close throttle on the other, and fly the plane at different airspeeds for a predetermined time (5 minutes) at each speed. Then determine at which speed the best rate of climb is obtained.

Three important principles to remember in the operation of twin-engine aircraft in order of importance are these:

1. Altitude is more valuable to safety after takeoff than airspeed in excess of the best rate of climb speed. A number of takeoff and climb-out procedures are available; let's analyze the extremes. First, we leave the ground, "hold her down," and go over the end of the runway at cruising speed, but at only 30 feet high, then we lose an engine. (An FAA publication tells us at 123 mph the drag on the windmilling propeller is 1½ times that at 100; at 200 mph drag is 4 times that at 100.) The pilot suddenly discovers that he converted all the energy produced by the engines into speed and the speed deserts him immediately. By the time he has control of the situation, he finds himself down to about the speed he should have been all the time—but still at 30 feet. From here he will have to climb to an altitude to clear the obstructions and get back to the end of the runway.

In other words, we have found that speed cannot readily be converted to energy to help you around the field. If the energy has been converted to height above the field elevation to permit you to clear all obstructions in level flight, the problem is much simpler. Using the same reasoning we use in single-engine aircraft, extra height can be traded for energy.

2. Climb or continued level flight is impossible with gear extended and a propeller windmilling in present Army multi-engine aircraft. When a pilot assumes the responsibility for a twin-engine aircraft, he

should determine in what configurations of gear, flaps, and propeller the aircraft will maintain altitude with full load and an engine out. Several fatal accidents have resulted from attempts to pull up and go around with the gear down when the aircraft was actually incapable of climbing in this configuration.

3. After an engine failure at cruising, METO* power should be applied immediately to establish single-engine flight. It is a recognized practice to apply maximum allowable power to the operating engine until level flight is definitely established. If the aircraft is found to be capable of level flight or climb with the existing load, altitude, and temperature, an appropriate power reduction can then be made. In no case should the airspeed be allowed to fall below the engine-out best climb speed, even though altitude is lost, since this speed will always provide the best chance of climb or the least altitude loss. The ability to climb at approximately 50 fpm in calm air is necessary to maintain level flight for prolonged periods, even in moderate turbulence.

*METO — The maximum power available from the engine for continuous operation.

A pilot with single-engine training and experience who aspires to fly twin-engine aircraft should study all available technical information on its performance and the operations of its components and emergency equipment. He should familiarize himself with the following general procedures for use in event of a sudden engine failure:

1. FAILURE DURING TAKE-OFF OR CLIMB-OUT

a. If airspeed is below V_{mc}, reduce power to maintain flight control and gain speed, by loss of altitude if possible.

b. If airspeed is below engine-out best climb speed, attain that speed before attempting to climb.

c. If airspeed is at or above engine-out best climb speed, keep maximum available power on good engine and hold engine-out best climb speed. If climb results, maneuver carefully for a landing back at the airport; otherwise prepare to land at nearest available area. Keep gear and flaps retracted until you are sure of reaching desired landing spot.

d. If sufficient runway is available, land straight ahead regardless of airspeed.

2. FAILURE DURING CRUISING FLIGHT

a. Increase power on good engine to METO.

b. Maintain engine-out best climb speed.

c. Reduce power only when unneeded altitude is gained.

d. Proceed to a landing at the first adequate airport or landing area.

SUMMARY

The above information must be considered as fundamentals of flying our Army's multiengine aircraft. To satisfactorily and safely operate a particular type or model, a careful review of the -1 must be accomplished with appropriate transition training covering this vital subject.

THIS SITUATION, even though it is hypothetical, will pertain to both fixed and rotary wing aircraft.

At 12:34:59 an aircraft is slowly flying in front of a group of Army Aviators at an indicated airspeed of 45 mph, at an altitude of 100 feet, with a 45 mph headwind on his nose, using whatever power needed.

Altitude—100 feet

Airspeed—45 mph

Wind—45 mph

Manifold Pressure—as necessary

Now for the hypothetical part: At 12:35 there is a drop in the wind to 0 mph. If the same attitude were held and the same manifold pressure were held: (1) What will the airspeed be at 12:35? (2) What will the groundspeed be at 12:35? (3) What, if anything, would happen to the altitude? (4) Would there be any danger of ground contact?

The recommended solution to the PUZZLER may be found on page 14.

With proper training and forethought you can enjoy

Mountain Operations

Lieutenant William A. Kilpatrick, Inf

TO THE UNINITIATED, operations from strips in higher elevations are a subject of respect, and in some instances awe. Mountain operations do present many problems, and different techniques are required from those used at sea level. Mountain operations, however, are not inherently dangerous if approached with proper planning and forethought, regardless of the height or ruggedness of the mountains.

If war should come, Army Aviation will be expected to fulfill its mission regardless of the terrain, and we should all be prepared to fulfill that mission. Those of us fortunate enough to have been stationed at posts near mountainous areas should be in good stead. Normally, extensive checkouts are required before the pilots are declared operational in such areas. Unfortunately, many posts have neither the terrain nor the necessity for such checkouts. Consequently, we often meet seasoned pilots who have mistaken ideas about the proper techniques in this field.

"Since the elevation of the strip was about 5,000 feet, I held 10 miles an hour excess airspeed on final."

"So there I was in this valley with the canyon walls about 2,000 feet above me on both sides when suddenly the walls came together."

Pilots experienced in mountain flying always breathe a sigh of relief when they hear statements like these, because they figure that at least one more pilot has learned his lesson about mountain operations without the necessity of having the story put together by the board of aircraft accident investigators. Incidents such as those could have been avoided by following a few simple rules concerning mountain operations. We learned those rules in basic flight training, but we've forgotten about them because of disuse.

Just in case you have forgotten them too, here are a few things to think about before taking off on that cross-country that will take you over mountainous terrain for the first time.

1. **Be aware of the effects of mountainous terrain on the existing wind.** There will normally be an updraft on the upwind side of a hill or ridge line and a downdraft on the downwind side, the severity of which is not necessarily dependent on either the velocity of the wind or the actual height of the terrain. Although this can vary if the wind is quartering to the terrain, it is important to remember when flying aircraft not equipped with oxygen which may require you to fly close to the terrain.

So, unless you are holding altitude that you are certain will allow you to clear, regardless

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Lt Kilpatrick is presently assigned to the 9th Aviation Company, Fort Carson, Colorado.

of the downdraft, approach at an angle of approximately 45°. Be prepared to turn away if it should become necessary. Try to avoid tight turns, but be ready to use flaps if necessary; they will reduce the turning radius of the aircraft considerably without standing it on its wing.

2. **Weather in the mountains is considerably more unpredictable than at lower levels.** Except for scattered air mass thunderstorms, we usually associate clear skies and unlimited visibility with high pressure systems. The existing weather can change and often does change far more rapidly in the mountains. Instead of flying off with a quick look at the teletype and glance at the weather map, get a good weather briefing from the man who has experienced it.

3. **Navigation in the mountains is normally more difficult due to lack of usual checkpoints.** This is true whether you are flying with ground checks or radio aids. In the more desolate areas, even the highways and railways are so winding and hidden by terrain that they are useless. So get back to the system taught in school of checking rivers, lakes, valleys, mountains, and other natural features. Keep a close check on your exact position; you'll be amazed how much alike all mountains can look once you're a little disoriented. Flying a valley in unusually high country can be a very good system, but be sure it's the right one and the canyon walls don't "suddenly come together." With the limited radios available in the L-19, airways are usually few, far between, and indirect. When you do find one, the MRA may be considerably above the 10,000-foot level.

4. **The stalling speed of any aircraft is the same indicated airspeed regardless of the altitude.** Many times when coming into an airport at an elevation of 4,000-5,000 feet for the first time, the pilot used to flying at sea level sets up landing approach that would do justice to an F-104, only to reach the roundout point, float half the length of the runway, then drop it in from about 15 feet. Naturally your true airspeed is higher, but your indicated gliding speed is the same as at sea level.

Another thing, one of the first points your instructor made when you started flight training was "always know where you're going to set the plane down if the engine fails." This point is particularly true in mountains because forced landing areas are few and far between. Although you may be indicating a lot of altitude, the ground may be much too close to consider the parachute as a means of transportation. Take some sort of survival gear with you, a regular kit if possible. If not, at least carry a few matches in a waterproof box and several candy bars; and dress warmly. The very thing that caused you to go in, such as weather, might preclude an immediate search and rescue operation. And it may be a long walk to the nearest farm house!

Scare rules? If approached with knowledge, respect, and by simply applying these few simple points, Army Aviators can operate as safely and successfully in the mountains as anywhere in the world.

Remember, although experience may be the best teacher, it can also be the deadliest, so do a little preflight planning, a lot of inflight thinking, and mountain operations can be as pleasant and gratifying as any in your experience.

Solution to This Month's Puzzler

The Puzzler questions were answered by the National Aeronautics and Space Administration, Langley Field, Virginia.

1. The airspeed at 12:35, after the 45 mph headwind subsides, would be approximately 0 mph.

2. The groundspeed at 12:35 is approximately 0.

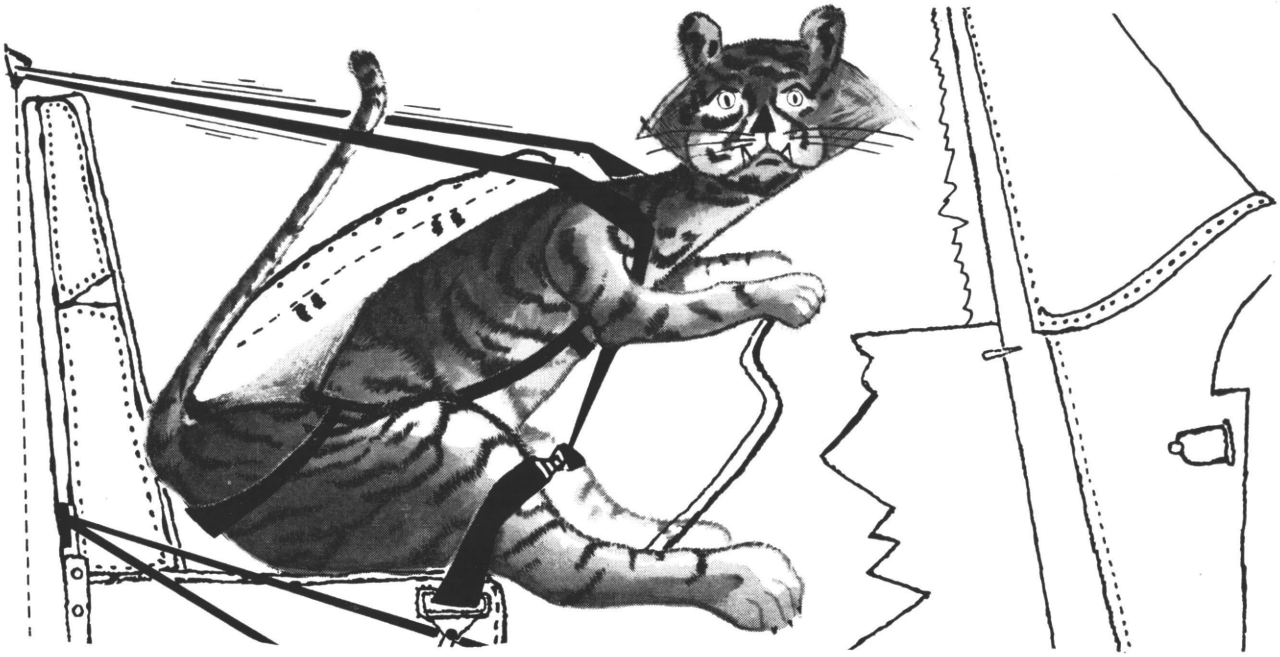
3. The aircraft will be unable to develop an aerodynamic force sufficient to support its weight. Stall or separation of flow about the wing will occur as aircraft begins drop with negligible forward speed.

