DECEMBER 1959

FLYING SAFETY

UNITED STATES AIR FORCE

A STEP TO THE STARS

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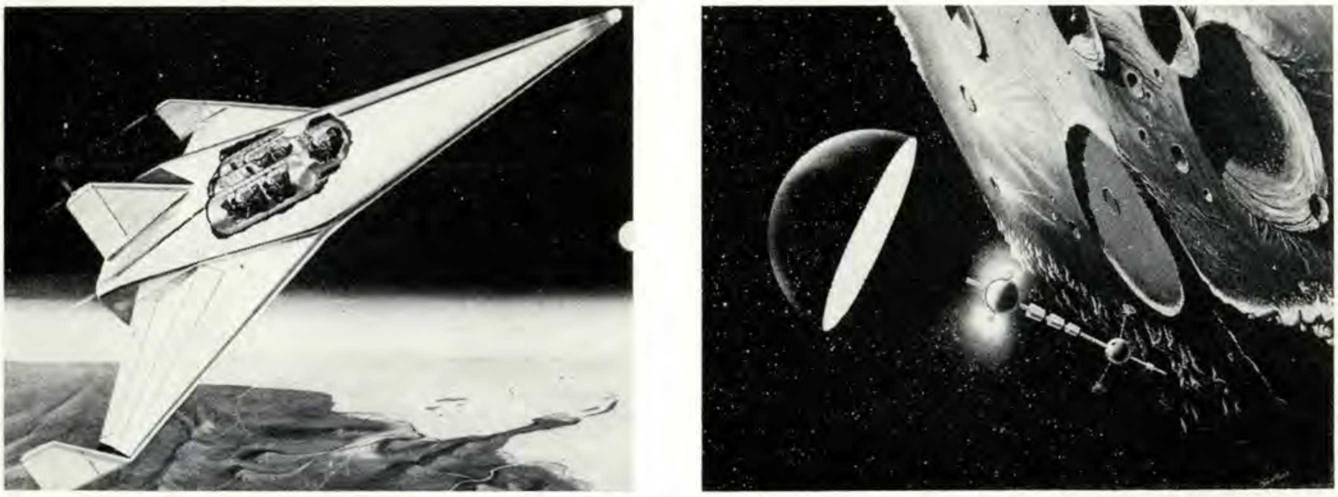
• VOLUME 15 NUMBER 12 USAF PERIODICAL 62-1 • MISSILES AND FUTURE AIR VEHICLES •



Left, third stage of Convair hypersonic personnel glider returns to earth. Above, constructed and launched from orbital satellite, solar-powered space vehicle nears moon.

THE EDITOR'S VIEW •

In July of this year, letters of inquiry were sent to organizations and units receiving *Flying Safety Magazine*. The purpose was to determine the correct mailing addresses, whether or not the unit still wanted to receive the magazine, how many copies are needed, and, last but not least, we asked for any criticisms or suggestions.

The results of the survey left a lot to be desired. More than 1300 letters were sent out and 133 units or offices didn't bother to answer. Those non-responders must be dropped from distribution.

On the brighter side, 105 responses indicated more copies of the magazine are desired. Every attempt will be made to grant these increases.

On the darker side again, only three per cent of the answers contained *any* remarks. This is a pretty poor showing, even though each remark was kindly and favorable. The remarks ranged from 'well done,' 'good show,' to a page of glowing words. These, the staff appreciates. You may be sure of that. However, what we really were after was constructive criticism or suggestions as to *how to improve your Flying Safety Magazine*. We knock ourselves out trying to give you readers the dead level best magazine possible. This is our contribution in the attempt to save lives and reduce the number of bashed airplanes. But we would like to know from you, the readers, what your ideas are on *how to improve the book*. If we know what *you* want, we'll do the rest. How about grabbing a pen, pencil or typewriter and knocking out a few lines and sending them to the Editor direct?

Let's get off that kick and on to another related subject: *Contributions*. Many of you readers with fine minds, long valuable experience and a wealth of information are sitting on your hands, as far as our staff is concerned. For some reason you are reluctant to sit down for a few hours or even a day, put your thoughts on paper and send them to us (*with pictures, maybe?*). While talking to the troops in the field, a lot of real fine ideas are expressed. Then I ask, "How about putting those thoughts on paper?" The usual answer is, "By golly, I hadn't thought of that," or "I've been meaning to do that but just haven't had time." Great balls of fire! Take the time! Maybe what *you* write will save a bird and/or a life.

