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VOLUME TWENTY NUMBER EIGHT — USAF RECURRING PUBLICATION 62-1

Lieutenant General Keith K. Compton

CHALLENGE OF THE SIXTIES

THE INSPECTOR GENERAL

LT GEN KEITH K. COMPTON, former Chief of Staff, SAC, has been assigned as The Inspector General, USAF. General Compton succeeds Lt Gen John D. Ryan.

A graduate of Westminster College, Fulton, Mo., class of 1937, he entered military service in February 1938. General Compton served initially with the 2d Bomb Wing, the first unit to be equipped with B-17 Flying Fortresses. In 1942 he joined the Eighth Air Force in England where he served as a squadron commander, and later as Group Operations Officer of the 93d Bomb Wing. He also commanded the 376th Bomb Group, which was awarded the Presidential Unit Citation for its operations in the Mediterranean in support of the British Eighth Army. General Compton was awarded the Distinguished Service Cross for flying the lead aircraft in the force of American heavy bombers that attacked the Ploesti oil refineries in 1943. He was credited with a total of 350 combat hours in flying 56 combat missions in the Middle East and European Theaters.

In July 1948, General Compton became Deputy for Operations, Air Proving Ground Command, directing test activities and flying all types of new aircraft accepted by the Air Force. He won the 1951 Bendix Trophy Race, at the same time setting a transcontinental speed record in an F-86.

Assigned to SAC in February 1953, General Compton successively commanded the 97th Bomb Wing, 813th, 823d, and 5th Air Divisions before being named SAC Deputy Director of Operations in July 1958. He became Director of Operations in September 1961, and was appointed SAC Chief of Staff in June of last year.

When we examine aircraft accident rates everyone in the Air Force can take just pride in the accomplishments of the past few years. There have been dramatic reductions in three areas of major concern — aircraft destroyed rate, major aircraft accident rate and the fatal accident rate.

Performance such as this is solid evidence that accident prevention efforts do pay off. History may well record the last decade as one of the most profitable eras ever from the standpoint of accident prevention. Commanders, supervisors, safety specialists and other concerned individuals, no matter what their job assignments, have teamed to establish a safety record that I believe will stand out in history as a glowing example of safety achievement. What this really means is that there are weapon systems and Air Force crewmembers available that otherwise would have been lost. Who among us would not be here today had the rates remained at the level of 1954? Which of our airplanes would be on the scrap heap if the rates had been allowed to stabilize at the mid-fifty's level?

Remember, too, that this safety performance was realized in an era of increased hazard potential. We had to cope with century series fighters, larger and faster jet bombers, a growing inventory of airborne missiles and rockets and demands for increasing combat and operational capabilities.

Methods by which reductions were achieved were to observe trends, spotlight problem areas, and concentrate on remedial measures. As problem areas were minimized or eliminated the rates cam down. Concurrently, of course, it became ever more difficult to ferret out potential accident cause factors.

Now, as safety specialists from Air Force units world-wide assemble at Maxwell AFB for the Safety Congress, the challenge is clear. Records disclose that, approaching the halfway mark of 1964, we are experiencing no decline in the major accident rate, the number of aircraft destroyed or total fatalities as compared to the same period in 1963.

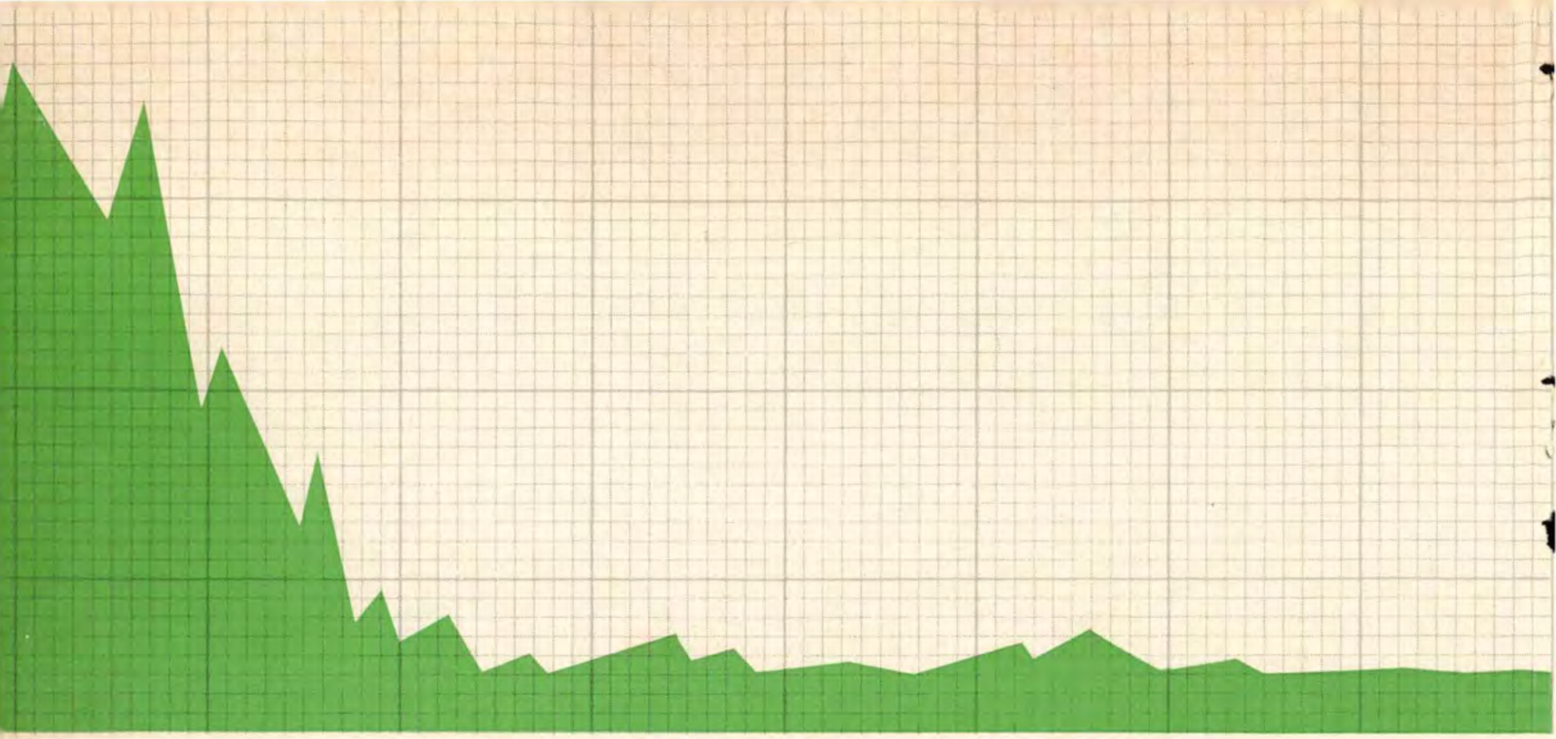
Obviously we cannot rest on past achievements. In fact, the future will be more challenging than the past. Several reasons stand out: As the accident rate lowers it becomes more difficult to reduce it further; our equipment is becoming increasingly complex; we are using new, heretofore unknown materials; we are using old materials in fantastic new ways and our missions are imposing new and ever-increasing demands on our people and equipment.

Faced with these truths we must learn new, as well as improve on present, methods of preventing accidents. We must rally all available resources in this effort. Every USAF agency must be conscientiously involved in the struggle. Every possible tool at our disposal must be employed — nothing less will suffice.

The rewards for this effort can be great. An accident prevented may mean a life saved, or possibly, a hundred lives. We do not have inexhaustible resources, so what we have must be preserved. Safety specialists at every level can and must play an important role in rallying the forces needed to meet the challenge of the sixties.

Jay T. Robbins

JAY T. ROBBINS
Brigadier General, USAF
Director of Aerospace Safety.



Some maintain that there is a point below which the number of accidents cannot be reduced. The author maintains otherwise.

It has been said often and with complete accuracy, I am sure, that the primary cause of accidents is people. There are some who maintain that the reverse is equally true. In any event the other side of the coin must also exist—that people prevent accidents.

People were working hard last year in each of our commands so that accidents could be prevented. In 1963 USAF experienced 288 major flying accidents; the year before 380 occurred. Through our collective efforts then we prevented at least 86 accidents — 86 accidents did not happen that would have happened had the accident rate remained at the same level as in 1962.

Each of our major flying commands, including the Air National Guard, reduced its rate. MATS, for instance, halved theirs. At the end of 1963, the MATS rate had been reduced to .8 from 1.6 in 1962. The number of accidents was reduced from 14 to 8. The Strategic Air Command had 10 fewer accidents in 1963 than they did in 1962, and their rate lowered from 2.1 to 1.5. USAFE, primarily a fighter-equipped command, almost halved their rate also. They went from 14.8 to 7.6. Sixty-six accidents were experienced in USAFE in 1962, and only 35 in 1963.

All of our predominantly fighter-equipped commands are nearing a rate of 7, and even as recently as three years ago this would have been thought an improbability, if not an impossibility. MATS and SAC, however, are in a frequency area where they may well be approaching that nebulous, irreducible minimum that we have heard so much about. So now we come to the problem of how to reduce our rates even further.

Invariably, in the business of accident prevention, we are drawn to the accident which has just occurred for our most precipitous prevention activity. There is no doubt in any of our minds just after the accident that exposure did indeed exist. Our prevention efforts following the accident can be specific. They are propelled by accident motivation, and if our efforts and direction are accurate and allowed to run their full course, they will eliminate the specific exposure which caused the specific accident. Stated another way, under this concept we need an accident to prevent an accident.

We are probably approaching a point in time when we can no longer wait for an accident to prevent an accident, because the accident we wait for is the very one we must prevent if our rates and numbers are to be reduced even further.

Our past actions have been effective — very effective — but our future actions, while encompassing those which are time-proven, must become more sophisticated and be directed primarily toward removing exposure before the fact. The identification of exposure before the fact becomes a necessity if we are to become more effective in our prevention efforts. Can this be done? I am sure it can; in fact, I think it is already being done, to a degree at least, throughout all of our commands.

My interest lies primarily with the fighter-interceptor accident picture. The Air Defense Command, which also experienced a rate reduction in 1963, keeps track of their exposure in terms of precautionary landings. Every precautionary landing considered of any consequence at all by the unit safety officer is reported. In 1963, ADC flight safety officers reported 1208 precautionary landings. With this large sampling a good feel for exposure is possible.

For instance, F-101 pilots made 308 precautionary landings which did not qualify as incidents. Ninety-five of these occurred because of engine or associated engine system

THE IRREDUCIBLE MINIMUM

Lt Col Merle B. Nichols, Directorate of Aerospace Safety

malfunctions; an additional 52 single-engine landings were made which *did* qualify as incidents. Not one accident involving ADC F-101s occurred last year as a result of an engine or engine system malfunction. It is obvious that exposure exists in the engine and associated systems as installed in the F-101, but it is equally obvious that, through a process of training and because two engines are installed in this aircraft, the exposure has been neutralized very nicely.

However, the pilot of a single-engine aircraft, faced with an engine system failure, is in rather different circumstances. F-102 pilots in ADC made 162 precautionary landings for engine system malfunctions; in addition, 19 incidents occurred. Out of the 11 F-102 accidents experienced in ADC last year, six were caused by engine and engine system failures. Had two engines been available, it is very likely that no 102 accidents would have occurred due to an engine system malfunction.

Returning to the 101B, 78 precautionary landings were reported as a result of landing gear system malfunctions; 14 incidents were also listed due to these causes. However, six major 101 gear accidents occurred where the landing gear systems failed in some manner. With the 102, conversely, the gear was not a critical factor. Problems that were predominant in the gear system and caused some 70 precautionary landings primarily concerned the warning switches, microswitches, valve and linkage adjustments, rather than basic structural failures. Only one accident occurred involving the gear on the F-102, and it was the result of a local unapproved mod in the gear well, which resulted in one main gear failing to extend.

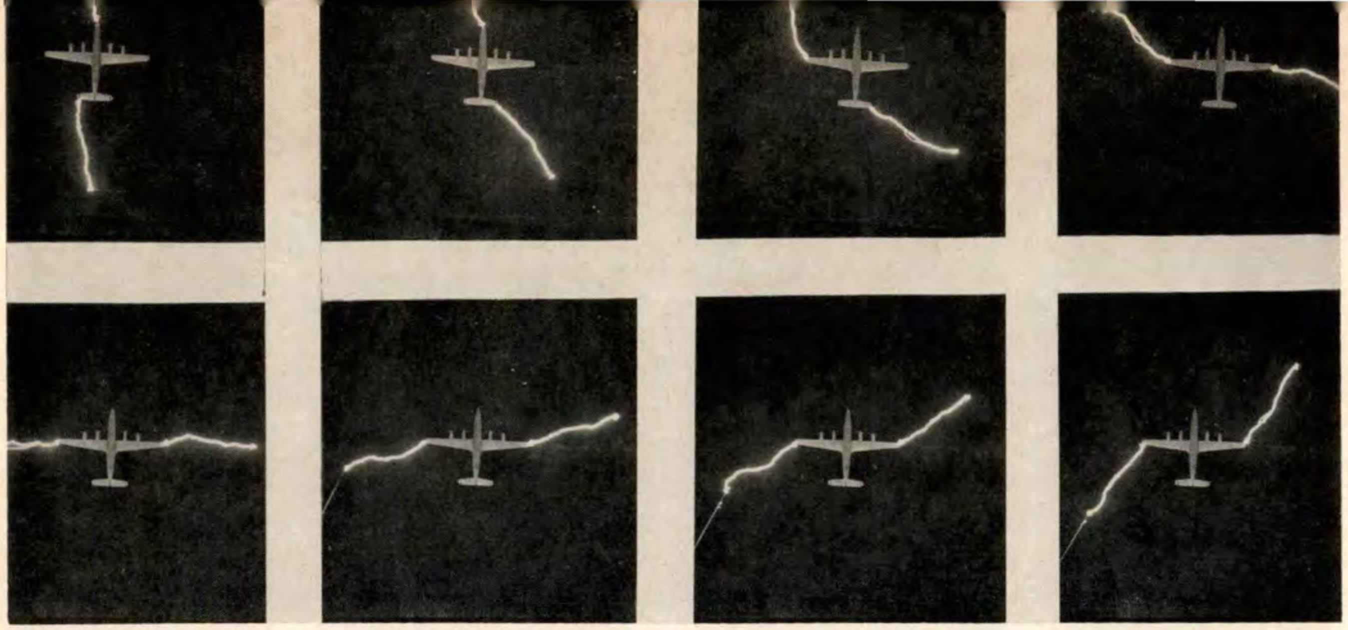
It becomes clear, then, upon examination of the ADC exposure that, when the frequency of precautionary landings and incidents of type is high, and if alternate systems are not available to neutralize the exposure, the accident rate will also always be high. It is clear that exposure can be identified before the fact in at least broad terms, and it is obvious that before rates can be reduced, that exposure must be reduced — exposure of a nature that cannot be neutralized by the pilot or backup systems.