4. Since the aircraft is not developing a lift equal to its weight, the acceleration due to gravity will cause the aircraft to fall toward the ground. Propeller thrust for the assumed aircraft would have only a secondary effect during the fall. Ground contact could be expected.

The aircraft will have no forward momentum with respect to the ground at 12:34:59.

Inertia will have the effect of seemingly resisting motion as in Newton's Law: If a body is at rest, it will continue at rest; and if it is in motion, it will continue in motion with constant velocity unless there is a net force acting on it.

STRAP THAT TIGER DOWN



Gerald M. Bruggink

THE WAY some pilots treat their shoulder harness reminds us of what the actress in one of her revolutionary moods remarked to the bishop: "Sometimes I wonder. Are girdles a necessary evil or does evil make them necessary?" Many more pilots would be around today if they had been as meticulous about their shoulder harness as American women are about "hip harness." If this sounds like a bold statement, we remind you that it is based on the evidence of hundreds of aircraft accident reports. We do not believe it necessary to use the gory details of some of these reports to convince you of the importance of the shoulder harness.

Mr. Bruggink is an accident investigator with Aviation Crash Injury Research of Flight Safety Foundation.

WHY USE A SHOULDER HARNESS?

Basically, we use a shoulder harness to keep our faces from ramming into the instrument panel or other solid objects during heavy decelerations. Personally, we think very highly of anything that safeguards our bodies. And so does a friend of ours, after he smashed his jaw against the control wheel during a most unfortunate encounter with trees. He had a shoulder harness in his aircraft, but a fancy seat cover prevented his using it.

Besides this basic function, a properly used shoulder harness has other advantages, such as preventing injury in turbulent weather and reducing the chance of vertigo under instrument conditions.

HOW TO USE THE SHOULDER HARNESS

Have you ever seen the completely intact cockpit of a crashed aircraft and been surprised to hear that although he did not have a scratch on his face the pilot received serious spinal or internal injuries? Did you ask yourself how these things happen? If you are not allergic to numbers, you can find an answer in the following discussion.

Suppose you are driving along comfortably in a 40 g stressed cockpit. Make you feel pretty safe, those 40 g's, don't they? It will take some beating before that protective shell around you collapses. But what about your own design strength? If you are Mother Nature's standard edition, you'll probably take about 40 g horizontal and 25 g vertical deceleration before developing serious aftereffects. This means that the engineers have put you in a wheelhouse that takes approximately as much punishment as you do in longitudinal decelerations and even more in vertical decelerations.

Let's now suppose that you are faced with a situation "that only happens to the other guy": a forced landing in extremely rugged terrain. You touch down at 112 mph with an impact angle of 18°; the aircraft starts horizontal deceleration at 35 g's. (All figures quoted are based upon actual NACA tests.*) Just as you begin to wonder when this thing is going to hurt, you become completely unconscious. What has happened? Very simple: although the aircraft was decelerating at a tolerable 35 g's, you were subjected to a peak load of 45 g's because you had not taken all the slack out of your shoulder harness.

WHAT ABOUT THE INERTIA REEL?

Sure, that inertia reel worked exactly as it was supposed to. But it did not take into consideration your negligence to take all the slack out of the harness and a few other things such as: the stretching of the shoulder harness under tremendous loads and the "elasticity" of your body and clothing. We'll go a little deeper into this.

ANALYSIS OF A 'BIG KICK'

When the seat, as part of the aircraft structure, and your hips, which were well secured by the safety belt, started decelerating at 35 g's, your upper torso was thrown forward with a force 35 times its own weight. The shoulder harness locked at the first onset of the g-loads, but between the comfortable adjustment by the spring tension of the inertia reel only and the hard manual pull on the straps in the "lock" position, there are always a few inches to spare. Add to this the unavoidable "give" of the shoulder harness material itself and the elasticity of your body plus clothing and it becomes obvious that you had a certain amount of freedom of forward travel. The result was that your rate of slowing down, momentarily, was less than that of the aircraft.

This would be a desirable situation if it would last indefinitely. Unfortunately, it came to an abrupt end when the shoulder harness, reaching its limits, became as taut as a steel cable and reduced that speed differential to zero in the form of a snapload on your torso.

Assuming that the aircraft had slowed down to 90 mph while your upper half was still going at 95 mph, this speed differential would only be 5 mph. But if your "catching up" with the aircraft took place in approximately 1/50 of a second, this would result in a 10 g snapload on your body. (This is a simple demonstration of the axiom that it is not speed that hurts but rate of change of speed.) Add these 10 extra g's to the 35 the aircraft had already and you have a 45 g peak, which will answer the question about the ill-feeling pilot in the good-looking cockpit. In addition, these peak loads sometimes have the nasty habit of exceeding the tie-down strength of your seat, shoulder harness, or safety belt (in which case you have our deepest sympathy).

Summarizing, we arrive at a healthy conclusion: to avoid dangerous snaploads (load-amplification) during heavy decelerations a pilot **should take the last inch of slack out of his shoulder harness.** What we have said in no way reflects on the ingenuity and workmanship of the inertia reel manufacturer. Actually he'll be the first to admit that the inertia reel does not allow for carelessness. He'll also admit that you can obtain maximum tightness of the shoulder harness manually only and in the "lock" position, for reasons explained previously.

It is a proven fact that the automatic features of the inertia reel will provide adequate protection under severe impact conditions, **if the shoulder harness is properly adjusted.**

We have been discussing an extreme case in which you and your aircraft went to the limits of structural integrity. The NACA tests proved that your survival in such a borderline case may well hinge on the length of the loose strap-ends, flapping carelessly in front of you.

ATTENTION LIGHT AIRCRAFT PILOTS

The foregoing might create the impression that we are

*NACA Research Memorandum RME 57 G 11, "Accelerations in Fighter-Airplane Crashes."

Note: The aspects of the vertical deceleration will not be discussed here.

mainly concerned about the heavy-stuff drivers. This is purely accidental; and we'll conclude with a few points of special interest to the light aircraft pilot.

1. The g loads a pilot can be exposed to during a crash are more a function of impact angle, speed and terrain, and other unpredictable circumstances than of the type aircraft he is flying. Consequently, the proper use of the shoulder harness is as important in a Tri-Pacer as it is in a 707.

2. Several types of light planes with a shoulder harness lack an automatic locking device, which makes proper manual adjustment more critical.

3. Experience has shown that during severe impacts in single engine light aircraft, the engine is often pushed back into the instrument panel. This decreases the distance between the pilot and possible lethal objects in front of him and indicates the need for a "face-saving" device in the form of a good shoulder harness.

4. Since the tie-down strength of seat, belt, and harness in light planes is often less than that in heavier aircraft, snaploads can easily contribute to tie-down failures. There is nothing funny about becoming a human missile in an aircraft.

We agree that the shoulder harness makes a dull subject. All it does is help you keep alive when you know how to use it.

STORM EVASION BY OMNI

"If you do not have radar, your omni receiver might offer interim assistance in the avoidance of areas of hail and heavy precip." At least that's the opinion of one airline captain.

". . . when airborne radar is not available, good use can be made of the VHF navigation receivers by keeping one tuned to the station ahead. The short wave signals used by VOR give evidence of not readily penetrating hail shafts or areas of heavy precipitation. I have made successful use of this 'theory' during the past three thunderstorm seasons. . .

For example

"At the time of takeoff from point A to destination B there were no thunderstorms reported on course, but there was a line of storms parallel to and north of the course that were forecast to hit the course in little over two hours.

"Flying at 6,000 feet IFR and on instruments, I had my omni receiver turned to the VOR immediately ahead of me, on course and about midway between point A and my destination. About halfway to the site of this VOR and some 10 minutes before reaching a river that bisected the course, the omni course needle began to oscillate badly. I called in and was told that a severe thunder and hail storm had struck suddenly. Almost at once we hit heavy turbulence and rain which necessitated our turning south in search of smoother air. Finding it, we flew a course parallel to the original one, but the course needle did not steady until we were southwest of the VOR station to which we'd been tuned.

"We then letdown to 4,000 feet, but couldn't pick up our destination or talk to it for another 10 minutes. In the meantime, however, we could see heavy lightning to the west. Not until we were about 50 miles out from our destination could we tune them in, and then with severe oscillation of the needle. We were told our destination had a severe thunderstorm and hail. But being short on fuel, we decided to continue on in and ask the tower for radar assistance. . .

Clutter

"Confirmation of what our oscillating course needle was saying came when we were told their scope was completely cluttered with precipitation and they could not see us.

"A VOR station beyond our destination came in steady so we obtained ARTC permission to detour and stayed on that course until we were some 15 miles south of destination B. Getting a steady course needle at that point (220° from destination), we turned toward destination B and went on in through heavy rain but relatively smooth air. . ."

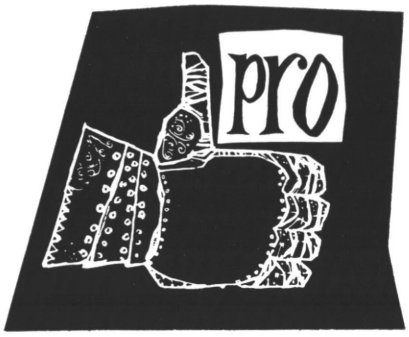
And the captain added, "Of course, it will not tell you which way to turn, but a good knowledge of current conditions usually will provide this information. Also, some common sense has to be used, such as knowledge that you are at a normal position for reception, etc. It will not take the place of radar, but it is an aid that we now have and should be using. Thus used, it is my belief that the addition of one ADF set to 150 kc can save many bumps and much damage . . ." **(Flight Safety Foundation)**

Do We Need An

Centralization Is the Answer

A branch is the surest means of integrating aviation's potential into the total ground effort.

Captain Larry S. Mickel, Inf



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FORECASTING THE shape of future wars is a continuing process. Perhaps the most valuable contribution such thought can make is in pointing out deficiencies in our current organization and equipment. We like, for instance, to picture the aerial vehicle as deploying hard-hitting troop formations to the farthest reaches of the battlefield with unparalleled speed. Such thoughts are healthy and stimulating, but they conceal the simple fact that Army Aviation as organized today cannot achieve these mobility goals. An examination of the facts is revealing.

Army Aviation is presently organic to seven branches. Each of these branches claims to have definite need for integrated aerial support. Each is vitally interested in its growth and development, but for separate and distinct purposes. This splitting of effort has permitted numerous organizational and operational concepts to arise. These concepts have generally become separated into two schools of thought.

On one hand, we find the service branches — primarily the Transportation Corps — which consider Army Aviation to be logistical in nature and, therefore, subject to control of the services. On the other hand, the combat arms desire an air capability subject to immediate operations and contingent only on the requirements of troop commanders. The service branch concepts have predominated, presumably because of the status of the Chief of Transportation at Department of the Army level. The Chief of Transportation, directly responsible to Deputy Chief of Staff for Logistics, has no counterpart in the combat arms. Army Regulations dictate the Chief of Transportation's responsibility for doctrine, procedures and techniques relating to aviation, while the combat arms are given a similar mission without equivalent status at the Chief level.