IN THIS ISSUE

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BALLISTIC MISSILE SAFETY

Lt. Gen. Bernard A. Schriever, Commander, Air Research and Development Command, Andrews AFB.

Here, General Schriever explains ARDC's Missile Safety Program so that those interested may gain insight to this important part of the missile program.

In the 14 years that the United States has been testing ballistic missiles, they have caused not one fatal accident or serious injury to the launching crews, to tracking personnel down-range, or to innocent bystanders.

More than 1900 of these volatile weapons, varying in size from tactical rockets up to intercontinental ATLAS and TITAN missiles, have been launched under operational test conditions. A few have blown up; some have had to be destroyed in flight; but the procedures developed to cover these emergencies have worked so well that the missile safety record as of the day this is written, is 100 per cent.

The few mishaps that have occurred at missile test facilities have been the regrettable ones that happen now and then in any industrial plant. Heavy objects have been dropped from hoists, or men working on scaffolding have fallen. A contractor's representative was killed during a test of ground support equipment. None of these accidents was peculiar to missile operations. The misfortunes that were expected have not materialized.

The succinct observation that "the best weapon is the most reliable one," is as valid for the ballistic missile as it was for earlier and far less sophisticated weapons. No matter how good a weapon may seem, it must possess inherently the characteristics of reliability and safety in handling and performance or it will be of negligible value in our defense arsenal.

Consider, for example, the club. It is a simple, reliable, easily handled weapon. It is effective because nothing much can go wrong with its single working part.

By the same token, consider a weapon with over 300,000 individual parts. Consider its requirement for enormous quantities of dangerous fuels and supercooled liquids. Consider the tremendous pressures and high voltage needed to make it operate. Consider its guidance system which must function perfectly to avoid premature impact on friendly territory or a complete miss of a vital target. In short, consider the most complicated weapon ever devised: the ballistic missile.

The advent of the ballistic missile has created a multitude of technological problems never before experienced. Not the least of these concern the safety of missile crews and the protection of life and property over which a missile must fly. For safety engineers this has meant finding solutions to problems upon which, to a large measure, the ultimate success of the new weapon depended. Indeed, never before has safety *per se* played such an important role in weapons development. It is, in short, conservation of our missile capability.

Missile safety begins at the assembly line and extends through the launching phase to impact. Basically, it may be divided into two major categories:

- Ground safety, including common industrial hazards, like fire, toxic materials, high voltages and noise.
- Inflight safety, including all those hazards unique to the ballistic missile program.

Each is of utmost importance to the ultimate success of the program.

First, good ground safety practices must be observed or the missile may never reach the pad. The bulk of our ballistic missile safety experience has been obtained at ARDC's Air Force Missile Test Center. Since it began missile research and development flight testing in 1950, the AFMTC has not had a single fatality that can be attributed directly to a missile launching. Its accident record is in

Surveillance Plotting Board shows location of ship and plane in flight path or impact area. Launching of missile is delayed 'til cleared.

Left, two TV cameras are used for each launching and data sent to Range Safety Console. Right, a simple vertical wire skyscreen allows Range Safety Officer to judge deviation during lift off. Parallel wires are coated with fluorescent material and illuminated by black light for night launching.

fact far better than that of the average industrial plant of comparable size. This means that careful planning and thorough safety procedures—patterned after those set up for hazardous industries—can be applied to the ballistic missile program with striking success. The techniques devised and the knowledge gained at Cape Canaveral have paved the way for establishment of the Air Force-wide ballistic missile safety program.

In the ground handling, assembly, and checkout phases, all of the common industrial hazards are present. The major difference is that they exist in a greater degree than in practically any other industrial operation. Briefly, missile safety hazards may be categorized as explosive, toxic and flammable. For example, liquid nitrogen and liquid oxygen—both of which are used extensively in our present-day ballistic missiles—are particularly dangerous. Although nontoxic, they exist at extremely low temperatures in their liquid state. Handling them requires constant precautions and protective clothing.