Probably the most important factor influencing the single engine accident rate across the board concerns the reliability of the engine and its associated systems. Regardless of the type mission in which they are engaged, the single-engine aircraft will probably always have a higher accident rate than the multi-engine birds. The ADC accident experience reveals that almost 50 per cent of their single-engine interceptor accidents were caused by engine and engine system malfunctions. Out of 33 major accidents, 16 occurred for these reasons. I have examined the ADC exposure in some detail, but it is likely that in any fighter-equipped command the same conditions will exist generally. Probably only the degree will differ.

Before we can take a crack at reducing our fighter rates to an even lower level than they are now, we must make an identification of our specific engine accident exposure before the fact. Then, if our action is effective, there will be no so-called irreducible minimum, whether we are talking about fighters or those "flying towns." There is no question about it — we do have built-in basic exposure because of materiel, maintenance, and pilot reliability factors. But our birds are better and are becoming even more reliable all the time; our maintenance troops are doing a fine job, and our pilots are preventing many times more accidents than they are causing.

Still, if our fighter engines and engine systems are to become as reliable as we want them to be, total assaults must be made on engine systems reliability. With a malfunctioning engine, a fighter pilot will probably bring it home for you; with one that quits, he still may try, but the odds against his success are horrendous. The problem of before-the-fact accident exposure identification and neutralizing action lies for the most part with the support agencies of the Air Force. The on-the-line operators and maintainers are forced to play the hand out pretty much as dealt them. The improvement of system reliability may begin on the line, but the ultimate action is always the responsibility of support agencies at all levels.

In the next 12 months I challenge each of you to keep engine reliability as your goal. From the hand that holds the wrench to the hand that designs the change, concern yourselves with engine systems and engine systems reliability primarily, and if you do, I am naive enough to expect that we can cut our engine-induced fighter accidents by at least one full third in the next 12-month period. ☆



Photographs of one series of artificial-lightning tests on airplane model to determine probable stroke-interception points.

Lightning and Aircraft

Adapted from a longer work by the Editors of the Lockheed Field Service Digest and reprinted by permission of the Lockheed-California Company.

WHEN LIGHTNING STRIKES an airplane, a variety of effects can result, but in the vast majority of cases, damage will be slight. Injury to occupants is quite rare, fortunately, and we have seen no reports of an occupant of a metal airplane receiving a fatal shock.

If the aircraft were a perfect, uninterrupted, metal shell with no insulated conductors, such as antennas, leading into the vehicle, it is probable that a dangerous current would never be transmitted internally. Damage would be limited to pitting or occasional puncture of the shell. In many cases, occupants (including flight crews) are not aware that their aircraft has been struck unless a witness reports it, or damage is discovered after landing. Generally, skin damage will be limited to minor pitting or fusing of a few rivet heads, but small punctures do sometimes occur.

Evidence indicates that the path of the lightning in relation to the flight path is apt to determine how severe the damage is. A quick succession of strokes often follows along the trail of ionized air created by the first stroke. If the aricraft is flying along the ionization trail, a sustained flash (consisting possibly of a dozen or more strokes) may contact the skin at one spot and burn a small hole, such as an arc-welder electrode will produce. Such a hole could be an inch or more in diameter, depending on the thickness of the metal. If the stroke path is perpendicular to the direction of flight, however, successive strokes will make contact progressively farther aft as the ionization trail "washes" aft in the slipstream; the resulting damage is then more widespread, but of a lesser degree. It is also conceivable, depending upon the attitude and flight path of the aircraft in relation to the ionization trail, that an initial stroke to a wing tip for example could be followed by a succession of strokes moving inboard.

Scientists have recorded the wave pattern of many lightning strikes and have found a wide variation in current, duration, and other factors. Despite the wide variation, some authorities classify the lightning as hot or cold according to the type of damage inflicted. In general terms hot lightning involves lesser currents of longer duration and has inflammatory tendencies. On the other hand, cold lightning (high current and short duration) is more apt to inflict damage by the explosive heating of moisture or air in wood and in man-made materials of like composition.

These distinctions are mentioned here as a matter of academic interest only. Obviously, man has no control over the nature of the stroke. We have to assume that aircraft will continue to be struck and do what we can to lessen the possible damage or, assuming a certain amount of damage, ensure that flight safety is maintained at a high level.

One factor which determines the extent of lightning damage — the conducting quality of the exposed target —is controllable, but only insofar as other factors such as function and cost will allow. In modern aircraft structures, cost is usually of secondary importance compared to function but, even so, it is obviously impractical to build the complete airplane of thick enough aluminum or other metal that it would be quite immune to lightning damage. The weight penalties involved would make such a design impractical.

The usual approach to the problem is to determine for each type of aircraft the points of the airplane which are most likely to be struck by lightning. Generally speaking, these points are the extremities of the airplane but, as outlined above, the problem becomes somewhat more involved than this when considering an aircraft's motion through the atmosphere.

To gain some background of information about an airframe in relation to lightning, manufacturers may submit metal scale models of new designs to a specialized laboratory such as the Lightning and Transients Research Institute (LTRI). In this laboratory, the model is subjected to artificial lightning from various points of a spherical perimeter. Once the probable points of interception are known, more detailed studies are often made on actual aircraft components to develop the lightning protection best suited for specific applications. Figure 1 shows just one such series of tests on an aircraft model. In other series of tests on the same model, the airplane attitude was changed to cover as many variations as possible of aircraft position in relation to stroke path.

Unfortunately, as mentioned earlier, aircraft are not, and cannot be, perfect metal shells. The extremities—which most often serve as electrodes for the strike—are commonly fitted with non-metallic radomes; antennas of various kinds project beyond the shield of the metal shell; and flight control surfaces and propellers offer pointed projections which are vulnerable because of their shape, their extreme location, and their bearing attachments to the shell. As might be expected, these are the components most often damaged by lightning strikes (see Figure 2).

RADOMES. Non-conductive shells such as radomes present particularly thorny design problems, and in view of the high incidence of lightning strikes which involve radomes, they warrant some particular attention. Their susceptibility to lightning damage stems principally from their location and their non-conducting qualities. Although they are primarily shields for the antennas, their streamlining is also an important factor to the aircraft's flight characteristics, and if a forward radome is damaged by lightning, debris carried aft by the slipstream can do additional damage.

One apparent incongruity here is that *non-conductive*

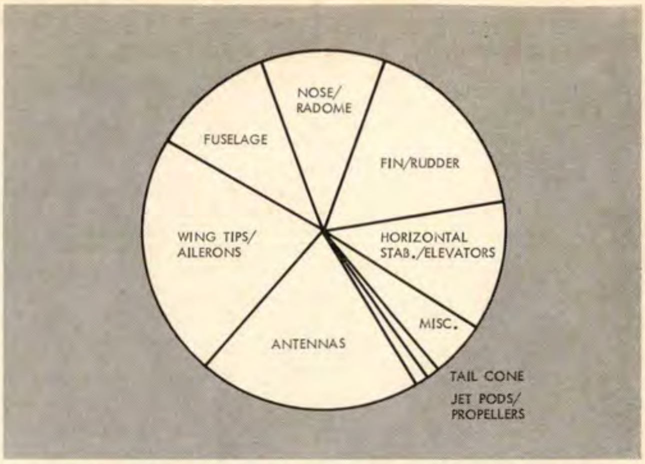


Fig. 2. Approximate distribution of points on aircraft struck by lightning. Estimated from various military and commercial strike reports.

Fig. 3. Lightning protection of P-3A nose radome.

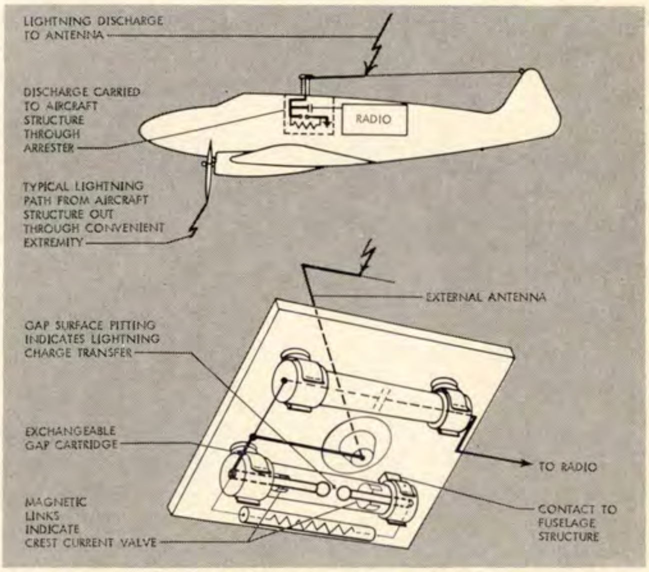


Fig. 4. Typical lightning arrester protection system for aircraft antennas.

radomes should be struck by lightning at all. The explanation is that the radar dish and metallic parts under the radome send out streamers, which are induced by an approaching stepped leader. Being a dielectric, the radome is heated intensely by the subsequent lightning stroke, and, although damage can be limited to pitting or small punctures, heating and consequent expansion of the composite material often causes fairly large holes to be exploded into the shell. In other instances, where radomes have been lost completely, it seems likely that explosive heating of the air beneath the radome was a factor. It should perhaps be mentioned that tiny punctures can also be produced by friction charge accumulations on the external radome surface, which puncture through to the interior. In any event, damage or possible loss of a radome is something that has to be considered in the design of an aircraft, mainly from the aerodynamic viewpoint.

It is generally not feasible to alter the location of a radome or its material to provide lightning protection, for the field of surveillance and/or the range of the radar would suffer. The only alternative is to divert the stroke to the skin by a chosen path via a conductor placed so as not to interfere unduly with the operation of the enclosed equipment. Diverters of two general types are in use, the consumable and the permanent.

For most applications, the consumable conductors are in the form of braided wire or narrow thin metallic strips, cemented longitudinally to the radome outer surface, and bonded to the metal skin. The length of the strips, their location, and their cross sectional dimensions are determined by tests to be optimum for the particular application. That is to say, they are planned to provide the best balance between lightning protection and loss of performance from the enclosed equipment.

The wires and the thin strips are not designed to survive a lightning strike, but they can divert a stepped leader to the skin, and even after they vaporize, strikes following in quick succession will find a residual ionized channel to the skin (see Figure 3).

Obviously, if the aircraft should intercept a second strike after the ionized channel has washed aft, a part of the radome protection system will be missing, but the protection zones of the strips are made to overlap, so that the radome is still well protected. In many cases, radomes will remain intact, and the only repair required will be the replacement of the braid or metal strip. The radome should be closely inspected, of course, for the local, intense heat may cause local delaminations of the inner or outer radome skin that are not readily seen. Also, tiny pinholes are sometimes created, and if water enters through such punctures it can interfere with radar operation.

An extensive protection system of the permanent type is the MAD boom of the P-3 anti-submarine aircraft. The rods, which extend almost full length on all four sides, are interconnected at intervals, providing a Faraday cage intended to spread the current so that the tendency of one rod to induce secondary currents in internal components is largely offset by an opposing tendency in the opposite rod.

ANTENNAS. These are often instrumental in leading lightning into the cabin where it damages transmitting-receiving equipment and exposes personnel to hazardous voltage. For this reason, lightning arresters (such as that shown in Figure 4) have been developed. These usually include a special spark gap between antenna and aircraft structure, a dc blocking condenser, and a static leak resistor all encased in metal/glass enclosures. They are located in the antenna lead-in adjacent to the aircraft skin. The arresters are expendable, that is, they must be expected to sustain some damage in diverting the heavy current, and should be frequently inspected to ensure that the correct spark-gap is maintained. Note that they are not intended to protect the external antenna, but are simply intended to provide a calibrated weak point in the antenna system which will break down and carry off the destructive peak voltage through a safe path rather than allowing the lightning to flash-over to structure inside the fuselage at a spot of its own choosing. Arresters are not provided for all antennas in all locations. Generally only those which are likely targets because of their shape and location are fitted with lightning arresters.

CONTROL SURFACES. Rudders and elevators, in particular, are prime lightning targets because of their location, and are susceptible to damage because they are necessarily hinged and constructed of light-gage material. There is no practical way to preclude *all* current transfer through hinge bearings, but it can be reduced to a certain extent by providing bonding jumpers between the fixed and the movable structure. This provides paths of low resistance in parallel with the hinges, so that a large proportion of the current is bridged safely. However, when millions of volts are applied — perhaps repeatedly — current will inevitably flow through the bearing. Consequently, the bearings should be inspected if a flight control surface is thought to have sustained a strike.

STRIKE EFFECTS AND SOME PRECAUTIONARY MEASURES. The intense field created by a lightning strike can, on occasion, be quite troublesome

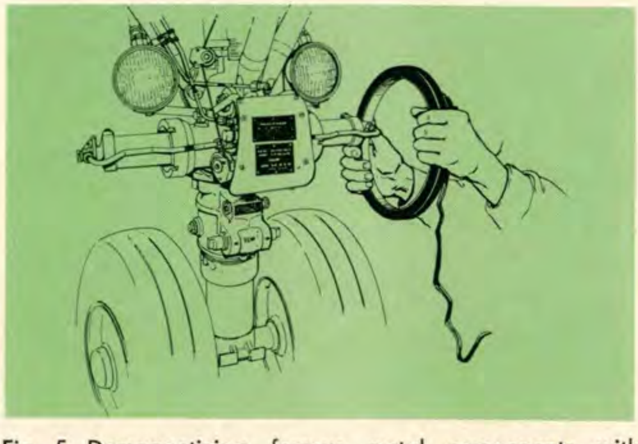


Fig. 5. Demagnetizing ferrous metal components with portable de-gaussing coil.

to flight crews and maintenance crews alike. Ferrous metals may become magnetized, and indicators which utilize magnets may be disoriented by local steel parts. Magnetic compasses are most vulnerable in this respect, and after a strike has occurred, compass readings are suspect, and should be cross-checked by whatever means are available before trusting them for navigation. In this respect, the pilot can take the precautionary measure of ensuring his gyro-compass accuracy when static build up and/or region of strong potential gradients, often presaging a strike. Gyros are not so prone to malfunction if a strike occurs, and will provide an immediate — although only approximate — check of magnetic compass fidelity.