An examination of aviation management shows a confusion of responsibility, though the Director of Army Aviation, within the office of Deputy Chief of Staff for Operations, is responsible for over-all staff supervision and coordination of Army Air effort. Army Regulations dictate that the Commanding General, USCONARC, has specific responsibility toward aviation units and personnel in CONUS, except for activities directly assigned the Chief of Transportation. Yet, the Transportation Corps has identical responsibilities for all transportation units except Army transportation helicopter units. Further, the Chief of Transportation has a responsibility to advise the Army Aviation School on **all** matters relat-

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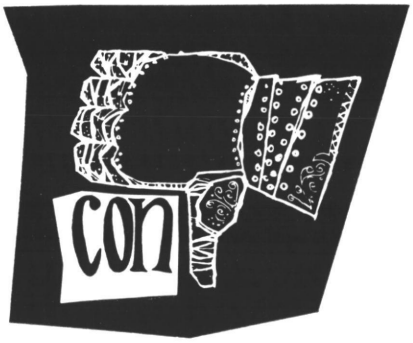
A graduate of the USAIS Advanced Course, Capt Mickel is now a member of the Air Mobility Group of the Airborne-Air Mobility Department, Fort Benning, Georgia.

Aviation Branch?



ission of INFANTRY magazine,
y Center, Fort Benning, Georgia.

Not Branch, but Balance

An effective combination of overall direction and specific ground control means greater combat power.

Captain Roger M. Pezzelle, Inf

WITHIN THE ARMY as a whole, and particularly within Army Aviation itself, there is clear dissatisfaction with the state of Army air. An Army Aviation branch is frequently advanced as an acceptable solution to these difficulties. Proponents of a separate branch organization claim that it would reduce the disproportionate control which the Transportation Corps now exerts over the aviation program, eliminate the problems which have arisen over the "dual proficiency" requirement, and produce better equipped, more responsive, more effective Army air.

It is easy to understand why a separate aviation branch is the favorite suggestion — on superficial view, it seems to solve the immediate problems. As Army men, we automatically react favorably to any proposal that appears to strengthen Army air. Yet the fact is that an aviation branch might eventually complicate existing problems, and might create significant new problems which are too rarely mentioned.

To begin with, an Army air branch would encourage an ambitious expansion of Army air functions in the wrong directions. The mission, "to augment the capability of the Army," is so broad that, given the opportunity, there is little doubt that vast programs of research and development, independent applications of the air potential and over - refinement of standard methods and equipment would encroach upon the simple capability to "conduct prompt and sustained combat." It's easy to visualize aircraft which are the result of what aviation branch wants rather than what the Army as a whole needs—delicate and overspecialized equipment which is out of place on the battlefield and ill-adapted to it. It is easy to visualize methods and techniques which are the result of aerial convenience rather than ground necessity. The proper missions of Army air require a stark functionalism which is impossible under full branch organization.

Moreover, an air branch would further separate by echelons and physical distance the combat commander from the aircraft which should be operating in close support of his unit. When the Army Air Corps was established as what was in effect a separate branch, the airplane was separated from the ground commander in a somewhat parallel way. In view of the types of aircraft and functions involved, this separation was logical at that time. While the commander received less of the kind of close support that Army Aviation is now striving to provide, the Air Corps itself was left free to perform some major functions for which its equipment was

Continued on page 21

Capt Pezzelle completed the USAIS Advanced Cource in 1958 and then began his present assignment in the School's Combat Developments Office, Fort Benning, Georgia.

Centralization Is the Answer

ing to aviation — a rather sweeping coverage in view of the functions of aviation which are entirely unrelated to the Transportation Corps mission. Then, the Aviation School represents all seven of the Army Aviation user branches; furthermore, user branch schools represent themselves in matters concerning branch air doctrine.

This muddle closely approximates the situation which existed in the Army Air Corps prior to the establishment of the United States Army Air Force in 1941. From the period 1935 to 1941, the responsibility for air activities in the United States Army was divided between the Air Corps and GHQ Air Force. This responsibility was shared with nine corps areas (later called Service Commands), established on a geographical basis. In theory, GHQ Air Force had operational control, with administrative support the responsibility of the Air Corps, while the corps areas assisted both. A result of this divided responsibility was an inadequate system of supply, maintenance and training.

The words of the War Department Special Committee on the Army Air Corps, published on 18 July 1934, are true today. "The normal position of the Air Corps in the administrative organization of the Army should correspond to its functions, (1) as a combat arm . . . and (2) as a procurement and supply service. This was the lesson of experience in the World War and the lesson embodied in the National Defense Act of 1920." In other words, aviation must be accorded a branch status.

Among the problems which branch status would eliminate for Army Aviation is the unusual policy for officer aviators called "dual proficiency." As described in AR 600-105, "Army Aviation Career Program," an aviator is required to maintain ground proficiency consistent with his nonrated contemporary.

The announced objective of "dual proficiency" is to "produce and develop qualified and experienced commissioned officers for the professional and technical phases of Army Aviation." Yet, it is true that an aviator entering the "best qualified" echelon of promotion **must** have a high degree of branch proficiency to compete with the nonrated officer whose entire time is spent in branch-material assignments.

During those periods when an aviator is on a ground assignment attempting to retain his branch proficiency, his flying proficiency will suffer, since in most cases he is able to accumulate only the minimum of 80 hours flying time per year. Thus, the program defeats the first priority task for the aviator: achieving the maximum combat performance from his aircraft.

A recent survey of aviators at Fort Benning shows that 18 percent of the 150 aviators questioned had transferred, or intended to transfer, from the Infantry to the Transportation Corps. Aviators see in the Transportation Corps a unifying Chief and an opportunity for a full-time aviation job, with a wide variety of aviation assignments and command opportunities. Infantry pilots further note that TC is the procurement agency for Army Aviation, that Transportation Corps is authorized a larger percentage of field grade aviators than any of the combat arms, and that Transportation Corps assignment means an opportunity to fly large aircraft.

As a consequence, the Transportation Corps will become the "aviation branch" unless sweeping changes are made in the aviation organization.

Already the Transportation Corps' very strong hold on aviation has had some undesirable effects. Army Aviation has cost $900,000,000 in the last eight years, the majority of these funds going to procurement of "freighter" aircraft that are too large to be concealed in the combat zone and too expensive to be risked forward of the FEBA. The battle group has not one single aircraft.

Under a branch system, coordination of aircraft procurement by the Chief of Army Aviation would insure the necessary balance between heavy transport and frontline aircraft. Establishment of an aviation branch as a combat arm would further guarantee that development and procurement are consistent with Army Aviation's mission: "To augment the capability of the Army to conduct prompt and sustained combat, incident to operations on land."

Establishing an aviation branch, which is within the statutory authority of the Secretary of the Army, would provide a solution to the majority of growing pains now suffered by Army Aviation. It would involve major changes, and would encounter strong oppo-

Continued on page 22

Not Branch, but Balance

especially designed. Even then, though, it was clear that versatile light aircraft had an important role in close support, and that such aircraft would fulfill this role especially well if placed directly under the control of the ground commander. In 1942, for instance, light aircraft were authorized to the Artillery as aerial observation platforms.

This broad separation by types and functions clarified the role of aircraft in warfare, and contributed to the general efficiency of air support. On the one hand, large, fast, heavily armed aircraft would have strategic and certain tactical functions, and on the other small, slow, lightly armed or unarmed aircraft would have only immediate tactical functions. By establishing an Army Aviation branch we would be destroying this useful specialization which has developed as a result of the original separation. By repeating the original separation we would only be confusing it, and we would be seriously impairing the capabilities for close support that now exist.

Only very recently the regimental commander had organic to his unit—and therefore immediately responsive to his commands—two light aircraft. Now he has none. At a time when close air support has assumed great importance for reconnaissance, command and liaison transport, delivery of troops and supplies and, in some cases, as a weapons platform, we have made that kind of support less available. Even the pooling concept, which resulted from the great and various demands made upon Army Aviation, is a step in the wrong direction, simply because the ground commander has had to "beg" for whatever air support he gets. Because aviation has itself an argument against branch. On the one hand, branch is predicated on the basis of use, and not equipment. That is why we did not create a separate missile branch, but integrated our new missiles within appropriate existing branches. We gave the missiles to the people who would use them. Similarly, we must give the aircraft to the people who will use them—Infantry, Artillery, or whatever, must have organic aircraft. On the other hand, aviation, if left to itself in a branch organization, would, precisely because of its difference, tend to acquire trappings of mystery and witchcraft which do not contribute to efficiency. Airplanes are in every sense "air vehicles," and there is nothing exotic about them. As "vehicles," they must be controlled by the user, the ground commander.

Furthermore, with the advent of the zero ground-pressure device, a separate aviation branch would not only be inadvisable, but impracticable. This piece of equipment, presently in the developmental stage, may soon be as common as the jeep is now. Plainly enough, the logical direction of Army Aviation is not towards more sophisticated aircraft but towards equipment which is easy to operate, simple to maintain and economical to produce — and which, moreover, will be available and appropriate for sustained tactical use on an unprecedented scale. We must not allow branch proponents to imprison Army Aviation within the 1959-1960 time frame, for branch and AV are incompatible. Imagine, for example, how absurd it would be to talk about a "jeep branch," and yet branch exponents are in effect talking about the same kind of thing. When zero ground pressure vehicles are a dime a dozen, then obviously the domain of the air must be common to all branches.

If officers continue to pilot Army aircraft, the branch concept would also create prohibitive personnel difficulties. The role of Army Aviation is so defined by law and convention that though at the lower echelons a considerable number of personnel are required, at the higher echelons of command and on staff levels there simply would be no room for placement within a branch. Even now, field-grade, air-qualified officers must be employed in other duties than Army Aviation. When expanded aviation requires expanded numbers of lieutenants and captains as pilots of light aircraft, then high-level command room will be even scarcer. A profusion of AVs would complicate the problem, and adding branch on top of these elements would create an inoperable system.

Frequent assignment of Army Aviation personnel of one branch to air support duties with another has already taken its toll in efficiency of operation and good personnel management. Infantry officers who should be flying with Infantry units are flying with separate Artillery battalions, and Artillery officers are flying for Infantry battle groups. Situations like this contribute to a lack of effective support. If,

Continued on page 23

Centralization Is the Answer

sition as it has since 1954 when first recommended by Army Aviation representatives in the Department of the Army. This opposition has developed as a result of a fear that the Army Aviation Branch would develop an "Army Air Corps attitude," thus separating itself from the ground combat echelons of the Army, and on the other hand, that constituting an aviation branch would provide the Air Force with an argument for assimilating that organization into its structure.

The first of these fears stems from the historical background of military aviation. Now that the Air Force has assumed the strategic aviation roles, there is no reason to suppose that the proposed aviation branch would follow the example of the Army Air Corps, which grew to have missions so independent of the ground arms that it ceased to provide them with effective support. Army Aviation's mission is clear enough and the pre-existence of the Air Force will effectively discourage any departure from it.

The fear of assimilation by the Air Force is also groundless. It need only be pointed out that the Air Force has constantly treated those missions now assigned Army Aviation as a thorn in its side. The use of supersonic aircraft in ground support roles indicates an apparent lack of interest in aviation aspects of the ground fight. The Army is now authorized by law to engage in aviation activities and a reorganization of Army Aviation in the interest of efficiency would be of no more concern to the Air Force than any other internal activity of the Army.

The Army Aviation Branch, although primarily a combat branch, would function as both an arm and a service, as for example does the Corps of Engineers. The responsibilities for development, procurement, organization, maintenance and training would then logically come under one office for direction and coordination, the office of the Chief of Aviation. Aviation units would be assigned within the combat arms and technical services as required. Here they would respond to operational requirements of the ground commander under the same command relationship as found between the Infantry Division and the Infantry Division engineer battalion.