All ferrous metal components in magnetically critical areas should be ground checked after a lightning strike, for it is often necessary to de-magnetize them. Portable de-gaussing devices are available, some of which have proven capable of de-magnetizing even large components such as landing gear and their truss structures without removal from the aircraft (see Figure 5). Following the de-gaussing operation, all compasses should be re-calibrated by compass swinging.

Secondary currents are often induced by the near passage of a lightning bolt, and sometimes there are annoying side effects when induced currents flow in circuits where momentary potential produces actuation. Such incidents are comparatively rare, but cases have been reported in which all the passengers' emergency overhead oxygen masks have dropped out on a high altitude jet transport, bomber tip tanks have been jettisoned, and, by the rarest coincidence, on successive days armament pylons were jettisoned from two fighter aircraft of the same squadron. Most such side effects are spectacular and difficult to overlook when inspecting for strike damage, but it will be well for maintenance personnel to know their aircraft devices — such as electrically discharged fire extinguishers — and check them during the post-strike inspection.

Secondary currents sometimes work through audio circuits to produce a temporarily deafening crash in earphones. Here again, the crew can take heed of static build-up and unseat the earphones by way of self protection.

Fig. 6. Cumuliform clouds responsible for lightning strokes. Throughout the article we intend the term "thunder cloud" or "cumulo-nimbus" to apply also to the cumulus congestus — the most advanced stage of cumuliform cloud before its final evolution as a cumulo-nimbus.

There have been many instances of crews becoming temporarily blinded by lightning strikes while flying at night, and such blindness has often persisted for several minutes. One precaution which might be taken at the flight crew's discretion is to turn up the cockpit lights to full bright and keep the eyes focused on the instruments when static, St. Elmo's fire, or other warning signs indicate the likelihood of a lightning strike. This action will have the effect of contracting the pupils of the eyes, making them less susceptible to damage from a subsequent lightning flash. Of course it would never be advisable for the entire flight crew to restrict their vision in this way, but if one member does so, the small loss in observation will be well repaid by the degree of protection gained against an entire flight crew being temporarily disoriented.

AVOIDING LIGHTNING. The golden rule in avoiding lightning is to not fly in, or in the vicinity of, thunderstorms or any of the clouds with high vertical development. These are often called collectively clouds of the cumulo-nimbus type but a meteorologist would also include in the list of various clouds to be avoided others, such as the cumulus congestus, which are simply advanced stages in the development of a cumulus aspiring towards a cumulo-nimbus (see Figure 6). Of course, as far as this golden rule is concerned, the problem of possibly being struck by lightning is not so serious as the problems of encountering turbulence, icing, and/or hail — all of which are particularly associated with the thundercloud. However, if we assume that we are forced to fly in the vicinity of a thunderstorm for some reason or another, then it might be helpful to discover some more rules.

Statistics on lightning strikes to aircraft seem to show that altitude plays a minor role, in a practical sense, as far as determining the likelihood of being struck. Reports show that most strikes to aircraft occur below 20,000 feet with a certain emphasis on the 5 to 10,000-foot level but these figures also appear to reflect the altitudes where most flying occurs — even jet aircraft spend a large proportion of their average flight time climbing or descending at low operational levels. About the only conclusion that can be made is that strike probability drops sharply above 20,000 feet. Incidentally, this statment is further supported by Air Force statistics which show that 9 of 11 strikes reported on B-52's were below 20,000 feet, but is somewhat repudiated by another record of 14 jet aircraft strikes which shows a wider spread of altitudes corresponding more closely with the greater range of operating altitudes of the pure jet. However, strike probability almost certainly coincides with the altitude range of the cumulo-nimbus which, in general terms and depending upon world location, is commonly found between 3 and 30,000 feet, is somewhat less frequent up to 50,000 feet, but can even extend to higher levels than this.

Perhaps a more satisfactory method of avoiding strikes near thunderstorms is to keep a watchful eye on the ambient temperature. The majority of lightning strikes (about 8 per cent) occur in the temperature range — 10°C to +10°C. Thus it appears that a good precaution to flight crews would be to select a flight level where the temperature is not near freezing, although it should be noted that — 70°C to +10°C corresponds to a considerable range of altitude (2500 feet to 12,500 feet). It should also be noted that temperatures inside and outside of clouds can vary a great deal. Incidentally, the fact that most strikes occur near 0°C correlates quite well with thunderstorm electrification theories that charge separation occurs at about the freezing level. However, it is to be expected that positive charge centers at the tops of tall clouds are at much lower temperatures than this.

RELATED ITEMS AND QUERIES

STATIC DISCHARGERS. These are commonly fixed to the trailing edge of aerodynamic surfaces, especially flight control surfaces, to aid in the dispersion of friction charges which accumulate on the skin of the aircraft. There are a number of designs, the most common type being a carbon impregnated wick, frayed at the trailing end to provide intimate contact with the slipsteam. After a lightning strike, they should be inspected and replaced as necessary. Except for this reference, any further discussion regarding these devices should hardly be justifiable in an article about lightning. However, one purpose of this article is to dispel popular myth. The purpose of a static discharger is just what the name implies — to discharge static. A widespread misconception that they serve a dual purpose and also, in some way, discourage lightning strikes stems from the equally popular misconception that an aircraft can become sufficiently charged during flight to originate its own lightning discharge.

Many reputedly authoritative articles on the subject draw definite distinctions between bolts of *natural lightning* and bolts due to *static discharge*. It should be emphasized that aircraft skin friction can at most generate moderately high voltages of about 100,000 volts with charging currents of 0.0005 amperes. These values hardly bear comparison with those of a "natural" lightning discharge, which involves potentials of 10 to 100 million volts and currents sometimes exceeding 100,000 amperes.

However, as indicated earlier, static dischargers do enter the lightning picture to a certain extent. Under certain conditions, they can provide a local diverting action to a lightning bolt for a distance approximately equal to the length of the dischargers. It follows that static dischargers should not be installed on an airplane without due regard to this diversion factor. One placed on the outboard end of an aileron for example could well direct a lightning stroke to itself away from the wing tip, and to quote Newman and Robb, ". . . strikes (which are diverted) to most of the short dischargers in current use jump off the discharger over to the adjacent metal skin resulting in a costly and time-consuming aircraft repair problem, i.e., the repair of skin damage." (From a report by Messrs. M. M. Newman and J. D. Robb, Lightning and Transients Research Institute.) While on this subject, Newman and Robb also believe that the present dischargers could be mounted with bases which would greatly reduce the damage either adjacent to or at the base of the discharger.

We might at this point answer a question that is relevant and is often asked. High speed fighters frequently do not have and do not require static dischargers. The jet engine exhausts are usually sufficiently ionized to carry off most of the accumulated charges of precipation static. However, this is not true of all jets and, as a general rule, static dischargers are necessary as jet aircraft size and performance increase.

Incidentally, Lightning and Transients Research Institute has developed a graded resistance lightning diverter rod which combines the function of a static discharger with that of a lightning rod. The use of such a device controls, to some extent, the specific localized point at which lightning might strike (Figure 7). The diverter rod base is designed to carry the stroke currents without damage to the skin or air frame at the attachment point.

RADAR AS AN ATTRACTOR OF STRIKES. The incidence of lightning strikes to radar devices is inevitably high for reasons which have already been discussed. It is also well known that the energy transmitted via some radar beams is of a high enough order that it can (in some combinations of wave-length, range and power) burn a living organism internally, illuminate incandescent lights, or perform similar feats. Not unnaturally, this has caused some speculation as to whether it is possible for radar to produce ionization of the atmosphere, and thus attract lightning discharges.

Lightning and Transients Research Institute conducted a study on this particular problem of lightning diversion. Selecting an altitude of 40,000 feet as a basis of evaluation (generally speaking, the problem increases with altitude), they arrived at the conclusion that the possibility *might* exist at that altitude if the power flux of the most intense radar beams existing today were increased by a factor of 10.

We recently requested Mr. Robb of LTRI to comment further on this interesting subject. Taken slightly out of context, the reply was: ". . . we do not believe for average radars in present use this is much of a factor as the maximum electric field magnitudes are rather low, well below the ionization levels for medium flight altitudes where most lightning strikes occur. However, it is granted that for very high power radars, high HF antenna voltages, and high altitudes, ionization could be a significant factor in attracting strikes." ☆

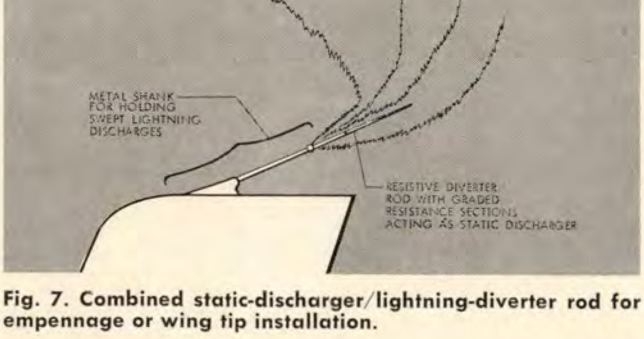
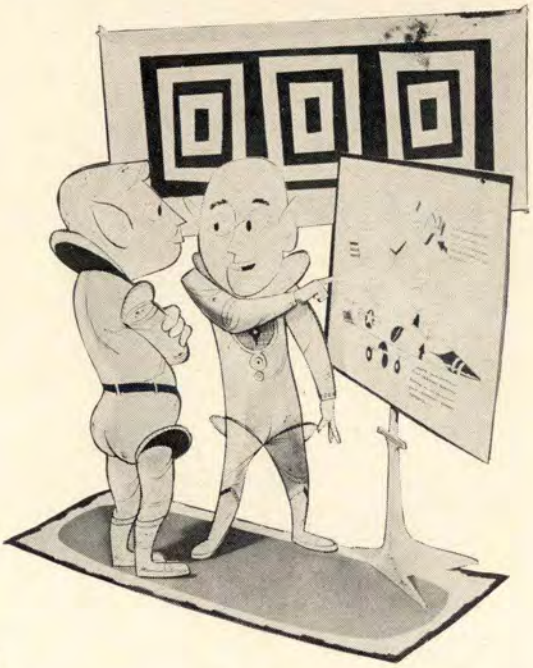


Fig. 7. Combined static-discharger/lightning-diverter rod for empennage or wing tip installation.

TWANG

A Science Fiction Saga that may border on truth . . .



At the duly convened meeting of the CIA committee of the MIPA (Martian Interplanetary Progress Association), the problem for resolution was personnel emergency exit systems as employed by inhabitants of other planets. To be more specific, the best intelligence brains, with the help of engineering specialists of course, were dedicated to resolution of why earth men favored such highly intricate systems for emergency ejection of aircrews. The chairman rapped the table with his gavel.

"Gentlemen, F-3 has just returned from an observation mission to planet earth and has charts and diagrams outlining the systems in use there. He will show these, then we will attempt to rationalize why such systems are used and make a determination as to whether we should recommend any such similar devices for our use." A few of the Martians snickered and shook their heads, causing the chairman to hastily add, "Gentlemen, we must be fair. Surely, though I admit not one of our colleagues has been able to determine why, there *must* be a reason why the earth people always go to complicated systems. Okay, George, go ahead with your briefing."

George did. He unfurled charts and diagrams, all drawn in multicolors, and explained briefly the operation of the systems and their history. It was obvious that complexity was an indication of progress as, in earlier days the chutist merely flipped his machine inverted and undid his belt, or stepped over the side. In the most modern systems George pointed out that the trend was toward:

- An intricate network of safety pins and lanyards that could only be properly positioned with the aid of a printed list of sequential instructions.
- Ballistic devices that performed such functions as shearing pins, tightening leg lanyards, compressing elbows, deploying chutes, even swatting the occupant's posterior, all in a critical time sequence.
- A system of rails, tubes, gas chambers, ballistic channeling devices and recoil absorbers.

Then, to illustrate that the trend showed no indications of abatement he furtively unfolded a chart he had filched. This one, with TOP SECRET stamped all over it in red, provided details of a system wherein explosive bolts were used to separate the personnel area as a unit. It incorporated some of the latest designs of the older systems and had an intricate system of fins, chute deployment devices, and other stabilization paraphernalia.

When George had finished, there was considerable head shaking and moaning. One of the members complained that he was feeling ill, but the chairman refused to excuse him. Another took out a rubber band, stretched it and let go. It shot across the room. The chairman frowned. The guy who had shot the rubber band shrugged. "No offense intended, sir. That device came from down there. It's simple and reliable . . . works every time. I was just wondering why they don't use rubber bands?"

"George," the chairman signified the Martian standing by the charts.

"My deduction is," and he unrolled another sheet of paper with a bar graph on it as he spoke, "they have apparently reached an acceptable success rate. It's not as good as they had when they flew biplanes, but it has held almost constant for the past several years. Obviously, the stability of the success rate has bearing on designs they accept."

"Is it a good one?" another member asked, obviously in disbelief.

"Well," George hedged, "my personal opinion is no—only about 80 per cent survive, but . . ."

At this point the one who had shot the rubber band interrupted. "It's time for lunch," he said. "I recommend that we close out this project with the endorsement of our system and let the earth inhabitants go about their expensive, unreliable way. A lot of them must keep occupied, designing, installing, learning to use and maintain their system. If they went to ours it would throw a lot of people out of work. That might pose a bigger problem. There may be economic-political factors we haven't considered." As he said this he rose, pressing down firmly with a pudgy right thumb and forefinger on an object he had placed on the desk. "But for the sake of the poor misguided ones who have to ride around with such a system we might leave a sample of a device we have found works 100 per cent of the time, is simple to construct and install, and needs no maintenance. George, next trip down, why don't you just leave one of these on the seat of one of their airplanes?" At that moment he parted thumb and forefinger and a small spring shot up, striking the ceiling hard enough to leave a dent.

The committee members nodded in agreement and as they left for lunch, the room still rang with the last echoes of the sound made by the spring, "T. . w . . w. . a. . a. . n. . n. . g ! ! ! ☆

DISORIENTATION

Maj William R. Detrick, Aviation Physiologist, Medical Group, DTIG

The weather en route for eight F-100s on an overseas deployment was essentially as forecast with broken cirrus layers overhead and a broken to overcast underdeck. The flight leader, Waxy 41, established radio contact with the KC-135 tankers approximately 80 nautical miles prior to reaching the first air refueling check point. The flight was informed that the tankers were maintaining 29,000 feet and were ready to rendezvous.