Many advantages would accrue from an aviation branch. These include: central control of responsibilities for aviation, centralization of career management for Army aviators, elimination of the need for "dual proficiency," elimination of the present "struggle for power" between the branches, and provision of a basis for rapid mobilization expansion. Further, an aviation branch would insure that proper recognition is given to the growth of all Army Aviation functions.

The Army must recognize that Army Aviation is a full-time profession. As a corollary, the Army must also recognize that a properly developed and vigorously executed school, unit and combined arms training program is the surest means of achieving effective, integrated performance of aviation and combat arms on the battlefield. The Infantry and other combat arms must finally recognize that the ultimate organization for Army Aviation is an aviation branch—a combat arm and service so organized that it centralizes all aviation effort now fractionalized between seven arms and services.

Army Aviation has come to have a variety of roles, some of them conflicting. To fulfill them efficiently under all conditions, Army air must be balanced and adaptable. An aviation branch is the best and most equitable way of insuring that we give every role the emphasis it requires, that we develop the equipment needed to fulfill each role in the best manner possible, and that we make maximum use of Army's aviation potential.

Ultimate maturity in Army Aviation will only be attained when junior officers in command positions utilize available assistance and publications to the maximum and insist their commands live by this guidance.

Brig Gen William B. Bunker
Commanding General, TMC

however, an aviation branch were adopted, it is likely that aviation personnel would become even more disoriented. Whereas there is at the present time some incidence of branch uniformity between aviator and supported ground forces, under the branch concept, of course, there would be none.

Perhaps one of the most compelling considerations acting against the branch concept is also one of the least mentioned. The fact is that the country simply cannot afford a fourth air force. The Army doesn't need, doesn't want a "private" air force. We don't feel possessive about aerial warfare. What we do want is an Army air that will help us to do the Army job. What we need is an integrated air capability that allows an Army which is thinking in three dimensions to act in three dimensions — to perform its unique Army missions. For the Army's sake, as well as the country's, we need organic air and not a separate branch.

Nevertheless, problems do exist in Army Aviation and, if an aviation branch is no answer to them, neither is the preservation of the status quo. But a separate aviation branch is by no means the only alternative. There are certain logical revisions of the present aviation program which would solve these problems without creating new ones.

Generally speaking, Army Aviation grew in response to short-range necessity rather than long-range planning. It is not surprising, then, that the program is out of joint and has major defects, and that rather sweeping changes are indicated.

Among these is a concentration of budgetary responsibility in an overall aviation authority. The Director of Army Aviation should, in coordination with using branches, be given research, procurement and doctrine responsibility for Army Aviation. In this way, the requirements which ground forces have for air support would be developed by air personnel, adjusted by ground personnel and supervised within a single framework of control. The Chief of Transportation would in this case no longer have total responsibility for aircraft procurement, and equipment design would be equitably coordinated among all the users. The ground forces would obtain a direct, balanced voice in Army Aviation. No longer would there exist the unfortunate situation which has Infantrymen operating on the FEBA in aircraft better suited to carry bulky cargo in rear areas. No longer would essential reconnaissance wait upon complicated maintenance. No longer would aircraft arrive too late to carry too little too short a distance. Aviation would be what it has not yet been—and would not be under the branch concept—**Army** Aviation.

In addition, Army Aviation should be completely integrated within the combat arms and services in supports. Only in this way will we forestall the fascination with branch, with pooling and with centralized control of operations — and, more important, only in this way will we remove once and for all the "borrower basis" on which field commanders must operate at this time. Pooling of aircraft at higher and higher levels may, indeed, decrease maintenance problems. I suggest that this decrease occurs partially because pooled aircraft are less frequently used than they would be were they organic. But the point to remember is that fewer maintenance problems must not become an end in itself. We are not primarily concerned with increasing maintenance ease, but with providing effective support. And organic aircraft are the only ones that can give us effective support. In addition, while centralized control of administration and procurement is fine, when applied to operations centralization is distinctly harmful. We want equanimity, not unanimity, and there is a difference between the two.

One further alteration will solve what is among the most pressing difficulties now facing Army Aviation: the "dual proficiency" requirement. The whole dual proficiency problem arises from the fact that commissioned officers pilot Army aircraft, for dual proficiency itself is by no means an extraordinary requirement. The jeep driver is also a radio-telephone operator. The NCO tank commander combines the functions of a communicator, an Artilleryman and an Ordnance shop foreman. It is only because careers are at stake that dual proficiency in Army Aviation has assumed its present proportions, that there have come to be major personnel difficulties. Even though it may be unreasonable to require of the officer aviator a performance of competitive quality in two fields, the concept of dual proficiency in itself is not unreasonable.

Not Branch, but Balance

The obvious solution, therefore, is to substitute for the officer aviator a noncommissioned officer aviator. After all, the tradition of the officer pilot is nothing but a vestige of the days of the leather helmet, the white scarf and Eddie Rickenbacker's Hat-in-the-Ring Squadron. We have demanded —and successfully—a high degree of technical competence from the modern NCO. There is no reason why we cannot apply the NCO technical potential to Army Aviation by assigning NCOs as aviators. In fact, the NCO is likely to develop a sustained excellence in the technical aspects of Army air which is beyond that allowed by the present system.

Actually, this transition from officer aviator to NCO aviator is not one of choice. The aerial vehicle—designed for operation by enlisted men—will unavoidably change the face of Army Aviation. Just as the AV invalidates the branch concept, it invalidates the commissioned pilot custom. With expanding Army Aviation, it is quite likely that, even disregarding the AV, we would soon need more pilots than our officer-procurement program could provide. Because Army Aviation will always have an auxiliary role, we cannot afford to divert to Army air sufficient resources to support a continuing officer-pilot program. Clearly, a change is in the offing. To prevent the lack of consistency and system which has sometimes characterized the development of Army Aviation in the past, we should accept the NCO pilot concept now, and we should begin a coordinated program of planning and training.

We can do this without wasting the valuable reservoir of knowledge and experience which is represented by officer pilots. This knowledge and experience would, in fact, be demanded by the type of aviation program described above. Aviation-trained officers would be used as "air officers" on the staffs of the units they supported. They would be used in research and development programs in the office of the Director of Army Aviation. They would be used as instructors in aviation - training. And, of course, they would be used to supervise, guide and direct the program as a whole.

If there is any impetus within the Army to extend Army Aviation into the area of legitimate Air Force operation, then it is not the result of Army ambition. We must not, however, seize upon the failure of the Air Force to provide the kind of support to which it is committed by law as an excuse for falling into the aviation branch trap. The branch concept promises a great deal, but in reality would operate with only the same efficiency — and sometimes with considerably less efficiency — than the present system.

What we really need is a sensible revision of this system, which creates an Army Aviation that is less than an air force or branch, but substantially more than an uncoordinated and unbalanced stepchild of necessity. Such a revision is the only way we will obtain practical responsiveness to the tactical commander's will, refinement of the equipment development process, effective use of personnel and an equitable emphasis within the Army on specific air functions.

TREOG

THE AVIATION ELEMENT of the U. S. Army Transportation Environmental Operations Group (TREOG) returned to Fort Eustis from Greenland where the group spent the summer of 1959 on exploratory missions. The latest in cold weather transportation, equipment, and technique were utilized by the TREOG group.

Three major operations were accomplished during this period. OPERATION LEAD DOG was the farthest north penetration of the Arctic by surface mechanized equipment; OPERATION TOP DOG explored the feasibility of using sea ice as a long range avenue of transportation for logistical support of military operation; OPERATION FLYING FROG resulted in the farthest north landing and the longest flight over the permanent icecap by U. S. Army aircraft.

The TREOG group also made an altimetry survey, established astro positions, and proved the reliability of the Overland Train. The Train supported 437,000 ton miles of cargo at an average speed of 4.2 mph.

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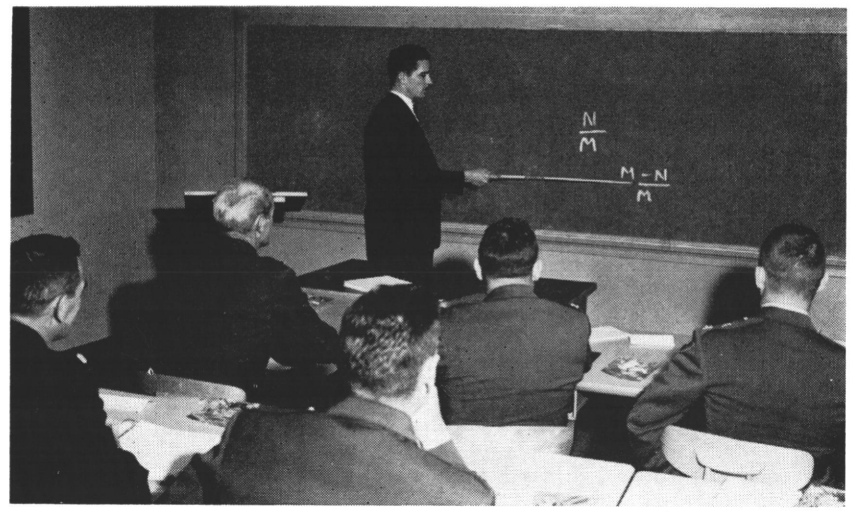


Statistics for Accident Prevention

THE ORIGINATOR of the phrase "Figures lie and liars figure" may have had accident statistics on his mind. Disraeli put it even more succinctly when he said, "There are three kinds of lies: lies, damned lies, and statistics."

Take the matter of comparative rates. Using a flying hour comparison even though engaged in a more hazardous type of flying, Army Aviation has a fatality rate 20 percent lower than general aviation.

With these figures we can predict that 1 out of every 150 Army aircraft will be involved in an accident causing a serious or fatal injury each year. If an average Army Aviator flies for 30 years, his chances of being in a fatal or serious injury accident is 30 times greater than 1 out of 150. Reducing this mathematically, the exposure rate to death or injury in 30 years would be 1 out of 5.

This article was prepared by the U. S. Army Board for Aviation Accident Research.

The secret language of statistics, so appealing in a fact-minded culture, is employed for many reasons. Statistical methods and statistical terms are necessary in reporting the mass data, but they have their limitations. Basically, the procedure should be used to represent how accidents are distributed by organization and permit a true correlation of occurrence and exposure.

"The effectiveness of an organization's accident prevention program," said Gen Nathan F. Twining when he was Chief of Staff, United States Air Force, "cannot be assessed solely on accident statistics."

The General pointed out that rates are measures of the aviation hazard experienced and represent probabilities of an accident occurring per unit exposure. He emphasized that accident rates per se do not represent the true effectiveness of accident prevention efforts.

The term aviation safety generally conjures up a mental picture of a vast statistical program of some type. While statistics are useful if properly interpreted and used, they in themselves are not the end result. Unfortunately, a great many people who are engaged in compiling statistics consider statistics the end result rather than the reporting system they actually are. Again, the negative approach comes to mind when we realize that by changing the definition of "an accident" or a "serious injury," the rate produced by our statistics will also be changed.

The technical definition of an accident is "an unintended interruption of a planned sequence of events." AR 385-40

defines an Army aircraft accident as an unexplained event involving damage to an aircraft in the Army inventory equal to or in excess of the criteria for the repair of damage listed in Table A, which occurs between the time the engine or engines are started for the purpose of commencing flight until the time the aircraft comes to rest with all engines, and propellers or rotors, stopped upon completion of flight, regardless of responsibility.

If we combine the two and disregard the damage clause, we find that an Army aircraft accident is an unintended interruption in a planned sequence of events involving the operation of Army aircraft.

Let's see how this affects the statistical picture.