The weather at this time was reported by members of the flight as VFR with 30 to 40 miles inflight visibility. The stars were plainly visible overhead and there was a thin overcast several thousand feet below flight level. The glow of larger cities could be seen through the cloud deck and occasional breaks in the clouds revealed surface lights.

As the flight approached the tankers, a call was made by Waxy 41 to position the tankers on the refueling heading. The flight established visual contact and the tankers began a left turn to an on course heading. The flight was then approximately four to five miles behind the tankers slightly low and closing slowly. Airspeed was increased from 300 to approximately 330 knots and Waxy 41 instructed his flight of four to "go loose right echelon" to a prebriefed refueling position. At this time Waxy 43 and 44 were in fingertip position on the left wing of Waxy 41. The second section of the flight, Waxy 45-48, was aft and to the right of the first flight. They were to rendezvous with the second tanker.

Waxy 43 didn't immediately react to the echelon right instructions. Then he started a slight right bank to cross over, held about 20 degrees of bank for approximately five seconds then rolled out straight and level. A few seconds later he entered a 20 degree left bank, held this for about five seconds, and again rolled straight and level. He then momentarily tipped his right wing and leveled out.

Waxy 44, the wingman, assumed he was to cross over to the right wing and started to drop back for the cross over. At this time, Waxy 43 stated, "Watch me, I've got vertigo." He then rolled to a level 90-degree left bank. Waxy 44 immediately transmitted, "You are in a 90-degree left bank, turn." Waxy 43 then rolled an additional 90 degrees to the left and disappeared below 44 who was three to four ship lengths behind and slightly to the left. Waxy 44 had to pull up to avoid hitting 43 and transmitted. "You are in a Split-S." He did not see 43 again.

The IP flying in the back seat of Waxy 41, an F-100F, heard this "Split-S" transmission and immediately transmitted, "Roll out and get on instruments!" He then asked 43 what his altitude was. At this time, other members of the flight stated that they heard Waxy 43 ask "44, where are you? I want to get on your wing." There was some confusion as to whether one or more transmissions were made by Waxy 43 of various altitudes but several members of the flight heard him state, "I am at 7000 feet." The lead ship IP immediately transmitted, "Bail out, bail out," and Waxy 43 replied, "I'm getting out."

The total time from Waxy 43's transmission of "Watch me, I've got vertigo" to his reply, "I'm getting out" was approximately ten seconds. The flight had been air borne one hour and 18 minutes. Waxy 42 flying on the right wing of the lead aircraft saw 43 enter the undercast and heard his transmission that he was at 7000 feet and ejecting. A few seconds after this transmission, the clouds lit up. He further stated the noise level behind Waxy 43's transmission made him believe that the canopy was off at the 7000-foot call.

The pilot's body was discovered still in the harness of an apparently normally deployed parachute. Although the ejection seat was never found, it is assumed it worked properly in all sequences. The parachute was found by the search party to be fully deployed without any torn panels. The medical officer attributed the pilot's death to injuries sustained during ejection at over 550 knots. Evidence indicated extreme flailing due to windblast. Although high speed ejection is rare — about one per cent above 500 knots — and lethal flailing is an extremely rare phenomenon, the potential hazard is recognized. The need for simple and efficient restraints for the extremities is quite real, provided they do not compromise reliability for low level ejections. Cause of the accident was attributable to failure to recover from an unusual position after spatial disorientation.

A possible contributing cause was suspected failure of the attitude gyro system giving the pilot improper attitude indications.

Although this pilot's transmissions aided in determining the cause of this tragic, fatal accident, not all such accidents are as easily solved. Many, however, continue to be blamed on spatial disorientation or "pilot's vertigo." Much has been said on these pages and others on the subject. But the fact remains that we continue to experience accidents from this cause. So, let's air the subject again.

Spatial disorientation can range all the way from simple confusion as to exactly which way that aluminum arrow is aimed, to complete vertigo with the accompanying spinning sensations, twitching of the eyes and perhaps even losing the "cookies." The physiological mechanism can be explained by your flight surgeon or physiological training officer but for now let's concentrate on *when* it happens and how to *prevent* it. You see, the idea is to keep from becoming *disoriented* in the first place and, should it occur, to *reorient* in the least possible time.

Remember that man must have a *visual* reference to maintain orientation in flight. He must have visual contact with the ground, his instruments or another aircraft in flight. Any other sensations such as the "vestibular apparatus" or "muscle sense" must be ignored.

Second, our accident reports show that the problem is usually one of change-over from one set of horizons to the other: changing from ground contact to instruments, or from formation to the gages.

In the fatal accident related above the pilot was no greenhorn. He had over 1700 hours flying time of which 1300 plus were in this model aircraft. He had recent experience in night and weather flight and had completed a proficiency flight check less than a month previously. His last instrument course seven months back had included the command's vertigo training course. So, what happened? Part of the answer is that even experienced pilots can experience disorientation — it becomes less likely with more experience— but it *can* happen.

In the accident at hand the pilot reported that he was experiencing vertigo. This is entirely possible since he was in night formation with many misleading lights — his flight leader's, the stars, the tankers' and, periodically, the ground. Since he was attempting a crossover from behind and below, his head was tilted back slightly. Next he accomplished two turns. These conditions can cause some disorientation of either minor or major degree.

At this point, it is entirely possible that a cross reference to his instruments gave him *mis*-information. (The attitude gyro had a history of erratic behavior and had to be coaxed to erect properly on engine start prior to takeoff.) Disorientation plus *mis*-orientation soon put him in an attitude and at an airspeed where ejection was the only choice and proved fatal due to high speed. At this point, each of us might review ***his*** procedure for proper recovery from unusual positions. Power adjustment is always high on the priority list.

What's the answer? How can we prevent more accidents of this type? Only by an overall attack on the problem. First, training in the problems of disorientation must continue. Second, the instrument people *must* provide reliable instruments! Our recent history of attitude indicator failures is too high. *Any* failure of this vital instrument is unacceptable. In the meantime, good instrument practice will give us a cross-check to the *other* instruments in the cockpit. Use the airspeed, altimeter and stand-by gyro. An antiquated instrument such as the needle/ball (turn and bank) is of limited, if any, value in century series aircraft. The best life insurance is still practice.

Is it *mis*orientation or *dis*orientation? Mox nix! The result can be the same. And it can happen in a hurry — no time to plan or make mistakes. Action must be preplanned and practiced. Get on the gages — but use them all. ☆

HISTORY REPEATS REPEATS

LAST YEAR AN ARTICLE titled "Kilo Confusion" appeared in this magazine. It told how a flight of Air Force aircraft was recovered during submarginal weather. They made it in an environment that included such disaster primed situations as one-eighth mile visibility on the landing runway, identity confusion, low fuel states, two other aircraft with emergencies, improper call signs, unnecessary radio transmissions, a less-than-100-feet near-collision and unreliable radar due to heavy precip.

Call it fate, chance, luck — it all adds up to a miracle — they all made it.

Two years ago an article titled "Non Support of the Pilot" appeared in this magazine. This article dealt with one of a flight of aircraft trying to get in under somewhat similar conditions. Weather was indefinite, 500 obscured, visibility one mile in a heavy thunderstorm, the AC system went out, radar contact was frequently lost because of precipitation, the aircraft was descended below minimum altitudes and unauthorized transmissions added to the confusion. Somehow the pilot managed to fly in and around this storm until out of fuel (38 minutes) before he ejected. This appears to be quite a feat when it is realized that he had no operating fuel boost pumps, air-speed-mach indicator, altitude-vertical velocity indicator, pitch and yaw dampers and windshield de-fog or anti-ice.

And now it's 1964. Late one day this spring a flight of aircraft was being recovered through thunderstorm packed skies. Here are excerpts from some of the pilots' statements:

"I called for a missed approach and asked to be lined up again on the ILS but got the same results as the first approach. I made several large corrections and got back on center line just as I broke out, about two miles out. The turbulence was moderate and winds aloft very gusty, causing airspeed control to be difficult, so I held an additional 20 knots to give me adeqate control for all this maneuvering on final."

"Turning on final I intercepted the ILS course and set up for final. Upon reaching the glide slope, my best flare was 184 and an approach speed of 194. I tried to maintain this but due to the wide variations I increased it to 210. At one time on approach it got as low as 170 before I could stop it with mil power. Completed approach and broke out at approximately one-half mile from the approach lights, 100 to 150 feet right of center line. My ILS indicated I was on course and on glide slope at this time. I could only see the approach lights and the approach end of the runway. I completed the landing from there. After clearing the runway I gave weather report to ground control. I judged it to be about 100 feet and one-half mile. I landed out of this approach due to the fuel condition I had at that time. I considered it safer to land than to pull back up into the weather since the weather was getting worse and with numerous thunderstorms all over the area."

"At approximately 20 miles out we turned left to 360 degrees going between two thunderstorms. On the final approach we broke out of the weather going past .... with turbulence increasing. The airspeed fluctuated 20 knots either side of desired. We flew the final at an average best flare speed plus 20 knots. At approximately two miles out we encountered low scud clouds and also rain which blanked out the runway. We leveled off at minimums and at one mile the runway still was obscured by rain so we made a missed approach. On downwind we encountered extreme turbulence. This was reported to GCA. The airspeed fluctuated between 230 to 270 with no change in power setting."

"At approximately 400 to 500 feet above the terrain an extreme wind sheer was encountered and our airspeed dropped from 210 knots to 165 knots (26 knots below best flare speed) in a matter of a few seconds. Throttle was immediately applied to mil power and the attitude was held until airspeed was regained and approach continued. It was difficult to ascertain where we broke out of the overcast, however, I estimate it to have been 200 feet. The severe turbulence ceased immediately upon break out and normal approach and landing were accomplished."

"I ran into lightning and severe turbulence north and west of the field. Arriving at minimums I first saw the strobe lights about 300 feet to my left and took it around. The weather was not 900 feet, but more like 300 feet. The second approach was about the same except I was to the left of the runway and it was too late again to line up on the runway lights which were somewhat

hazy. On the third ILS final Approach Control advised me their monitor light for ILS came on and to carefully check my instruments. About this time the off flag (I believe glide path) appeared and I leveled off at 1100 feet. As I passed over the field I only saw a haze of the ramp flood lights. I called for the .... weather and diverted with no further problems."

"I centered the CDI and picked up the glide slope. I broke out over the approach lights at about 500 feet. I hit extreme turbulence or a very great shear and the aircraft settled out. I applied military power but the aircraft touched down and I got it into the air. Immediately thereafter we struck the power lines."

The aircraft that hit the ground, took out the power lines and a fence, lost one engine and had only partial power on another, then diverted due to weather and aircraft damage, was the eighth aircraft. Here is what happened to the seven ahead of him.

The first two made it on the first pass.

Nr 3 landed on his second approach.

Nr 4 landed on his third approach.

Nr 5 landed on his second approach.

Nr 6 landed on his first approach.

Nr 7 made three missed approaches, then diverted.

Eight years ago an Air Force aircraft took off into a thunderstorm. hit a downdraft, crashed, and 46 were killed.

A few weeks ago an Air Force aircraft, making an approach during a thunderstorm, crashed with a higher fatality toll.

The same weekend another Air Force aircraft, flying through an area of severe thunderstorms, crashed and all on board were lost. A wreckage pattern over an area of approximately five miles indicates inflight structural breakup.

Following are briefs, selected from some of the incidents and accidents during the past two years, to illustrate the force of thunderstorms on various Air Force aircraft:

A T-33 nose gear failed on landing when the pilot lost sight of the runway just prior to touchdown due to a heavy shower. Weather: 3500 overcast, one mile in heavy thunderstorm. Wind southwest four knots, gusting to 33. Thunderstorm moving east.

F-102 damaged by barrier engagement after landing during a thunderstorm. During penetration weather deteriorated to 500 obscuration, three-fourths mile, thunderstorm, wind light and variable. Pilot had poor braking action and drag chute failed to blossom in heavy rain.

F-102 flight of two flamed out due to compressor stalls when a thunderstorm was penetrated at 45,000 feet. The flight had passed between two thunderstorms, but couldn't outclimb or outturn the one behind.

A C-131 (on ground) fuselage buckled in high winds. Ceiling and visibility were zero in a heavy thunderstorm, possible tornado.

Six C-123s were damaged on the ground by a thunderstorm.

An F-100 crashed during an attempted go-around during a thunderstorm. The flight had been recalled due to the approaching storm, but the landing attempt was made as the storm passed over the field. Fuel was sufficient to reach the alternate or for one hour holding.

A B-52 received hail damage at 35,000 feet in clear air with a rapidly building thunderstorm 10 miles away.

A B-52 was damaged by hail at 28,000 feet. Thunderstorms were being avoided and the hail came from a storm that appeared on radar to be below the aircraft.

A C-47 was lifted from chocks and blown 150 yards into a building. Visibility was zero in the thunderstorm with hail and peak gusts 56 knots but estimated to be 80 knots in the area due to venturi effect between buildings.

A C-123 encountered severe turbulence near a thunderstorm. One passenger was injured. The pilot considered a distance of 10 miles far enough to avoid turbulence.

A B-57 made an emergency landing after a lightning strike. Landing was made in a thunderstorm and the pilot retracted the gear to avoid overshooting because of poor braking action.

ED. NOTE: Help! We've been writing articles like this for years. In peacetime, can't Air Force pilots reduce exposure to weather associated incidents and accidents by holding, going to alternates, delaying takeoff, and flight planning around thunderstorm areas? Will someone help? Does history have to repeat? ☆

He who sits and waits may wait forever. Learn how to . . .

Help RESCUE Help You

John L. Vandegrift, Hq Air Rescue Service, Orlando AFB, Fla.

Rescue best helps those who help themselves. To approach the problem of staying alive following an emergency bailout, ejection, or crash landing, the professional pilot or aircrew member can do much to guarantee his eventual rescue if he knows and puts into practice well proven survival techniques and procedures.

Air Rescue Service has learned over the years that the odds are against luck alone in a survival situation — overwhelmingly so. Percentagewise, the man who chooses to leave everything to luck is a very bad insurance risk. The better you are prepared to meet an unexpected emergency, the better are your chances for collecting retirement pay.