An Army Aviator takes off from a tactical strip in a Bird Dog. His mission is to reconnoiter an aggressor column reported on the move. Shortly after takeoff, he discovers his windshield is fast becoming covered with a film of oil. The aviator aborts the mission and returns to his field. He makes a normal landing. He finds that his preflight failed to disclose that the mechanic had neglected to replace the locking pin in the oil filler cap. Is this an accident? Certainly not within the meaning of AR 385-40. The mission, however, was aborted. The interruption was unintended. If we're going to misuse statistics then surely this must be an accident.

Then there was the installation that had hangar space for only half the number of aircraft in its inventory. Wind and hail damages to the half that could not be placed under cover totaled $500,000. A survey team wrote these aircraft off and no accident report was made. Was this an accident? According to the survey team it was not; yet this same thing happened time after time, until the damages totaled more than $3 million.

This shows part of the problem. In one case the mission was aborted but no damage was incurred to the aircraft or injury to personnel. The other cost the Army $3,000,000. In neither case was an accident charged. Statistics do not reflect such situations.

The term safety is negative in that it connotes danger and at the same time desire for removal of danger. Corrective action could well be negative also. For instance, if the commander desires a low accident rate, all that is necessary is to cancel all flying. This immediately gives a zero accident rate.

Another negative aspect is in the concept of safety. To some people it means safety for safety's sake. This can lead to an inhibited frame of mind wherein a pilot may be concentrating so much on safety that his thinking becomes restricted and he does not utilize his aircraft to its maximum. The military goal for aviation is the accomplishment of the mission with minimum hazard.

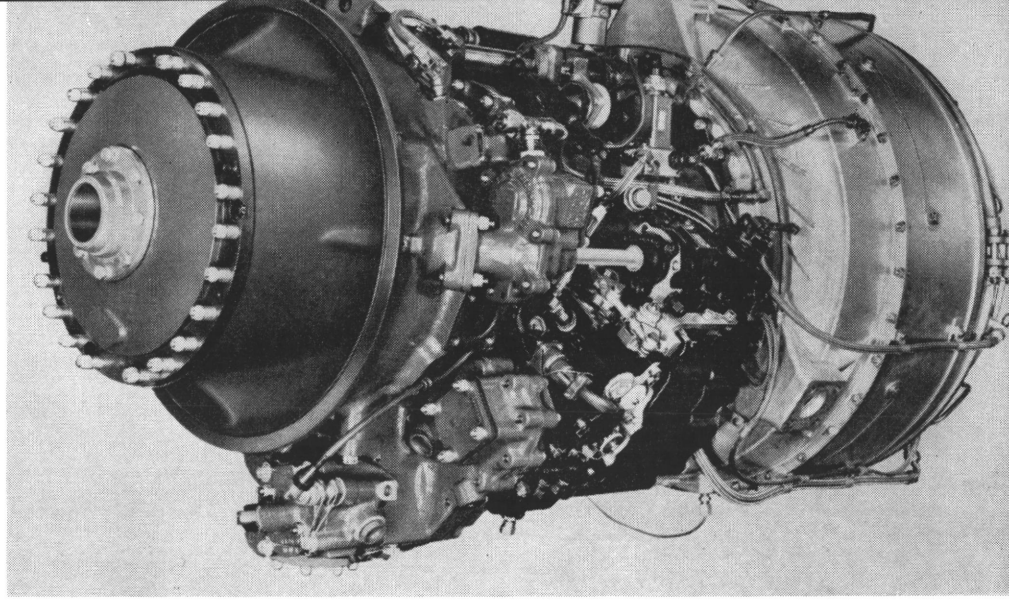
In an imperfect world there can be no absolute safety; hazards are faced daily. One can only speak realistically of degrees of safety and danger.

There are various ways of measuring safety and danger. If there is one losing card in a deck of 100, for every one draw, the hazard of losing is .01; the degree of safety against losing is .99.

Accident prevention also can be learned from experience. Records may show that out of m traffic movements in a certain area, n have led to accidents. It can be said that the hazard of an accident in one flight to this area is $\frac{n}{m}$ and similarly the degree of safety is $\frac{m-n}{m}$. Hazard and safety can be looked upon as probabilities, which are mutually complementary and add up to unity.

Another important concept in the philosophy of safety is that of the "acceptable hazard," and conversely the required degree of safety or the safety standard. This standard can be debated politically or philosophically but not scientifically. It is a matter of individual or public opinion, and in the Armed Forces one of policy. The Army, Air Force and Navy have departments staffed by competent physiologists and psychologists, aircraft performance engineers, and statistical experts who scientifically formulate flight operational limitations and double checks. Using facts from prior accidents, these experts design the limits and double checks in such a way that pilots may safely operate within their inherent weaknesses and within the design limits of the aircraft. When these limits are disregarded, accidents occur and statistics accumulate.

Such statistics are measures of the aviation hazard experienced and represent probabilities of an accident occurring per unit exposure. But they do not represent the true effectiveness of an accident prevention effort. If attention is focused on the causes of accidents, wherever and whatever they may be, the rates and statistics will fall into proper perspective. The goal must be a reduction of aircraft accidents and not that accident rates be administratively lowered.



Here's a Closer Look into the Development of the

Gas-Turbine Engine

CWO Paul J. Chauvin, TC

THE MODERN gas-turbine engine is based on the principles of jet propulsion known for over 2,000 years, but first stated as a law of physics by Sir Isaac Newton. His third law of motion states that for every action upon a body, there is an equal and opposite reaction. This law explains rocket thrust, one form of jet propulsion, but a full explanation requires his second law of motion also: the rate of change of momentum of a body measures in direction and magnitude the force acting upon it.

The rotating water sprinkler in your own yard is a common application of the principle of jet propulsion. Water enters the hollow shaft of the sprinkler under pressure, which serves as an axis for the rotating sprinkler head. The pressurized water flows to the nozzles and is ejected at high velocity. Consequently, thrust-forces developed at each nozzle cause the sprinkler head to rotate.

While the refinement of the gas-turbine engine is a 20th Century accomplishment, there are intermittent historical references of men experimenting with devices based on the jet propulsion principle.

As early as 120 B.C. Hero of Alexandria, Egypt, skilled in mathematics and physics, invented a device known as the Aeropile. It consisted of a hollow sphere mounted on an axle between two supports. When steam under pressure was piped into the sphere and allowed to escape through nozzles on its surface, the reaction caused the sphere to spin between the supports. We are not sure of how it looked, but it could have been a primitive form of the gas turbine.

The discovery of gunpowder further advanced the idea of jet propulsion and opened a new field of experimentation. When or where gunpowder was first used is uncertain, but we find mention of it in writings as early as 846. Chinese records reveal that in 1232 "flying fire arrows" were used to defend a walled city. These were probably rockets mounted on arrows for flight stability.

Leonardo da Vinci in 1550 sketched a device to be placed

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in the chimney to use the hot gases from the fireplace to turn a spit for meat. This, too, used the jet propulsion principle.

In 1629 an Italian engineer, Giovanni Branca, invented a steam turbine. A jet of steam was applied to drive a spindle very rapidly. Using cogwheel gearing, its rotational speed was reduced to drive a stamp mill. Perhaps the use of reduction gearing and high rotational speed in our modern turbojet engines originated in Branca's early turbine.

Most of these early applications used steam for propulsion, but in 1791 John Barber, an Englishman, patented a powerplant consisting of a gas producer and receiver, air and gas compressors, a combustion chamber, and reduction gearing. This was not a jet propulsion engine; however, it foreshadowed the turbojet engine, and many credit Barber with the invention of the gas turbine.

Today we regard our jet-propelled helicopters as modern inventions. Yet in 1903, an artist proposed the use of steam jet propulsion to drive a helicopter, using a rotary engine designed by a man named Avery.

Between 1905 and 1920 numerous gas turbines were built in Europe for driving air compressors. In 1902 the first gas turbine was built in the U. S. under the direction of Sanford A. Moss, who used it to obtain information for his doctor's thesis at Cornell University. Its earliest application was to drive a supercharger for reciprocating engines.

Even though there has been controversy over who or what nation should be credited with the development of the first successful turbojet engine, it seems that experiments and developments have continued concurrently by individuals and nations. However, the first airplane propelled by a gas turbine was flown by the Germans on August 27, 1939. This aircraft was designated as a research plane with no intended military application. Later German jet development reached 1,300 aircraft during World War II.

Practical development in jet propulsion was accelerated in the prewar years. Britain did much of the pioneering work in developing a gas turbine and kept the secret for several years, but gave full information to the U. S. in July 1941 under the Mutual Aid Agreement, then in effect. Unaware of the German development, the British had made their first flight of a gas-turbine airplane May 15, 1941.* The U. S. did not make their first jet flight until October 2, 1942.

No discussion of the gas turbine is complete without including the contributions of Sir Frank Whittle to the field of British design. While still a student in the R.A.F. Academy in 1928, he wrote papers on both the gas turbine and jet propulsion. Two years later he was granted a patent for a turbojet design. His was the guiding hand in British gas-turbine development.

Both Whittle's and the German aircraft flown two years earlier used the turbojet design. The rocket and the turbojet both obtain propulsive force by a rearward directed jet of hot gases. The rocket carries both the fuel and oxidizer, while in the airplane only the fuel element of combustion is carried.

*Powered by two turbojet engines, British fighters were first used against the German V-1 flying bombs in 1944.

JET ENGINES

There are two basic types of jet engines: self-contained engines which carry both oxygen and fuel (rocket); thermal air engines, which take their oxygen from the atmosphere. Thermal air engines are further divided into four types: **Athodyd,** or continuous-firing-duct; **pulse-jet,** or intermittent-firing-duct; **turbojet,** or gas-turbine engine; **turboprop,** a variation of turbojet using a conventional propeller. Various jet powerplants use a combination of types.

The postwar years have seen much progressive work in the gas turbine in America by many different companies, some under government contract. The first turbine specifically designed for the helicopter was developed by Lycoming Division of Avco Corporation in 1951—the T-53. In 1953 General Electric entered the field and developed and produced the T-58. The T-53 is used in present Army aircraft, while the T-58 is used in some experimental aircraft.

The performance of our advanced types of turbine-powered aircraft maintains developmental interest. Today we are standing on the threshold of scientific progress which will carry man into space.

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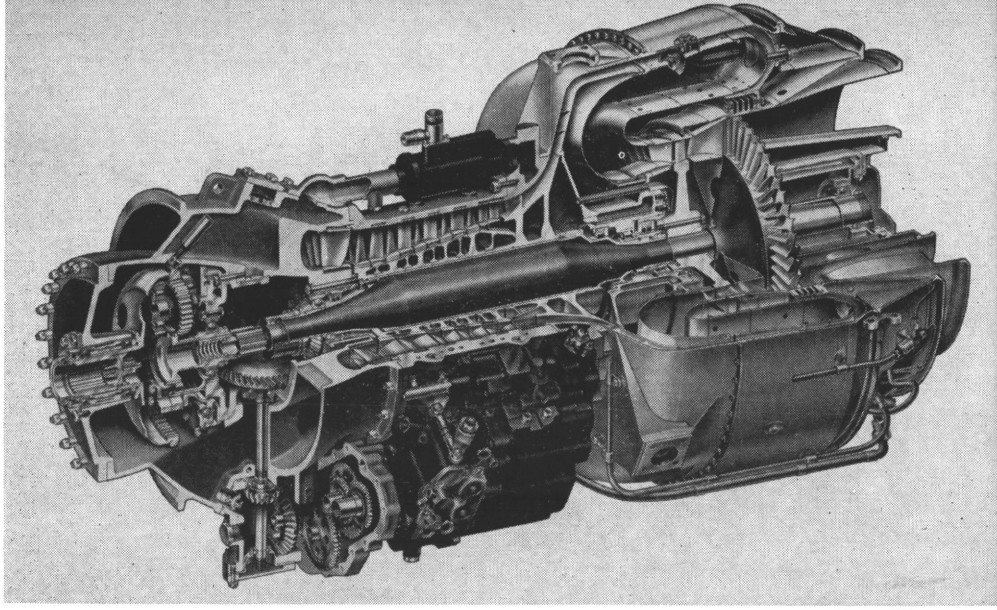

The T-53 Gas Turbine As Seen By Maintenance

James E. Mize

USE OF THE T-53 in the HU-1A helicopter and AO-1 aircraft presents a new type of powerplant for the Army. Familiarization with the (shaft) gas turbine, its systems, and operating principle is a must for flight and maintenance personnel if acceptable results are to be obtained.