The Air Rescue Service is in existence to help you reach this happy goal. The primary mission of ARS is to save the lives of USAF flyers in distress. Often people lose sight of this fact because of the large number of non-military mercy missions in which Rescue has been involved and about which there has been so much publicity. Floods, earthquakes, and avalanches attract world-wide headlines; the sick child saved and the lost hunter found make big local news. We also get a lot of publicity on our aerospace recovery work but never forget, the Air Force crewman is the real reason ARS is in business

Brigadier General Adriel N. Williams, Commander, Air Rescue Service, states: "Our motto has always been 'That Others May Live.' But we should add 'that they may fight again.' We are primarily a part of a military machine, and our humanitarianism is the wonderful and satisfying by-product — but it is only a by-product. Our principal job is to retrieve irreplaceable flight crews."

An earlier article discussed how and why an aircrew in trouble or in potential trouble should alert rescue facilities, specifically, what should be done and how it should be done. Now, let's discuss what survivors should do to aid the search and rescue effort and provide some useful tips on how to help the searchers find you.

Today's high-speed aircraft slice swiftly across the lines of latitude and longitude. When cockpit temperatures are controllable, it is easy to forget that the temperatures on the earth's surface can vary greatly from hour to hour. Be prepared for the worst. Dress to survive under the worst conditions you can possibly encounter on any particular flight.

In one incident, the fact that the man was alive to be rescued was, of itself, a minor miracle. Luck and guts made the miracle possible. He had been on a flight to test a fabric-lined, rubberized Alclad exposure suit and had been so uncomfortably hot that the other crewmen had tried to talk him into taking it off before he melted away. His decision to complete the test saved his life. He had protection against the cold when he was forced to eject from the aircraft, following an explosion, over bleak northern Manitoba, Canada.

When he hit the ground he had no survival gear other than his service .38, two matches, a bailout oxygen bottle, his parachute and six sulfa pills his wife had made him carry along to help ward off recurring pneumonia attacks. With these few items, plus courage and an unconquerable will to live, he survived where lesser men would have perished. He never quit trying.

Knowing he was partially hidden, he did his best to get a better spot but couldn't. The snow was soft and deep and the man was severely injured. He fired his pistol, hoping to be heard or seen. On the second night he ignited his oxygen bottle when he heard one of the search aircraft nearby. It made a good flare but he wasn't spotted. Despite pain and the drain on his dwindling strength, he gathered his chute around him for warmth when there were no planes around and spread it out for a signal whenever he heard the sound of engines.

He tried for food and managed to shoot a rabbit. Although it lay but 20 feet from him, he was unable to get to it because of the deep, soft snow and excruciating pain from a leg mangled by the explosion. After his rescue, the doctors were amazed at his remarkably good condition and credited the sulfa pills he had sucked on during his 79-hour ordeal with minimizing infection in his leg. In a situation most men would have considered hopeless, he never gave up hope, he never quit trying. He kept his head and he was alive when a Rescue chopper, airlifted into the area, lowered a pararescueman and hoisted him to safety.

Some men possess a working knowledge of the art of survival and practice it, others assume an "it can never happen to me" philosophy.

We will not concern ourselves with this latter group. Repeatedly, experience has demonstrated that they are poor insurance risks and in all probability will not be alive when Rescue makes the scene. But for the others, it might be well to point out that the relationship between good, clear signals and quick salvation is frequently more than coincidental.

Following bailout from multi-place aircraft every effort should be made to regroup in the vicinity of the aircraft when possible and then build the biggest most spectacular signal you can dream up under the circumstances. If no "store bought" signals are available, prepare signal fires, spread chutes — always remembering to break up the terrain and achieve as much contrast as possible.

Be ingenious, as the above survivor was when he tried to use his bailout bottle to improvise a flare. In the Arctic, for example, you may feel that you need a sea marker and Mae Wests or LPU's like you need more snow, but the fluorescence of the marker and the black smoke of a burning life jacket make excellent signals against the glaring white background.

Don't abandon your survival equipment—ever. There have been cases where survivors have departed the scene of an accident leaving many valuable aids behind. Most of them are dead. Protect whatever supplies you have; you may find a valuable use for them later.

The importance of regrouping when confronted with a survival situation cannot be overemphasized. Morale is improved and the group's collective skills and talents can be utilized to the utmost. United you can survive; divided you may fail.

During night searches for downed aircraft and survivors, Rescue aircraft will be on the lookout for any sign of light — flares, fires, flashlights. These can be seen for many miles. During the daylight hours, smoke signals and signaling mirrors are very effective.

As far as the more complicated survival gadgets are concerned, there can be no doubt that one of the most valuable aids in assisting Rescue to locate you can be the survival radio. When they work, and the new ones are getting more reliable all the time, they can make contact with Rescue aircraft on line of sight even when the survivors are hidden from view in wooded or broken terrain.

The old URC-4 operates on 121.5 mc or 243.0 mc and can be received up to 20 nautical miles on ADF or 30 NM on tone from search aircraft flying at 10,000 feet. The URC-10 is coming into the inventory, along with the personal locator beacon, URT-21.

Currently the standard item, the URC-11 operates on 243.0 mc and can be received up to 35 NM on ADF or 70 NM on tone from 10,000.

Even more sophisticated and powerful, the URC-10 operates on 243.0 mc and can be received up to 50 NM on ADF and 80 NM on tone or voice from Angeles Ten.

Something that has been needed for years is the Personal Locator Beacon. These electronic handy dandies transmit only a homing signal on 243.0 mc. Generously issued on the basis of one per aircraft position, one for multi-place life raft, one per alert crewmember when authorized for use by the using command, and one for parachute, this gadget should make homing in on a downed aircrew a comparative snap.

This radio operates automatically with deployment of the parachute during bailout and also can be operated manually after landing. Quite compact, the unit measures one and a half inches by three and a half inches by six inches and weighs but one pound.

The reception ranges of all these beacons can be increased by as much as 50 per cent by installing preamplifiers on aircraft UHF receivers, which is scheduled for all ARS search aircraft in the not too distant future.

Recent tests conducted on the URT-21 at the 55th Air Rescue Squadron in Bermuda give an indication of what a difference a pre-amp can make. At 10,000 feet the tone signal could be picked up at 70 miles with the UHF-DF reaching out 41 miles on voice with pre-amp turned off. With the pre-amp turned on, the tone came in loud and clear at over 120 miles while, for some mysterious reason, the UHF/DF range dropped to 35 miles. At 20,000 feet the tone could be picked up without the pre-amp at 75 miles; the UHF/DF at 50; with the pre-amp on, the tone was picked up at 138 miles, the UHF/DF at 54.

Another electronic device that has been needed for years—the crash locator beacon—may soon make the scene in spite of everything. Still in the development state, it is presently being tested on MATS C-135 and C-133 aircraft. ARS is scheduled to perform the search phase of these tests in the near future. It is possible that these or similar beacons will become an integral part of some USAF aircraft either by design or modification. Ejected automatically should an aircraft crash, they can also be ejected manually by the pilot in an extreme emergency.

This program has been evolving for more than a decade and has been constantly complicated by a variety of requirements for more and more sophistication such as

Man is tiny, the ocean huge. To save your life you should be prepared to Help Rescue Help You.

Help Rescue... continued

building complex flight data recorders into the system. Moreover, the problems associated with configurating each aircraft type to accept the beacon without degradation of performance will be a time consuming task. In all probability if USAF today procured a straight crash locator beacon with no frills or fancy adornments, it would take at least two years to equip the USAF inventory across the board.

Besides radios a number of other gizmos and bits of equipment are being developed to make it easier for you to help Rescue help you. For one thing the little grey, one cell emergency flashlight that has been with us so long will soon be on the way out. To this end a new survivor recognition light, the SDU-5E, light, distress marker, is currently being procured. They will be issued on the basis of one survival light per parachute or flight suit. Weighing seven and a half ounces and measuring four and a half to two and a half by one inch, the SDU-5E puts forth a flashing strobe light visible over three miles from 1500 feet. Close in on a dark night it will literally jolt your eyeballs.

The search goes on for new and improved survival kit flares and tests are now being conducted on a small hand-held flare launcher. This launcher is capable of tossing multi-colored light, smoke or noise flares to an altitude of 300 feet. From ground level the light flares are visible up to seven miles. About the size of a fountain pen, this flare launcher is designed to be carried by the individual crewmember.

Taking a completely different approach, ARS has submitted a qualitative operational requirement for sound fixing and ranging (SOFAR) equipment. It is a deep water location device valuable only in ocean areas. SOFAR charges will not explode in fires and must be hydrostatically activated. They are small—can be carried in a navigator's kit—have indefinite shelf life and need no fancy installation.

Essentially this SOFAR system consists of a depth charge that detonates automatically at a specific depth below the ocean's surface as the aircraft wreckage sinks after ditching. The detonation sets up a distinctive sound pattern that radiates in all directions through the water from the point of origin. At these specified levels sound travels thousands of miles and can be detected by underwater listening stations. The signal strength determines the range and its origin can be fixed within a few miles by triangulation from various listening stations. This technique, used successfully during Project Mercury on Scott Carpenter's flight, could quickly limit or confine an overwater search to a relatively small area.

These examples represent neither the extent nor the end of Air Force efforts to help the guy in trouble help ARS. Also in the mill, for example, is some chemical gunk that will make the time tested fluorine sea dye as antiquated as buggy whips and button shoes. (In this area our lips are sealed for the present.—Editor's Note.)

There is an old story about the farmer who was trying to teach a city boy how to handle a mule. His first move was to pick up a five-foot chunk of two by four and give the mule a heck of a belt right between the eyes. "First," he said to the city slicker, "you gotta get his attention." The purpose of all the new aforementioned gadgetry is just that — to get the would-be rescuers' attention. Once this is accomplished, help should be on the scene in a little or no time. But the battle is still not over.

Be prepared when help arrives to assist in every way. Even when Rescue is in the area and has you spotted, minutes still can easily mean lives. Know how to use your emergency signal and radio equipment quickly and effectively. Know what constitutes a suitable helicopter landing area and mark it.

Dust, sand, loose snow can blind a chopper pilot and make a tough pickup even tougher. Realize that innocent-looking bushes and scrub growth can play hob with a tail-rotor, and that it will do you no good to stay alive for days only to be knocked completely out of this bright blue-eyed world in an instant by getting excited and trying to run through that same tail-rotor.

Rescue missions are flown every day in all weather, under every climatic condition. The men who fly these missions get to see first-hand the grim results of failure to plan, lack of knowledge and preparedness. Don't learn the hard way that Rescue can only help you if you help yourself. ☆

Survival kits usually contain one of these survival radios, URC-11 (left), URC-4 (right). In cold weather batteries should be kept warm. PE shops should check batteries regularly.

MK 13 flare and pen gun flare provide downed person with means of attracting attention of rescuers. MK 13 is standard survival kit item, pen gun is authorized for local purchase.

FAA ADVISORIES

Robert L. Terneuzen
FAA Liaison Officer
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Aerospace Safety

SPECIAL USE CHANNELS — Effective July 1, 1964, Special Use Frequencies 296.7, 364.8, 369.9 and 321.3 mcs are direct controller-to-pilot communications channels. They were established to minimize frequency changes in order to provide an additional degree of safety to specific single pilot jet aircraft while in formation flight. These frequencies are to be used within the ARTC Center area of jurisdiction at FL-240 and above. Aircraft authorized to use Special Use Frequencies are:

USAF Strategic Air Command (SAC) B-58 aircraft while operating on an instrument flight rule flight plan when flying at supersonic speeds.

USAF Tactical Air Command (TAC), U. S. Navy and Air National Guard (ANG) single pilot jet aircraft formations operating at night or in instrument weather conditions. (Note: "Single Pilot Jet Aircraft" includes RB-66, F-100, F-102, F-4, A-1, A-4, TF-9, etc.)

ASSIGNMENT OF FREQUENCIES:

A. Special Use Frequencies are assigned to ARTC Centers in such a manner that adjacent Centers will not have the same frequency, thus minimizing radio interference.

B. The Special Use Frequencies assigned to each ARTC Center shall be shared by all high altitude sectors within that Center's area.

C. Controllers may not always know when a flight is operating in instrument conditions; therefore, pilots of aircraft in the above categories will request a Special Use Frequency by radio prior to encountering instrument conditions or entering supersonic flight (B-58). A Special Use Frequency should always be assigned by the controller during hours of darkness. Aircraft operating in Special Operating Areas (SOA), except en route aircraft flying through an SOA, shall not be assigned a Special Use Frequency. Controllers shall comply with pilot requests for a Special Use Frequency unless, in their opinion, use of this frequency would result in an emergency control situation.

D. It is not intended that priority handling shall be afforded aircraft using the Special Use Frequencies except in emergency situations.

E. A controller may assign the Special Use Frequency as "back-up" for the high altitude sector ultra high frequency (UHF) when direct controller-to-pilot communications are essential because of a potential emergency control situation.

F. Information concerning these frequencies shall not be depicted on aeronautical charts or publications since the primary function is limited to selected flights.

AVOIDING SEVERE WEATHER

Radar has become a valuable tool for use in the prevention of aircraft accidents. One way in which this tool is used is in vectoring aircraft away from areas of severe weather. It has its limitations, however, and there is evidence that some pilots do not appreciate these limitations or exactly the kind of aid they should expect from FAA controllers using radar.

Controllers assist pilots, particularly those on IFR flight plans, in avoiding areas of known severe weather. But there are times when the controller is limited in the assistance he can provide. First, it should be realized that his primary responsibility is the safe separation of aircraft. Then, work load and limitations of his equipment may reduce his capability to provide any additional service.

One thing pilots must realize is that radar does not "see" turbulence. It sees only areas of significant precipitation which are generally associated with turbulence. There is no operational equipment yet that sees turbulence as such.

With the above points in mind here are some suggestions for pilots:

- Penetrate thunderstorms only when there is no other choice.
- Report to ATC any severe weather encountered giving nature, location, route, altitude and intensity.
- Request assistance in avoiding severe weather as soon as possible, being specific concerning route and altitude desired. Review the Flight Information Manual pertaining to "Detouring Thunderstorms" and "SIGMET Procedure."
- Adjust speed as necessary to maintain adequate control of aircraft in turbulent air and advise ATC as soon as possible.
- Do not rely completely on air traffic controllers to provide information or to initiate radar vectors to aircraft for avoidance of severe weather, particularly when arriving and departing terminals or in holding patterns.
- Plan ahead to anticipate the need for avoiding areas of known severe weather. If necessary, delay takeoff or landing, as applicable.

BOAT SAFELY

Charles W. Russell
Asst. National Director, Small Craft
The American National Red Cross

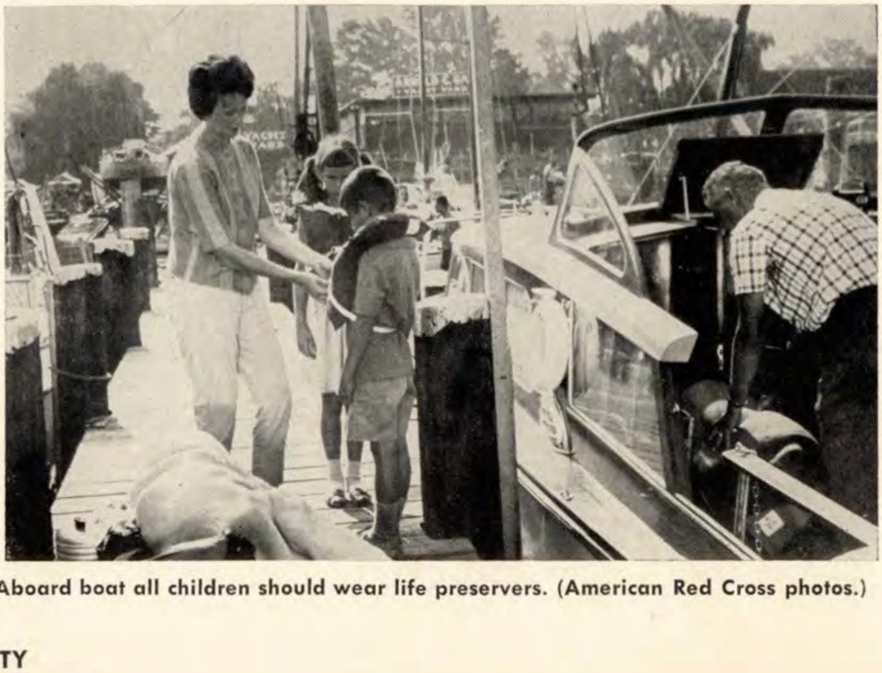
When 40,000,000 persons using some 8,000,000 boats ply America's coastal waters, rivers, reservoirs, and lakes this year, some avoidable accidents are going to occur. These accidents, most often, are the result of lack of knowledge and skill.

Although courses in boating techniques are offered, without charge, by the U. S. Coast Guard Auxiliary, U. S. Power Squadrons and the American Red Cross, among others, it is an acknowledged fact that, as of this time, the majority of boat operators will not avail themselves of this formal instruction. Furthermore, it is also recognized that many of these people cannot swim, or swim well enough to save their lives. It is for this reason that every means of conveying safe boating information to the public is used in an attempt to reduce the needless loss of life and property.

Capsizing and falling overboard are the causes of 65 per cent of the fatal boating accidents. Add to these two causes the third main cause, foundering, or sinking, and 85 per cent of all boating accidents can be accounted for. One can only draw the inference from these facts that the main cause of fatalities in boating accidents is the inability to swim — to take care of oneself in the water when separated from the boat. Falling overboard, capsizing, or sinking are not, in themselves, fatal occurrences.

In the case of swamping or capsizing, the best advice is to stay with the boat unless it is being carried toward potentially dangerous areas such as waterfalls, dams, breaking surf, or water intakes of hydroelectric plants. When water temperatures are extremely cold, it may be advisable to attempt to swim for shore. In all cases, lifesaving gear should be used if leaving the boat is indicated.

Many of the fatalities caused by falling overboard occur while the boat is moored, before the passengers have an opportunity to adjust to the comparatively unstable footing conditions that exist in small boats. Most, however, are caused by unsafe procedures while the boat is underway. Such unsafe practices include sitting on gunwales and decks, standing or moving about without holding on, turning tightly at high speeds without warning passengers, and slipping on oily or uneven sur-



Aboard boat all children should wear life preservers. (American Red Cross photos.)

faces. Wearing unsafe foot gear and engaging in horseplay are also frequent causes of falling overboard accidents.

Experienced skippers know the importance of keeping equipment and gear in excellent condition and ready for use. They also require those on board to abide by established safety procedures. It is essential for the operator to know beforehand the swimming capabilities of all on board and to insist that weak or non-swimmers wear an approved lifesaving device.

If a passenger falls overboard, the rescue procedure is based upon the ability — or inability — of the person in the water to help himself, and to a lesser degree, on weather and visibility conditions. Two basic techniques are used:

First — and the method of choice —is to toss a lifesaving device toward the victim, make the boat dead in the water, and have the victim swim to the boat.

The other method of rescue is to maneuver the boat back to the victim if there is any doubt about his ability to care for himself in the water. Swing the stern away from the side the victim falls from to reduce the danger of propeller injury. Stop the boat, and toss a lifesaving device toward the victim before turning the boat. Keep a close watch on him at all times and make the approach as you would a mooring— at low speed and slightly to windward if possible. Shut off the motor when the boat is within a few feet of the victim. The propellers can spin fast enough to cause an injury even when the gear shift is in neutral.

Some safety gear is required such as stern light, lower right of picture, and a life jacket for each passenger. Recommended for Class A boats are fire extinguishers (held by the author), oars, a signal whistle (lying on the oars), boathook, extra line, anchor, first aid kit, spare can of gasoline.

Here are some of the basic rules of boating safety which the careful skipper will always observe:

- Be sure everyone in the boat knows how to swim. If you have a non-swimmer aboard, make him wear a life jacket.
- Don't overpower your boat. Your dealer can tell you the safe size of motors.
- Don't overload your boat. Keep passengers down to a safe number.
- Equip your boat with such safety items aboard as anchor, oars, boathook, extra line, fire extinguisher, tool kit, first aid kit, and a life jacket for every passenger.
- Running lights are a must for operation at night.
- Check U. S. Weather Bureau forecasts before taking your boat in open water. If you are going far, take along a transistor radio to keep you posted on the weather.
- Don't smoke while refueling.

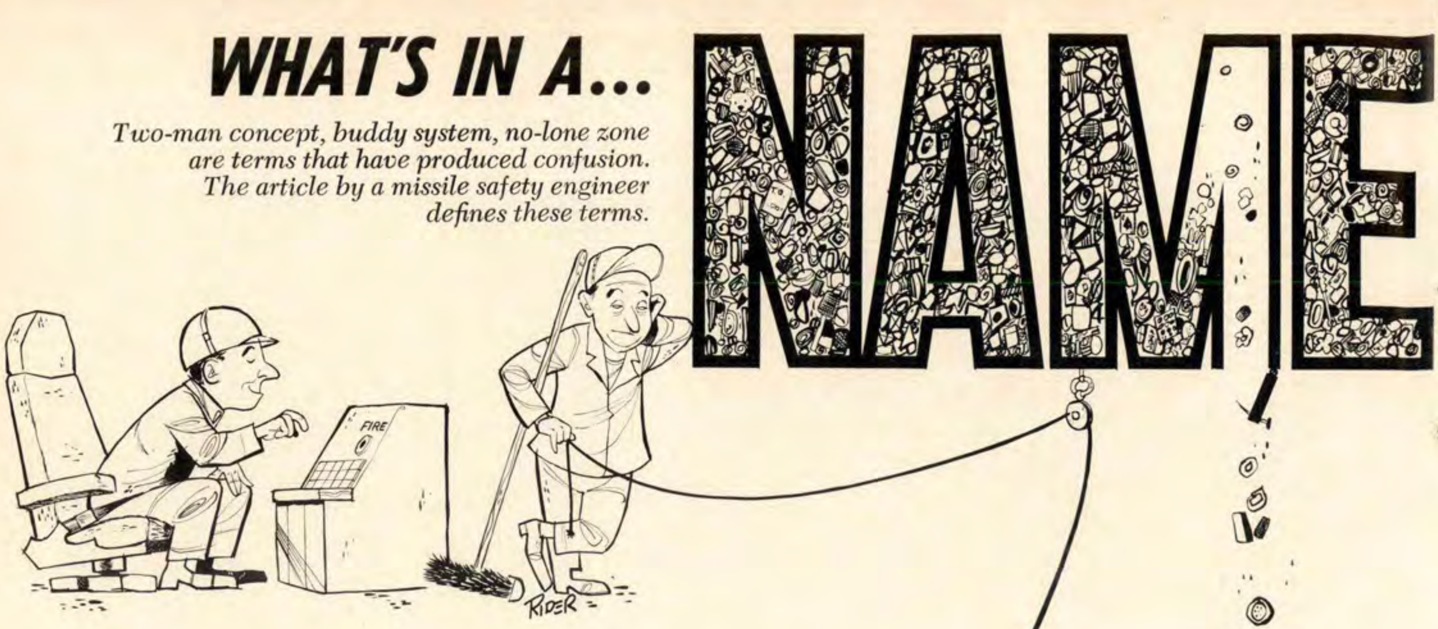
Good manners and observance of the "Rules of the Road" are essential to safe boating. These rules are:

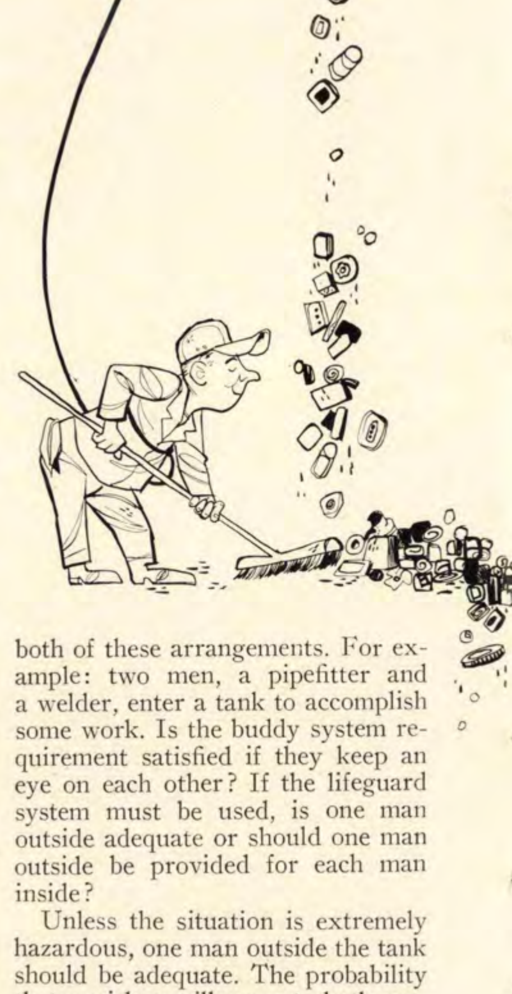
1. When boats approach each other at an angle, the boat on the right has the right of way, the boat on the left must yield.
2. Rowboats have right of way over power or sailboats.
3. Sailboats have right of way over power boats.
4. Boats being overtaken have the right of way. ☆

Short turns at high speed can cause boat to capsize.

WHAT'S IN A... NAME

Two-man concept, buddy system, no-lone zone are terms that have produced confusion. The article by a missile safety engineer defines these terms.





Air Force terms often are a mystery to others, but some of them even confuse Air Force personnel. A couple of these are Two-Man concept and buddy system.

Air Force Regulation 122-4 requires that commanders insure complete understanding of the Two-Man concept by all personnel involved in nuclear weapon system operations. "Buddy system" has its chief connotation as purely a safety term, but may also be associated with security surveillance. What is now known as the Two-Man concept was originally called the buddy system. The need for differentiation led to adoption of the new term. This created some confusion since the buddy system was still used in connection with other aspects of weapon systems. This article will try to clarify certain aspects of both the Two-Man concept and the buddy system.

Historically, the buddy system was the first to be used, long before intercontinental ballistic missiles. Many years ago, the use of the buddy system was recommended by the Red Cross and insisted upon by Boy and Girl Scout organizations whenever anyone went swimming or participated in any potentially hazardous activity. Both persons in this type of buddy system arrangement were subject to the same hazard at the same time. Each had to assure the well-being of the other and provide any necessary assistance in the event of a mishap.

In missile system operations, this type of buddy system arrangement is used by personnel during such activities as unloading a liquid oxygen or nitrogen tetroxide trailer, working on live electrical systems, or handling ordnance devices. In these examples, both buddies are subject to the same hazard.

In another type of buddy system, one person is subject to the hazard while the other acts only as a lifeguard. The lifeguard has no other duty but to safeguard the well-being of the person he is protecting. The prime example of this is in the support of a person who enters a tank. His buddy remains outside. He must permit nothing to distract him from his job of insuring his buddy's protection.

Distraction of a lifeguard almost proved fatal to a contractor technician who had entered a missile tank to examine the internal structure. The atmosphere in the tank was evidently low in oxygen, so he was suitably equipped with respiratory equipment. When he finished, he gave his buddy outside the signal to pull him up. The buddy apparently was concerned elsewhere, so the man in the tank shouted to attract his attention. To do this, he had to remove his facepiece, take a breath, shout and then replace his mask. After being assisted from the tank, he took two steps and collapsed. Luckily an inhalator was available and he was revived immediately.

Sometimes questions arise about both of these arrangements. For example: two men, a pipefitter and a welder, enter a tank to accomplish some work. Is the buddy system requirement satisfied if they keep an eye on each other? If the lifeguard system must be used, is one man outside adequate or should one man outside be provided for each man inside?

Unless the situation is extremely hazardous, one man outside the tank should be adequate. The probability that a mishap will occur to both persons in the tank is extremely low (though possible). In case of a mishap to one, the other and the outside man can remove the affected person. Additional personnel outside would certainly be helpful, but not absolutely necessary. The outside

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worker can use prearranged signals, a whistle or some type of electrical communication to attract attention in time of need.

In security practice, the buddy system may also be used as a safety measure in areas where air policemen may be assigned to remote, lonely or dangerous duties. Its use in security also permits mutual surveillance to be maintained in areas where lone access is not authorized.

The Two-Man concept is a measure involving access to nuclear weapons or nuclear weapon systems to prevent degradation of reliability, safety, or security. As mentioned in AFR 122-4, compliance minimizes "the opportunity for incorrect or unauthorized procedures which could result in premature arming, launching, firing, or releasing of a nuclear weapon by one person." Each of the two or more persons present under this concept must be capable of detecting incorrect or unauthorized procedures with respect to the task to be performed. (This does not require persons having "equal" knowledge; only the capability of detecting incorrect or unauthorized procedures.) This is in contrast to the buddy system in which personnel involved must be able only to recognize that the other person is in physical distress and to provide assistance.