Gas-turbine engines run too fast; the pressure is too high; operating temperature is too great; life of the engine is very short — these and many other statements have been made by some maintenance personnel. Some of these statements can only be answered as more knowledge of the engine and its components is gained.

Suppose we take a look at the speed of the T-53 and compare it to that of the R-985 used in the L-20 aircraft. The fastest revolving part in the T-53 is the compressor, which turns at 25,000 rpm top speed. The impeller wheel in the supercharger of the R-985 engine turns at 10 times crankshaft speed or approximately 23,000 rpm on takeoff. Trouble from the supercharger section of the R-985 is a rarity. So, if the impeller can rotate successfully at 23,000 rpm, why can't the turbine run at 25,000 rpm? It can.

We can see by this comparison that the difference in the speeds of the two engines is not great. Further investigation reveals that the gas turbine isn't so drastically different nor so complicated as may have been our first impression.

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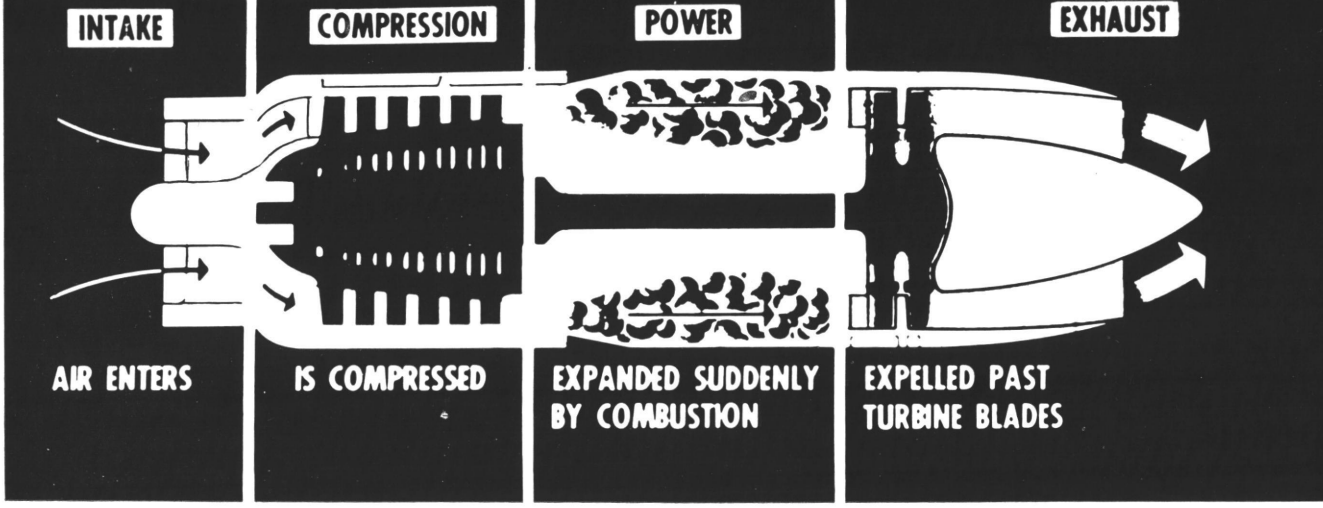
OPERATION

Sometimes it is difficult to understand the operation of an open type combustor, if you have worked with a closed one in the reciprocating engine. Understanding what goes on in the combustor is the key to the operation of the gas turbine. Air enters the front of the engine at atmospheric pressure, approximately 14.7 pounds per square inch, where it is compressed by a rotating compressor to a compression ratio of about 6 to 1, or 88.2 pounds per square inch.

At this pressure the air enters the combustor where fuel is injected and the mixture burned. Heat causes the gases to expand and move to the rear. The opening at the rear of the combustor is larger than the opening at the front, thereby inducing the gases to move rearward. Although pressure per square inch is less at the rear, the total pressure is greater because there is a larger area at the rear.

This total pressure differen-



The simplicity of a gas-turbine operating principle is shown above

tial front and rear is what causes the engine to move forward. If the pressure per square inch at the rear of the combustor should exceed the pressure per square inch at the front, the airflow will be reversed and the engine will stop. A turbine fastened to the compressor and placed in the path of the exhaust gases will increase compression. Another turbine placed in the same location may be used for power. This may be illustrated by the sketch of a simple gas-turbine engine.

The gas-turbine operating principle is developed from one of Newton's three laws of motion: For every action upon a body there is an equal and opposite reaction. For a more detailed understanding, let's follow the air as it flows through the Army's T-53, observing the temperatures, pressures, speeds, etc. Air enters the compressor at atmospheric or ram air pressure and passes a five-stage axial compressor where each stage increases the pressure a small amount. With this pressure increase the air passes a centrifugal compressor, making the total compression ratio about 6 to 1.

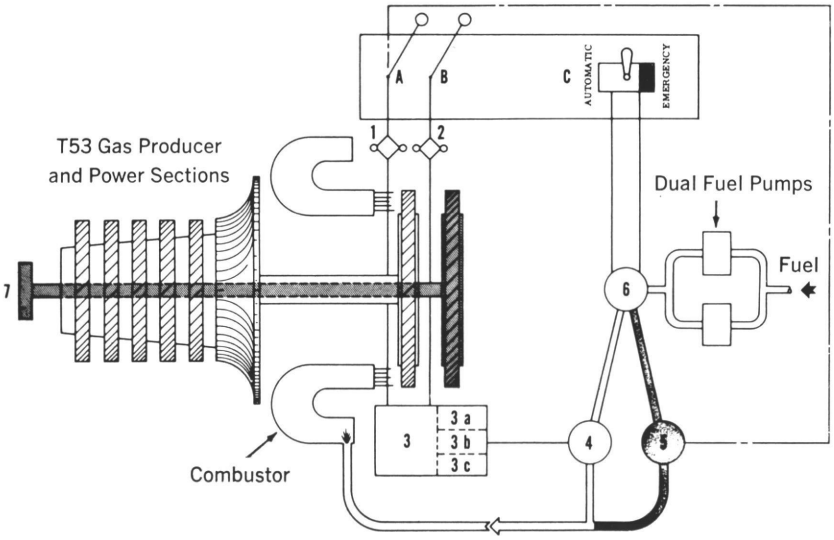
At this point, before entering the combustor, air may reach a temperature of 600°F. and be traveling at a speed of 1,000 mph. At this speed, temperature, and pressure, air enters the combustor where fuel is mixed with the air, ignited and burned. Temperature in the burning area may reach 3,000° F. or more, but the flame is not permitted to come in contact with the metal parts of the engine. Burning is completely encompassed by air. With this layer of air around the flame, it is possible to touch the combustor with the hand while the engine is running and not receive a burn.

Actually only 1/6 of the air entering the combustor takes part in the burning process. The remainder of the air is used to extinguish the flame and for flame control. By the time expanding air reaches the turbine, temperature drops to 1,600°F. and air at this temperature does touch the metal surfaces. Even at this temperature metal surfaces tend to lose their shapes, so there is an internal airflow for cooling the turbines fore and aft. Pressurized gases cause the first turbine—fastened to the compressor — to turn, thereby increasing the air pressure before it enters the combustor. The second turbine immediately behind the first is used for power. By the time the expanding gases finish turning the two turbines they are nearly expended and very little thrust is developed from the exhaust of the T-53.

FUEL AND FUEL METERING

Aviation gasoline for the reciprocating engine and JP-4 for the turbine develop 1 hp per hour on approximately 0.6 of a pound of fuel. Handling of JP-4 will have to be more carefully watched than the handling of gasoline because of impurities. While dirty fuel may not have a noticeable affect on the turbine engine itself, it is highly possible that impurities will cause the fuel control unit or some part of the fuel metering system to become inoperative due to plugging of the small passages. There are several screens and filters through the system but some are not accessible at organizational maintenance level, therefore strict regulations regarding fuel handling **must** be followed.

Generally speaking the fuel control unit does the same thing as the carburetor. Actually it has nothing to do with mixing fuel and air, as does the carburetor. Rather it meters fuel to the fuel manifold, which in turn injects fuel into the combustor where air is already present. Fuel is metered after



Power control system schematic

LEGEND

A. Main Power Control Lever
B. Power Turbine Speed Selector
C. Changeover Switch
1. Gas Producer Governor
2. Power Turbine Governor
3. Computer
a. Altitude Compensator
b. Temperature Compensator
c. Acceleration-Deceleration Limiter
4. Automatic Fuel Metering Valve
5. Emergency Fuel Metering Valve
6. Changeover Valve
7. Power shaft

compensating for air temperature, atmospheric pressure, fuel density, compressor and power turbine speeds and acceleration and deceleration. While in flight any of these factors can change in only a few seconds, placing the engine in a completely different environment. This could alter engine operation if these factors are not properly compensated for. Compensation is accomplished automatically by the fuel control unit and, like the carburetor, the complete unit may be replaced, but not repaired, in the field.

Both automatic and emergency fuel control modes of operation are available. These are the only controls used by the pilot for a power setting. In automatic, a gas producer (compressor) governor and power turbine governor influence a hydro-mechanical computer, which computes an optimum position for an automatic fuel metering valve. Since the gas producer is the primary source of power, the gas producer governor is the primary control element. This governor can be reset by the main power control lever from the cockpit over the entire operational range from zero to full power. The free power turbine governor can be used two ways: (1) where output speed selection is by external means, such as by propeller governor, the device acts as a safety control to prevent power turbine overspeed; (2) where no external speed control is used, as in a helicopter, the free power turbine governor is used to govern output speeds.

This governor can be reset over a range of $\pm$ 15% and will maintain desired rpm at all power up to that selected by the main power control lever. In emergency, a control panel switch actuates a changeover valve to route fuel from the automatic system to an emergency fuel metering valve. With automatic elements bypassed, the main power lever exercises simple faucet-like control over the emergency metering valve.

Even though JP-4 is the primary fuel, some unofficial experiments have reported that aviation and automotive gasolines are highly satisfactory and that no immediate damage was apparent. The higher the percentage of power operation, the more economical is the engine. The reciprocating engine reaches its most economical operating speed at about 50 percent of maximum. Because of its design and mounting, the fuel distributor manifold is replaced by field rather than organizational maintenance. Clean fuel, proper operation, no leaks, and main power control lever in cockpit being synchronized with linkage on the fuel control unit are the problems concerning maintenance personnel. Replacement of units and adjustment of linkage is not new to Army Aviation maintenance.

LUBRICATION

Lubrication circulation is much like that of the reciprocating engine since the oil moves from storage tank, to bearings, to cooler, and back to tank. Oil used in the T-53 is a synthetic, rather than a mineral oil base used in the piston engine. At increased temperatures and fast circulation, mineral oils fail to "hold up." With the absence of organic compounds in the synthetic oils, there is little or no "break down." There is, however, a very highly corrosive effect to the metals in contact with the oil. So all of these parts of the engine have a "dulite" protective coating. Because of this corrosive effect, it is recom-

mended that only chrome-plated tools be used while working on the engine.