The occasion may arise where access to certain areas in a structure may be restricted for security or safety reasons. Areas so restricted to assure compliance with the Two-Man policy are called no-lone zones. In some instances, the designation no-lone zone has been extended to limit access to equipment which if disabled would prevent accomplishment of the weapon system mission. Only authorized personnel, with a valid requirement, may enter these areas, and only when two or more are present. Men safeguarding each other under the buddy system do not satisfy the requirement for entry into a no-lone zone. On the other hand, each of the buddies may assure that the other does not enter such a zone.

Remember: Enter a no-lone zone only when authorized and when accompanied by at least one other qualified and authorized person. If two such persons are in a no-lone zone and, for some reason, one must leave, the other is obligated to leave, too. Operations performed must be authorized and must follow prescribed procedures. Both members of a Two-Man team must be in positions where each can determine whether any errors or unauthorized deviations are taking place in the task being accomplished.

The buddy system and Two-Man concept have one thing in common: the need for undivided attention to the task being performed. AFM 127-201 prescribes that when the buddy system is used, constant communication will be maintained between the persons involved. A person in a hazardous situation will remain within sight of his buddy at all times or otherwise maintain communication to indicate his well-being. Where a person is acting as a lifeguard outside a tank for a man inside, he will be given no other duty.

Personnel supervising operations in which the buddy system is to be used should indicate clearly what each person is to do. When in doubt as to the type of buddy-system arrangement which should be used, the safety officer should be consulted. Buddies must know the hazards involved in any operation, their duties as buddies, how to use prescribed rescue equipment, and emergency procedures, including artificial respiration. They must know all these before they take part in any hazardous operation. There is no time to learn them once the emergency arises. Supervisors must make certain buddies are equipped with necessary protective and rescue equipment before the operation begins.

Additional information regarding the Two-Man concept is contained in AFM 122-1. Personnel responsible for members of Two-Man teams, and the members themselves, should be familiar with the provisions of this manual. They should be familiar with and capable of performing prescribed procedures. In the event any person assigned to a task requiring a Two-Man team believes his knowledge or experience is inadequate to detect incorrect or unauthorized procedures, he should request replacement.

By keeping the well-being of the other fellow and of your country always in mind, you will be not only a buddy, but a pal. ☆

CANOPY JETTISON

Since the publication of "Jet Fighter Canopy Jettison" by Capt Donald H. Volz in the June AEROSPACE SAFETY, questions have been raised as to whether the procedure for retaining the canopy applies to off-base as well as on-base emergency landings. Off-base crash landings are generally more destructive, thereby increasing the probability of injury to the crewmember or damage to canopy release mechanisms. Also, crash rescue facilities are not as readily available. However, as in the case of an on-base emergency landing, the canopy affords temporary protection against heat, explosion and fire and provides additional time for the pilot to free personal leads and to evaluate the situation. Therefore the procedure for retaining the canopy applies to off- as well as on-base crash landings. It is anticipated that applicable aircraft Dash Ones will be revised in the near future to include this recommendation.

MISSILANEA

AGM-28 LOADING INCIDENT—A flight line tug was being used to position an AGM-28A under the wing of a B-52G in preparation for uploading. The missile was mounted on an H2-33-A trailer. After the missile was towed under the aircraft, the tug was disconnected from the tow bar and reversed in order to hook the tow bar in front of the tug. This allowed the tug operator to observe the directions and receive the orders of the uploading crew supervisor.

While positioning the trailer with the tug, the trailer tow bar was moved to approximately a 45-degree angle to the trailer and the tug became positioned at approximately a 45-degree angle to the tow bar (90 degrees to missile center line). This placed the front radiator guard of the tug in close proximity to the missile engine exhaust tail cone. The tug lurched forward and struck the exhaust tail cone, inflicting damage.

Investigation of the incident revealed that the tow bar on the H2-33-A trailer was not extended to provide adequate clearance between the engine exhaust tail cone and the front of the tractor. Paragraph 3 - 5P, Sec III, T.O. 21-AGM-28A-2-2 requires that trailer tow bar be extended to provide adequate clearance prior to attaching the tow bar to the tug. The H2-33-A positioning trailer being used had no capability for manual steering since the steering attachment lug on the front of the trailer had broken prior to this incident.

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Directorate of Aerospace Safety

SCAPE Notes. Humans, being rather tender, have to resort to the use of protective devices and clothing during certain occupations. An example of this clothing is the SCAPE used during transfers of Titan II propellants. Following are some safety slanted items about the suit, as noted by the Martin Company (Denver Division).

Each prospective user of the SCAPE must be certified in its use prior to wearing it under work conditions.

The primary hazard is the possibility of exhausting the supply of breathing air while in a precarious position or while performing a hazardous operation. To avoid this the minimum amount of liquid air in the unit should be measured by weight, then use of the unit timed and the user summoned to the change house in plenty of time to avoid running out of air. Warnings to the user or his buddy that air is running low include a change in sound made by the environmental unit; fogging of the face plate; deflation of the suit and clinging to the limbs as air decreases; difficulty in getting enough oxygen.

It is possible that components of the environmental unit might freeze, causing the user to suffer cryogenic burns. Indications prior to freeze-up are:

- Approximately five to eight minutes prior to freeze-up, a cracking sound will be heard as a result of heat-exchanger sump freeze-up. The plastic cover over the sump assembly will also freeze and begin popping at this time.
- Approximately three to five minutes prior to freeze-up, a sputtering, spitting sound will be obvious.
- Approximately two to three minutes prior to freeze-up, the air distribution panel, located on the wearer's lower left abdominal region, becomes exceedingly cold. The panel becomes so cold, in fact, that if the subject has on the properly prescribed underclothing, it will be impossible for him to wear the unit until he sustains a burn. He will have to remove it.

Other suggestions concerning wearing of SCAPE equipment are:

- As additional protection against cryogenic burns, individuals should wear a multi-folded towel covering the posterior from the waist to the lower part of the buttocks.
- It is essential that only the designed underclothing be worn while wearing the SCAPE.
- Always use handrails while climbing ladders. Watch for step-offs (holes, voids in work platforms). Never use without a buddy present. ☆

HIGH

From 1 January through November 1963, USAFE units equipped with aircraft utilizing J-57 engines reported 95 precautionary landings due to oil system abnormalities. Of this number, over half (50) proved to be malfunctions of the indicating system. A break-out by type aircraft looks like this:

Aircraft	REAL	FALSE
F-100	15	11
F/RF-101	19	19
F-102	11	20

Abnormal oil pressure readings are always a source of consternation to pilots, especially those with only one engine providing the locomotion. Very often, faulty relief valves or transmitters have caused erratic or erroneous readings, but to the pilot, it makes little difference. There is no way to detect a faulty indicating system while airborne. So, he must treat the occurence as the real thing, with engine failure some unknown number of minutes away.

The question often asked is how long will a particular engine run without lubrication to the bearings? The straight answer is you can't tell. There are too many variables . . . many of them unknown. There are cases on record where individual engines have run as long as 30 to 45 minutes. However, it appears that some lubrication had to be reaching the bearings.

There is one case on record where a J-57-P21 engine ran for 20 minutes on a test run with absolutely no oil reaching the bearings (a small plastic dust plug was found in the main oil pressure line). The Nr 4, 4½, 5 and 6 bearings never got any oil. The 20 minute run consisted of five minutes at Idle, 10 minutes at Mil Thrust for stabilization and trimming, five minutes at Idle and 30 seconds at Mil Thrust again when an explosive sound was heard . . . a severe compressor stall.

Compressor stalls often result from oil starvation for this reason: As bearing friction increases, slowing the N_2 turbine, the fuel control automatically compensates for this by delivering more fuel to the engine in an attempt to maintain that speed selected by throttle position. This, of course, can't continue for long. The process of increasing fuel flow to maintain the lagging RPM will eventually lead to severe overtemperature conditions and turbine distress. Then, when the selected RPM can no longer be maintained by fuel flow increases, compressor mismatch develops (N_1 - N_2 airflow incompatibility) which results in compressor stall. This is what happened in the preceding case.

That engine ran for 20 minutes. It would be great if we could count on all of them running that long. Unfortunately, for every one that does, there are many that quit early. Take the case of the F-102 driver on climbout. When passing 40,000 feet, AC power failed. Fifteen seconds later the oil pressure warning

continued on next page

LOW

Reprinted from AIRSCOOP, March 1964.

ZERO

LOW HIGH ZERO continued

light came on. At this point he reduced power to 85 per cent. All engine readings appeared normal. Three minutes later the engine began to vibrate, accompanied by compressor stalls. The pilot ejected successfully. Later it was determined that the Nr 4 bearing (thrust bearing) failed from oil starvation.

The time element then, depends upon operating conditions at and immediately after the time oil starvation occurs, as well as such things as condition of the bearings prior to oil starvation, operating temperatures of the bearings, and bearing loads. Engine operation is possible for a limited time at reduced thrust (such as cruise) with little or no oil pressure. However, at high thrust, operation for more than a few minutes is doubtful.

The events that take place within the engine go something like this: With little or no oil pressure, bearing temperatures begin to rise, since much of the normal engine oil circulation is required for bearing cooling. Failure of the bearings themselves begins slowly and will normally continue at a slow rate (depending on power setting) up to a certain point. As the bearings become overheated, however, the progression of failure accelerates rapidly. Usually the first bearing to fail will be the thrust bearing, because of highest loading. When it begins to go, vibration can usually be detected and may be accompanied by rising EGT and compressor stalls, for the reasons mentioned earlier. When vibration becomes moderate to heavy, complete failure is only seconds away. The best course of action when this becomes noticeable is to stopcock to improve chances for a successful ejection or power-off landing. With failure of the thrust bearing, the compressors shift, causing simultaneous compressor/stator blade interference with resulting disintegration of the engine. Occasionally, failures of this type affect flight controls.

Let's talk about pilot actions when faced with no oil pressure. The Dash One says to reduce throttle.

A scene like the one above may result when the oil pressure drops but may be prevented by a previously determined course of action.

The reason for reducing power is to relieve the thrust and friction loading on the bearings as much as possible while they are being undernourished.

In this condition the pilot should maintain altitude, if high enough for a flameout landing, or zoom to a reasonable altitude, then proceed ASAP to a point from which a landing can be made. While maneuvering, G-loads should be kept at a minimum. The throttle should be moved only when absolutely necessary and then slowly to relieve sudden bearing strain. In any event, it should not be reduced below a thrust level at which flight and landing can be accomplished (80 to 85 per cent being optimum). In the pattern, slow the aircraft by means of drag devices rather than by throttle movement. Retarding the throttle to a very low power setting may result in the engine's inability to accelerate if suddenly you find yourself short on airspeed. So long as no vibration or other indications of sudden failure are detected, press on, but don't let yourself get caught in a corner if the engine comes unglued. Fly a "standard" final approach, and keep 20 kts extra for zoom and ejection.

Low oil pressure is only one step removed from zero. Only the time element is lengthened some unknown amount. Pilot action is much the same. Namely, reduce power and point the nose toward the nearest available airfield. The trouble with low readings is that the needle seldom remains that way for long, but often unwinds and hits the peg. Pressures above 25 psi present no immediate threat *provided they remain constant*. In fact, Pratt & Whitney has stated that under *emergency* conditions the mission may be continued at T.O., and Military powers to 30 psi minimum oil pressure, and at cruise power to 25 psi. This, of course, is not recommended and appropriate Dash One corrective action should be followed to preclude bearing damage. It does show, however, that the engine is not likely to come apart before it can be brought back for maintenance to check out.

Recently, a flight of two F-100s was on the return leg of a low level profile mission when Nr 2 noticed his oil pressure dropping from 45 to 20 psi. They were indicating 360 knots at 4000 feet . . . about 65 NM from the nearest airfield. Within two minutes pressure dropped to 6 psi with fluctuations to zero. The weather, as usual, was poor with two-tenths obscured, 1.7 NM in fog and haze. Power was maintained at 85 per cent. Utilizing radar steers and TACAN, the aircraft was flown toward a modified low key flameout position. At a point 12 to 15 NM out, engine vibration became noticeable. The wingman noticed smoke belching from the tailpipe. A righthand turn was made to final from the 270 degree point and a successful landing accomplished with the engine stopcocked on the roll.

This one was close! A partial teardown of the engine revealed the Nr 4 bearing completely shot, with Nr 4½ and 5 bearings dry and heat discolored. Surprising as it was, the engine had not seized, but the charred and dusty condition of the thrust bearing indicated complete rotor seizure was only seconds away. When the pilot first noted the gage, it was low and falling. The time element from this point to touchdown was between 15 and 20 minutes.

High oil pressure, although generally regarded as less serious in nature, can cause grief. It can mean a malfunction in the regulating and relief portion of the system, or it can mean a restriction in the system. A restriction could result in complete lack of lubrication to one or more bearings. If pressure is high, due to bearing cavity breather restrictions, a pressure build-up on the oil seals may cause them to pass oil, resulting in depletion of the oil supply. This type failure most generally results in smoke in the cockpit, if the seals leak forward of the 16th stage bleed air take off points. If the seals leak aft of this station, the oil, which is being pumped overboard past the turbines, will show up as white smoke.

What's a high reading? Well, according to the Dash One, anything over 50 psi is abnormal. However, under emergency conditions P & W has stated the mission may be continued with max oil pressures to 75 psi. Here again it's not recommended. The only reason for mentioning it is that people tend to clutch-up when the needle's out of the green area and have ruined them selves making desperation type approaches.

The only course of action open to the pilot caught with a high reading is to reduce power and try to bring the reading down to normal while heading home. He must, of course, be alert for indications that the engine is failing. So long as there are no such indications, the engine is not likely to cause trouble, but just as with low or zero pressure, it should be flown as though it might at any moment.