Oil consumption is in the neighborhood of .03 gallons per hour, or about 1 quart for each 8 hours of operation. Of course this consumption will vary with the individual engine. Magnetic plugs are installed in the accessory gear box (same as those in the oil sump of the reciprocating engine) for catching any ferrous metal parts that may give way and be flowing through the oil circulating system. Oil flows under pressure (4.5 gallons per minute maximum) to the four main bearings, two rollers and two balls, and to other moving parts. There is a screen before each of the main bearings. Breathers are routed from the engine to the storage tank then overboard, rather than from the tank to the engine as in the case of the recips.

Oil handling is one of the more refined parts of maintenance that must be strictly adhered to because of the small passages throughout the system. Engine failure has already been traced to small paint particles from the containers used in servicing the oil system. This is one of the very touchy parts of proper maintenance of the T-53.

IGNITION

An ignition unit requiring from 14 to 28 volts furnishes power for two ignitor plugs. The ignitor plugs are located in the combustor at 120° and 240° and are used for starting only. Operation of the resistor type plugs may be checked by listening to a sharp crack while ignition is on and the engine is not running. Since these plugs are not used except for starting, the life expectancy is far beyond that of any spark plug used in reciprocating engines. Disconnecting the "power in" side of the ignition unit before working on the "hot" end of the engine is good advice to all maintenance personnel.

COOLING AND ANTI-ICING

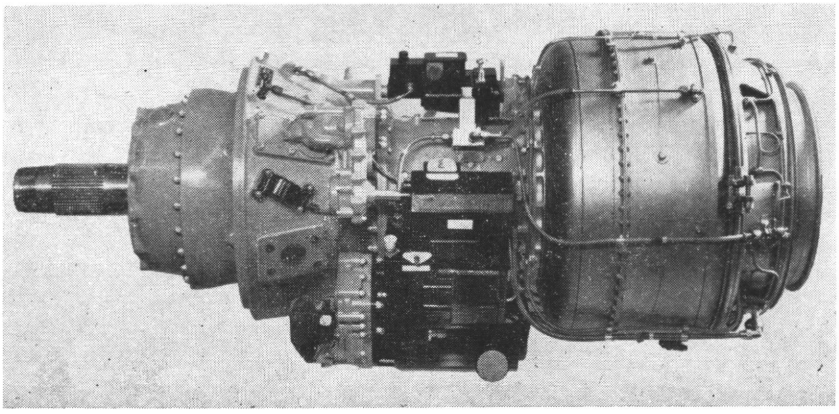
Contrary to the reciprocating engine, there are no provisions for external cooling. Internally the T-53 was a difficult problem for the designer, but it requires little attention by maintenance. Cooling air is tapped from the compressor and routed to the turbines, fore and aft, to the combustor liner, and pressurized oil seals. Some of the passages are very small and caution should be exercised as to what goes into the front of the engine.

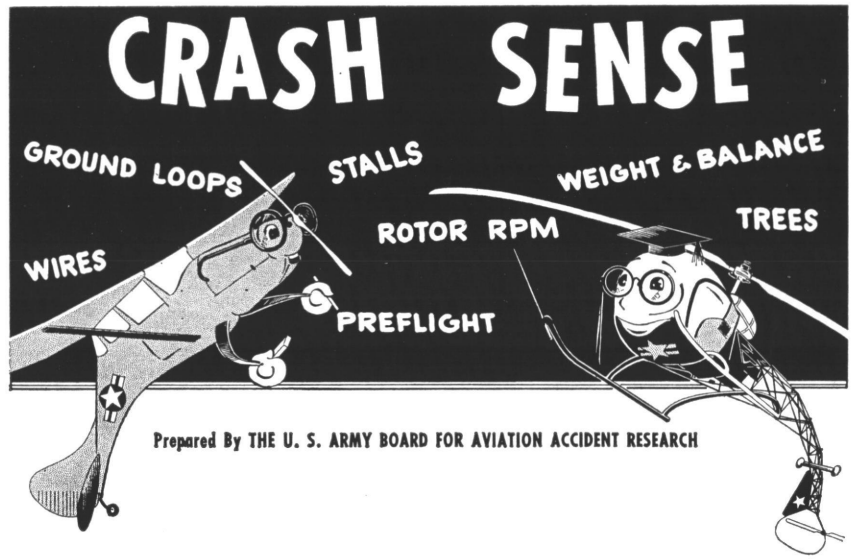
There is no icing from fuel vaporization, a common problem for reciprocating engines. There is, however, impact ice formed near the engine inlet housing. Ice at this point is melted by use of hot air from the compressor. Anti-icing air is controlled by a fully automatic "fail safe" unit electrically operated. When an icing condition is detected by the unit the electrical circuit is broken and a spring loaded valve opens a passage from the compressor to three upper front struts. "Fail safe" in this case means that if the current fails, the spring loaded valve will open and remain open for anti-icing all the time. Actually there are four struts in the inlet housing subject to icing, but hot oil flows through the lower one, preventing the formation ice.

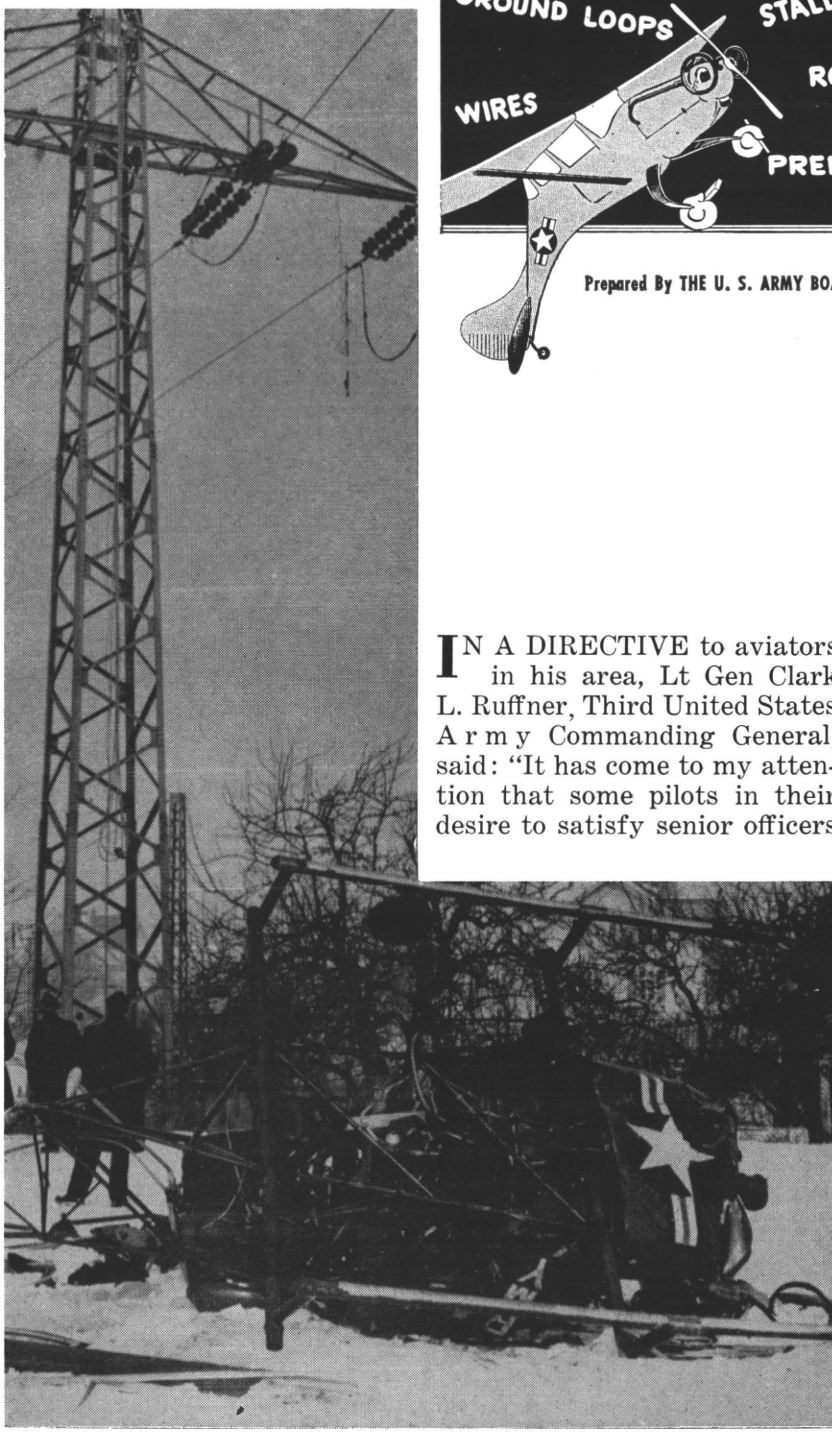
MAINTENANCE COMMENTS

A few special tools, along with chrome-plated hand tools, are required for field maintenance. No part of the T-53 maintenance seems as complicated as valve adjustment of a large radial engine. Storage is little more than spraying oil in the inlet while turning the compressor with an air hose. Engine removal and replacement is only a matter of minutes. Preflight and postflight inspections consist mainly of looking fore and aft for any loose metal objects, checking the condition of linkages, looking for leaks, and listening for coast-down (80 - 120 seconds). Knowing and respecting the strength of materials is most important to successful maintenance. Most of the maintenance problems seem to have been solved by the designer.

Turboprop Version







An unspoken desire probably caused this accident

IN A DIRECTIVE to aviators in his area, Lt Gen Clark L. Ruffner, Third United States Army Commanding General, said: "It has come to my attention that some pilots in their desire to satisfy senior officers have deviated from prescribed procedures. The pilot has the total and complete responsibility for the safe and efficient operation of the aircraft he is flying."

Psychological pressure engendered by the desire to please passengers of high rank does exist. While there is no known way to measure its effect, it may cause pilots to ignore their personal capabilities, regulations, and equipment limitations. Even though the desire of the high ranking officer may not be vocal, Army Aviators, eager to display the capability of their aircraft, interpret those desires and sometimes act foolishly.

A general officer bound for an inspection trip was called early one foggy morning and informed that although the weather did not permit flying by fixed wing aircraft, helicopters could be used.

The two Sioux (H-13) were ready when the general and a member of his staff, a full colonel, appeared at the Army airfield.

In the meantime the pilots, both lieutenants, had preflighted the aircraft. The senior aviator had received two weather briefings indicating weather forecast to be below helicopter minimums. The radio of one helicopter was not operating.

In spite of the weather outlook and a radio that wouldn't work, the two helicopters became airborne about 0730. The general officer and his pilot, more through luck than anything else, made it through. The second helicopter crashed into high tension wires 30 minutes after takeoff. Both officers were instantly killed.

After studying this accident report, the reviewing panel had this to say: "The pilot in command of the flight of two helicopters displayed poor judgment by proceeding with the flight despite two verbal weather briefings given within the 90-minute period prior to takeoff, forecasting visibility as zero to one-half mile, which is below helicopter minimums.

"The clearance for the flight is vague in the accident report (indicating lack of operational supervision). It is apparent that the senior pilot cleared the two aircraft for a local flight. A portion of the flight was conducted in violation of AR 95-8, paragraph 18b (4), which lists minimum visibility for visual flights in helicopters as one-half mile or more. Weather briefings place the visibility prior to and during the flight at below one-half mile. Statement by the general officer in the lead helicopter places the visibility at 30 to 40 feet during a portion of the flight."