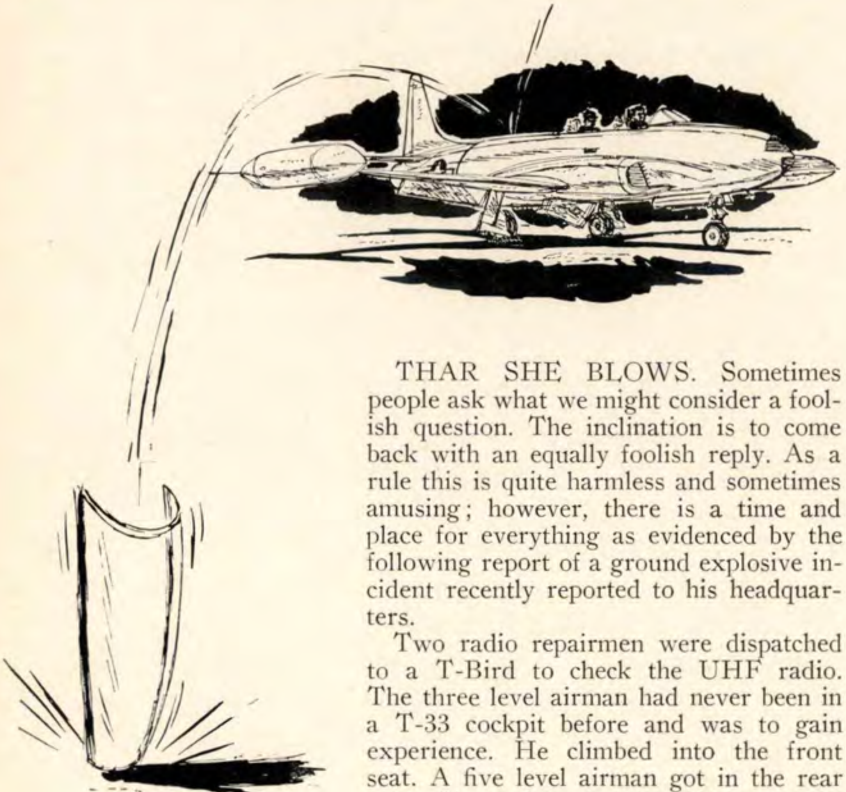
Since the end result of oil starvation is engine failure, the pilot's main interest should be to nurse the bearings along as much as possible until a landing can be made. While bringing it back, he should be alert for signs that indicate the engine's about to unstick. These are:

- Increasing Fuel Flow
- Rising EGT
- Decreasing RPM
- Compressor Stalls
- Smoke Emitting From Exhaust
- Moderate To Heavy Vibration

When vibration approaches the heavy stage, the best bet is to shut the engine down and either attempt a power-off landing or call it a day and step out. The chances of the engine running much longer are extremely doubtful and an explosive-type failure won't improve things.

To sum it up, if the malfunction is spotted early in the game, and if power can be adjusted smoothly to a setting that will allow flight to the nearest field, there is every reason to believe that the engine will hold together until a landing can be accomplished. If statistics mean anything, our experience has shown this to be true. ☆

Aerobits



THAR SHE BLOWS. Sometimes people ask what we might consider a foolish question. The inclination is to come back with an equally foolish reply. As a rule this is quite harmless and sometimes amusing; however, there is a time and place for everything as evidenced by the following report of a ground explosive incident recently reported to his headquarters.

Two radio repairmen were dispatched to a T-Bird to check the UHF radio. The three level airman had never been in a T-33 cockpit before and was to gain experience. He climbed into the front seat. A five level airman got in the rear seat. Since the wind was blowing, the airman in the rear seat closed the canopy. Subsequently, when the airman in the front seat wanted out of the aircraft, he looked around for a means of opening the canopy. He spotted the jettison handle, and, being completely unfamiliar with the T-33, thought this was the handle to open the canopy. He did ask the airman in the rear seat if the canopy would open if the canopy jettison handle were pulled. The airman in the rear seat jokingly replied, "Yes." The airman in the front seat then pulled the handle, the canopy jettisoned, blew back, separated at the hinges, struck the right side of the plenum chamber door and bounced forward off the aircraft, coming to rest on the ramp against the right side of the aircraft.

The airman in the rear seat, who was supposedly the supervisor, should have given the airman's question more serious consideration, particularly in view of his extremely limited experience. Another question that comes to mind is why the egress system ground safety pins were not installed. According to the Dash One, the initiator that provides the source of energy for canopy removal should have been safetied. Seems the responsible crew chief shares part of the blame for this needless incident.

If someone asks if the gun is loaded, assume he plans on shooting.

Robert H. Shannon
Directorate of Aerospace Safety

NAPALM DELIVERY—During a napalm delivery on a support mission the pilot of an F-84F reached down to position the compressor switch to ON as the aircraft approached the IP. Instead, he flipped the ATO ready switch thereby dropping two 150-gallon napalm tanks on the outboard racks. Fortunately the only damage was a slight fire in an unused field and fence damage caused by fire fighting equipment.

There were several reasons for this mishap, according to investigators. The ATO ready switch, normally safetied OFF, was not safetied because during a "Kids Day" demonstration, the safety wire had been removed and not replaced. Right next to the ATO switch is the compressor switch, which the pilot meant to actuate. The location of these switches led the investigators to find design deficiency as the primary cause.

Contributing were the pilot's action in setting up the armament switches prior to reaching the IP, Maintenance for not resafetying the ATO switch, and both pilot and maintenance failure to catch the absent safety wire during preflight.

CHUTE INSPECTION. When was the last time you personally observed a preflight inspection of your parachute???

The following experience of a T-33 pilot emphasizes the need for constant vigilance in this area. This does not excuse P.E. people from their responsibility for thoroughly checking out equipment vital to life and limb. Had the pilot involved in this incident been faced with an emergency necessitating ejection, the odds are he would not have made it. With the pilot chute already out, it is quite likely that it would have entangled with the seat preventing separation. Also, in a low speed, low altitude ejection, you need all the pull you can get from a proper functioning pilot chute to get the main chute canopy out of the bag.

"During descent, I leaned forward in the rear cockpit of the T-33 to pick up a paper, and my chute deployed. After landing, I had Major .... (front seat pilot) look over all my equipment carefully before I moved anything. We could determine no reason for the deployment. The lanyard was hooked, but no cables were pulled. We took the chute out of the aircraft carefully and found the lower pin (of the two pins) was pulled, and the pilot chute was out of the pack. The upper pin was in place. We carried it in to the P.E. room, where the P.E. people moved it around and pulled the top pin out. The only part that was out of the pack was the pilot chute."

Tests made of back-style parachutes in order to duplicate occurrence showed the lower rip cord cable pin had to be partially inserted. The pin end or tip had to be resting on the inside diameter edge of the grommet before any flexing of the parachute would cause the pin to move and allow the tension on the locking loop to tilt the pin end through the grommet and permit the locking loop to slip off, resulting in chute deployment. The tests also indicated the pin had to be at this

position since the time last inserted. The current T.O. for this type parachute, 14D1-2-81, states preflight inspection shall be accomplished on parachutes immediately before issue for flight. This inspection includes assuring rip cord pins are properly inserted.

The T.O. also indicates routine inspections be performed by qualified personnel only. The minimum requirements are the completion of a 10-day period of indoctrination and training and passing the written examination prescribed in par 5-2 of Section V. Unless the user is qualified, he is not authorized to inspect the pins for proper insertion. This was verified by MAAMA Tech Services people. In this case, the pilot had not preflighted the parachute, because there is no known requirement for his doing so. Further, he possessed no certification by the commander or his representative qualifying him to make routine inspections.

Recommendations: That parachute users who are not qualified or required per T.O. to perform the parachute preflight inspection personally observe the preflight inspection accomplished immediately before issue for flight. This is to assure users that pins are properly inserted and of condition and status of other items requiring preissue preflight inspection and setting.

NEW EXPLOSIVES SAFETY MANUAL—A revised Explosives Safety Manual, AFM 127-100, dated 20 April 1964, has been published. It provides an authoritative ready reference for all operations involving explosives. Publication of the manual represents Phase 2 of a three-phase program. The third phase will consist of refining the manual by amendment.

Red is for Roses

. . . AN OFF-COLOR STORY

Capt John T. Taylor, Flight Safety Div., Robins AFB, Ga.

When it comes to getting up before 0630, I'm like most — reluctant. So, when the phone jumps off the hook at the horrible hour of 0500, the little wife answers it. She can't stand ringing noises. It usually has to ring four or five times before yours truly is stirred from deep slumber.

On the morning of 25 January, my (censored) phone did ring at 0500. The wife answered and interrupted my peaceful sleep with words to the effect that an aircraft had been serviced with contaminated fuel. The words "contaminated fuel" will always jolt me to the wide-awake condition. The call was from Base Ops, and here is the story:

A DC-6 had been refueled during the predawn hours with a *red color* fuel. This, to say the least, caused some concern on the part of the crew. Most of us reciprocator types have been thoroughly brainwashed to accept only *purple-dyed* fuel, and fuel of another color is just out of the question!

Now the picture really gets involved! The true beginning of our story backs up a week or so to a depot project aircraft — a C-118—which had an elusive fuel leak. During the early morning hours, the work crew decided to add red aniline dye to the avgas (115/145) to aid in detecting and correcting this pesky leak. This did the trick. However, the troops overlooked one serious aspect: they failed to check for authority to add dye to avgas. T.O. 42B1-1-10 provides instructions and authority for dyeing JP-4 jet fuel for leak detection purposes but makes NO provision for using this same procedure for avgas. The dyed avgas was defueled from the C-118, and the defueling/refueling unit was isolated by POL pending word from the Chem Lab exonerating the avgas from contamination—a proper precaution on the part of POL.

The lab report indicated that the fuel was safe for use. POL proceeded to issue the avgas; and, at this point, communication was permitted to break down. Pilots were not informed of the dyed condition of the fuel! A lot of grief could have been avoided had the pilots or flight engineers been apprised of the additive dye and been given the option of accepting or refusing. This was not done, and the flight safety officer was awakened from peaceful slumber to look into the matter. The aircraft involved was defueled, and the familiar purple petrol was substituted. Samples of the red dyed 115/145 were forwarded to the base lab and exonerated with the exception of anti-knock rating. Anti-knock for our fuel samples was not altered.

The laboratory at MacDill has been requested by the base laboratory to add dye to 115/145 to determine the quantity of dye necessary to alter anti-knock characteristics of 115/145. When this has been determined, the prime AMA (Middletown) will be in a position to either authorize the dyeing of avgas for leak detection or prohibit such action.

At any rate, our POL Division has put out the word to this effect:

- Any request to defuel an aircraft containing grade 115/145 fuel other than the normal purple color will be refused pending investigation as to cause, purity, and if dye was added, by what authority.
- The POL foreman in charge will start the investigation by taking a sample of the fuel to determine if the color is other than normal. If so, he will immediately notify his section chief, flying safety officer, supply duty officer, and the Chief, Petroleum Branch.
- This is to advise that no authority or regulation exists at the present time authorizing additional dye to be added to 115/145 fuel to check for leaks. Aircraft Repair Branch is aware of this and has issued instructions to its organization that no more dye will be added to fuels, other than jet (JP-4), pending authority from Hq AFLC or MAAMA.

Our supply of off-color 115/145 avgas was exhausted by use in base assigned aircraft with the full concurrence of each pilot and Flight Safety and *only* after the anti-knock rating was determined "not affected" by the MacDill laboratory.

The crew which first detected the fuel in question filed an Operational Hazard Report which generated considerable corrective action locally, at AFLC, and MAAMA. Follow-up action is currently in the mill; however, it could happen elsewhere, which is why this short story was written. We sincerely hope that it will be passed to the appropriate agencies at your base to prevent your coming to grief with a similar problem. ☆

WELL DONE

1st Lt. GERALD M. MAY

PORTLAND AIR DEFENSE SECTOR (ADC), OREGON

On 20 March two F-102A's, Papa Lima 23 and 23A, were scrambled from Portland International Airport during a Division Tac Eval. The B-57 target was intercepted at 35,000 feet, 230 NM southwest of Portland, approximately 150 NM out over the Pacific Ocean. During the breakaway, PL 23 noticed his speed brakes would not retract. All emergency procedures failed to move the speed brakes from the full open position.

1st Lt Gerald M. May, the controlling Intercept Director at Portland Sector, was monitoring the conversation between PL 23 and 23A and realized the potential short-of-fuel situation developing. When it was determined that no emergency procedure would correct the situation, PL 23 requested RTB and a straight-in approach to Portland International Airport. Cloud cover was solid throughout the area up to 23,000 feet. Lt May began vectoring the aircraft toward home and advising the pilot how much time would elapse before touchdown.

At approximately 175 NM southwest of Portland it was determined that fuel would not allow the aircraft to reach Portland. Lt May suggested the closest available airport was Newport, Oregon, with a 5100 foot hard surface runway. Newport weather was reported at 3500 feet overcast, ten miles visibility. PL 23 requested to land at Newport, but needed radar vectors to align with the runway since neither TACAN nor ILS was available.

Seattle Center was advised of the emergency and requested to clear all controlled traffic from the Newport area. PL 23 was now in a descent and in IFR conditions. Lt May, being an aero club pilot and having flown into Newport occasionally, gave PL 23 a complete rundown on local terrain features, angle and distance from town to the airport and suggested runway 20 for landing. Vectors were given for a right descending turn to line up with runway 20. Several 3500-foot hills surround the approach path, but Lt May vectored the aircraft clear of these hills and continued advising 23 he had adequate terrain clearance. Although weather had been reported as 3500-foot overcast, PL 23 reported that at 2000 feet he was still IFR. Lt May advised he was six miles out from touchdown and lined up with adequate terrain clearance. Descent was continued and at 1200 feet, 23 broke out, four miles out and lined up with runway 20. A successful landing was accomplished with less than 300 pounds of fuel remaining.

Lt May's timely and accurate analysis of the situation allowed him to give quick and accurate information to the pilot. His ability to think and act professionally in an emergency demanded complete confidence in his ability by the pilot and saved the Air Defense Command an interceptor and possibly a highly trained pilot. WELL DONE! ☆

The 45 Tactical Reconnaissance Squadron, Misawa Air Base, Japan, has been awarded the Colombian Trophy for 1963 for meritorious achievement in flight safety.

In winning the trophy the squadron compiled more than 13,000 hours in RF-101 aircraft without a single major accident and has been accident free since September, 1961. During the award period, the squadron successfully conducted flights which included low level high speed navigation, long overwater flights, day and night air refueling and formation flying. Aircraft were deployed to locations over three thousand miles from the home station.

The safety achievement of the 45 Tactical Reconnaissance Squadron perpetuates the highest traditions and standards established for the Colombian Trophy and reflects great credit upon the 45 Tactical Reconnaissance Squadron, Pacific Air Forces and the United States Air Force. ☆

COLOMBIAN TROPHY

awarded to the 45th Tactical Reconnaissance Squadron

Lt Col James A. Bryant, Commander 45th Tactical Reconnaissance Squadron, Misawa AB, accepts Colombian Trophy for Flying Safety from Mr. Henrique Molano Campuzano, Republic of Colombia ambassador to Japan. Brig Gen Jay T. Robbins, USAF Director of Aerospace Safety, observes the presentation. He had just presented the squadron with a USAF Flying Safety Plaque.

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