When mechanical deficiency is a supervisory error

Apparently the pilot did not land when encountering below minimum visibility because he felt he had to "get through" to satisfy the unspoken desire of a high ranking passenger.

As General Ruffner has so forcibly pointed out, the pilot alone is responsible for the safe operation of the aircraft he flies. There can be no relaxing of this regulation if lives and equipment are to be preserved for the ultimate mission of combat.

BUILT-IN BOOBY TRAP

Not all ground loops are the result of inexperience, preoccupation, or extreme conditions of wind and tac strip. There are times when a "built-in" booby trap caused the unsuspecting aviator to spin like the handle on a henhouse door.

This accident happened during a tactical field exercise. When the student found that the aircraft assigned to him had an entry in the 781-2 indicating a weak right brake, he talked to the pilots who had previously flown the Bird Dog. They told him the brake was spongy but effective. After consulting maintenance personnel, he was informed that the trouble was air in the brake line, but that the aircraft was safe to fly.

Thus reassured, the student climbed in the aircraft and fired up. The brake effectively held the Bird Dog during run-up at 2250 rpm. He again checked the brake during taxiing and found that it was spongy but would still hold.

Taking off, the student headed for an adjacent tactical strip. The approach was normal and the landing was a smooth three-point touchdown with flaps at 60°. The Bird Dog rolled straight down the runway for about 300 feet and then started a turn to the left. The rudder and brake were not effective. Full travel of the brake pedal produced no braking effect. The aircraft continued to the left and into a ground loop. The right gear was sheared and the aircraft heavily damaged. Fortunately the student was not injured.

The student simply did not have ample control at his disposal to prevent a ground loop after an initial loss of directional control. Supervisory factor was evident in allowing the student to use his own judgment as to whether the aircraft was in a flyable condition.

The old booby-trap was good for World War II, and it actually has flourished since the Stone Age. Many ingenious devices have been developed by soldiers over the wars, some so clever that even the origina-

tor was trapped. This fiendish device has no place in a student training program. Those in authority must take the initiative in removing them at any cost.

STORM WARNINGS

When a hurricane moves in toward our coast, storm warnings indicating intensity of the winds are displayed. Usually these signals are not ignored by weatherwise residents in the hurricane belt. To do so would imperil their lives.

Other warnings often appear in supervision, training and operations indicating trouble ahead. Unfortunately, these storm signals are sometimes overlooked.

A field grade officer was cleared to the omni at 5,000. He was instructed to proceed off airways for his turn and report back over the omni at 5,000. In the meantime another aircraft at 4,000 was cleared to 3,000. When the report was received that this aircraft was leaving 4,000, the field grade aviator was cleared to descend to 4,000. He acknowledged the clearance and then proceeded to let down to 3,000. Luck alone prevented a mid-air collision in the clouds.

That was bad enough but another aviator holding on top of the stack at a busy metropolitan airport was told he could expect an approach clearance in 50 minutes. He had just about that much fuel so this bright young lad descended through the stack, landed VFR, refueled and then took off, climbed on top, and resumed his position to accept approach clearance at the proper time.

An instructor pilot and instrument student were cleared to Omni A, to hold and wait further clearance to Blankville. Upon approaching A, FAA radio cleared them to "en route frequency." Even the instructor didn't catch that one; they proceeded on course, overflying the omni. FAA had them reverse course just in time to avoid a collision.

An instrument pilot filed an IFR flight plan from Blankville to Dokeville, by way of Corncob Intersection, thence airways to Dokeville. Approach control gave him a clearance from Blankville direct to Ipswitch Intersection, thence airways to Dokeville. The aviator flew his original flight plan as filed, proceeding by way of Corncob Intersection and then airways to his destination. When faced with a violation he said, "I didn't notice that the clearance differed from my flight plan."

None of these resulted in an accident, but here's one that did.

The aviator took off shortly after midnight for a long cross-country. Time to his first stop for refueling was estimated to be 4 hours and 5 minutes. He added 1 hour and 20 minutes to reach his alternate, even though a better alternate was located only 59 miles from the point of his first intended landing. With a full load of fuel he should have had enough range for 6 hours and 30 minutes, but he didn't visually check his tip-tanks.

Shortly after takeoff he learned that weather at his destination airport had deteriorated to below landing minimums. He continued on, however, and made an instrument approach from which he had to pull up. After making a missed approach 4 hours and 27 minutes after takeoff, he requested clearance to his alternate, even though a closer field was reporting superior conditions.

Still 109 miles from his destination, the aviator realized he was running short of fuel. He requested and received

Fuel ran out 6 hours and 10 minutes after takeoff

clearance to slow cruise to reduce gas consumption. In spite of this, just 6 hours and 10 minutes after takeoff his fuel was exhausted. He shut off all switches, trimmed the aircraft for level flight, and prepared to bail out. He called May Day three times over the radio and then had to fight his way out of the aircraft. He'd never read the -1 (TO-1L-20A-1, Section 3, page 32) so he didn't know the proper bailout procedures. Had he been at a lower altitude or had there been reason for a rapid exit, such as an inflight fire situation, he would have crashed with the aircraft in attempting to use the pilot door as an exit.

Fortunately, this aviator did land safely by parachute and did not incur any physical injuries in the bailout.

The Accident Investigation Board concluded their report with these seven reasons for the cause of the accident:

1. The pilot's violation of AR 95-8, paragraph 24b.

2. The pilot's failure to take into consideration the weather advisory given him by Military Flight Service.

3. The pilot's preplanning based upon 6 hours and 30 minutes of fuel and not knowing if all fuel tanks were full enough to provide 6 hours and 30 minutes flying time.

4. Poor judgment on the pilot's part in electing to proceed to destination, knowing the weather was below landing minimums. The pilot knew this to be true shortly after takeoff.

5. The pilot's violation of AR 95-8, paragraph 22h (4) in electing to make an instrument approach at destination airport fully aware of the existing weather.

6. The pilot's poor flight planning, in that he apparently did not take into consideration the time necessary to make an approach, missed approach, and get further clearance to an alternate airport.

7. Poor judgment on the pilot's part in not selecting a closer alternate airport reporting more favorable weather.

All these incidents and the accident have one thing in common: laxity in the cockpit, an ineptness shared by instructor, field grade aviator, and young pilot alike. Ignoring storm warnings such as these can be even more dangerous in flying than facing hurricane weather on the ground.

THE NEED FOR SUPERVISION

Many aircraft accident reports are received at USABAAR which reveal a serious deficiency in standardization of unit instructor pilots. Some of the instructor pilots in units draw up their own syllabus. The syllabus thus drawn is not always in accord with accepted technique.

An instructor pilot habitually overloaded his training aircraft on the assumption that "if the student can handle this, he can handle anything." His errors in technique and judgment were not noted until an accident resulted, destroying the helicopter and seriously injuring the student.

Another instructor pilot showed poor judgment in cutting an engine on takeoff to simulate engine failure. The list goes on and on, revealing that correction is sorely needed in the selection and standardization of unit instructor pilots.

Fostering the condition is the lack of standards in selecting unit instructor pilots, lack of standardization of these pilots after they've been selected, and a serious deficiency in training literature for units in the field.

Experience and skill alone cannot replace the requirements necessary for a good instructor. Judgment, ability, and a desire to teach are the minimum qualities for a successful instructor.

Frequently an aviator is assigned the important task of instructing unit pilots because "he's the only one available." He is allowed a free hand in teaching what he thinks should be taught, rather than a standardized syllabus. In fact, very few training syllabi are in existence. The training circulars are, in most cases, simply lesson outlines.

Designation as a unit instructor pilot, to all outward appearances, marks an aviator as outstanding. All too frequently some pilots assume the mantle of IP relieves them of all responsibility for observing simple rules of common sense, the Flight Handbook, and unit SOP.

Conditions such as these can snowball, errors in technique being passed on from instructor to student in a chain that eventually results in an accident.

The only cure for this situation is strong action on the part of each commander to ensure:

1. that the most suitable pilots are designated as instructors;

2. that he be subjected to a course of instruction to make certain he knows what and how he will teach; and

3. that he is given the training circulars necessary, written in a clear and concise manner, explaining each maneuver in detail that he is to teach.

USABAAR Visits USARPAC

General I. D. White, Commander-in-Chief, U. S. Army, Pacific, welcomes USABAAR team to Headquarters, Fort Shafter. The team was composed of Captain Walter F. Jones, center, Chief, USABAAR Investigation Division, and Captain Quitman W. Jones, Chief, USABAAR Human Factors Section.

During the month of October, these officers presented 17 aviation accident prevention orientations in Hawaii, Korea and Japan. These sessions were attended by 85% of the Army Aviators in the areas visited, as well as mechanics and staff members of the various units. The lectures were illustrated with motion picture film and still slides.

Two major points covered by the USABAAR team were the necessity to develop professionalism among Army Aviators and mechanics, and the importance of commanders backing aviation to attain maximum capabilities for providing battlefield surveillance, control of forces and communications, and limited logistical support.

Maj Gen Normando A. Costello, Assistant Chief of Staff, G-3, USARPAC, introduced the presentation at Headquarters, USARPAC. General Costello is a rated Army Aviator.

General White, long a strong advocate of Army Aviation, continues to show deep concern for stimulating application of uniform and correct aviation accident prevention measures within his command. He firmly believes that Army Aviation is one of the great assets of the United States Army in the Pacific and gives it his wholehearted support.

During the past year, other USABAAR teams presented aircraft accident investigation and prevention orientations in all major commands of the United States and Europe.

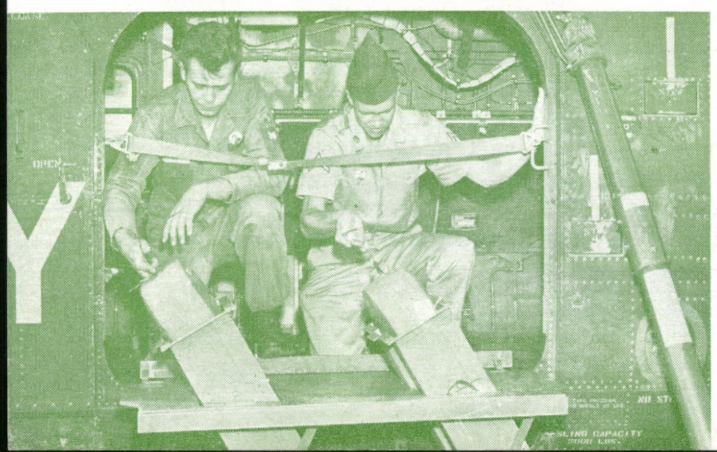
New Airlayable Wire Dispenser Tested

The field telephone held by Secretary of the Army Wilber M. Brucker represents the base end of a 4-mile-long telephone line which was laid in 4 minutes flat by an H-19 Chickasaw.

The key to success of airlayable wire is the M-8C dispenser, developed by the Signal Corps. Light and easy to handle, the dispenser fits in the floor of any of 5 types of helicopters and can be loaded with wire during flight. Communication can be maintained with the ground during flight to immediately detect and repair breaks. Signal Corps experts estimate that an entire airborne division could be wired within 20 minutes after a combat jump was completed.

Although the Secretary witnessed several dynamic demonstrations at the U. S. Army Electronic Proving Ground, he showed particular interest in the airlayable wire demonstration.

"This is truly a historic event," he said to the technician aboard the helicopter.

The demonstration was especially significant for the battlefield commander. Airlayable field wire solves the problem of communications where terrain or enemy jamming might make radio communications unreliable or impossible.

M-8C dispenser installed on H-34 (lower left), an H-21 (lower right), and H-13 (above)