When liquid oxygen is mixed with a hydrocarbon fuel, it unites to form a highly explosive gel. This has created a multitude of special design considerations. Moreover, LOX will boil away at temperatures above minus 297° F. Because of the extremely low temperature requirements, many metals and other materials needed to feed LOX to a missile become extremely hazardous when they come in contact with it. Thus, valves, fittings, pipes, and gages must be selected with great care to insure that they are compatible with the liquid. Any improper material in a valve, for example, upon coming in contact with LOX could cause a serious explosion and destroy a valuable missile and much of its vital ground support equipment. As far as metals are concerned, missile designers are limited in their choice to stainless steel, aluminum alloys, copper, brass, pure nickel, monel and inconel. Care must be taken to insure the use of fittings which will not freeze when they come in contact with extremely low temperatures.

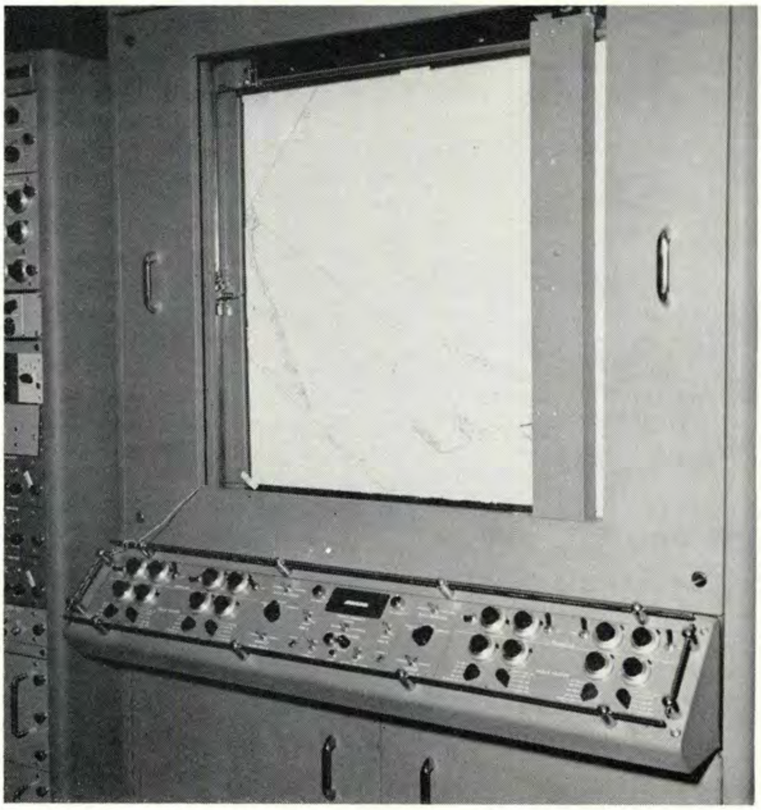
Another LOX safety consideration is that its vapors can linger up to two hours and during that time will support combustion violently. Therefore, a prime requirement when working with LOX or practically any other missile liquid is a housekeeping one —cleanliness.

Other high-pressure gases used in liquid-fueled ballistic missiles are almost equally hazardous. These include helium, nitrogen and acetylene. Helium, for example, is used to pressurize propellant tanks during a missile flight. It is contained in titanium spheres maintained at pressures over 3000 pounds per square inch. The dangers inherent in handling containers under such pressures are obvious.

Briefly, other over-all missile safety problems concern the types of solvents and lubricants used, high voltages present in the missile and blockhouse consoles, destruct charges, rocket engine noise and—in the operational configuration — nuclear radiation.

The philosophy of missile ground safety is to create a safe working environment without impeding operations. We have achieved these objectives for the most part, but it is a process of constant planning and education. Moreover, by solving these problems we have made a major step forward to the ultimate goal of reliability. We know that we can live with ballistic missiles but ground safety vigilance must never be relaxed.

The inflight safety aspect of the



Upper left, optical skyscreen detects deviations from planned trajectory. Upper right, impact predicator plotting board charts missile course and predicts impact point. L/C R. D. Stephens, Senior Range Safety Officer, at console, is responsible for destroying missile headed into danger area.

problem has been one of the major concerns of the safety engineer. Since ballistic missiles may be said to have only recently emerged from their initial development phase, there was almost no backlog of experience and information to fall back on. Problems were solved as they arose.

The principal inflight safety requirement is to maintain adequate control over a missile at all times to insure that it will impact in its predetermined impact area.

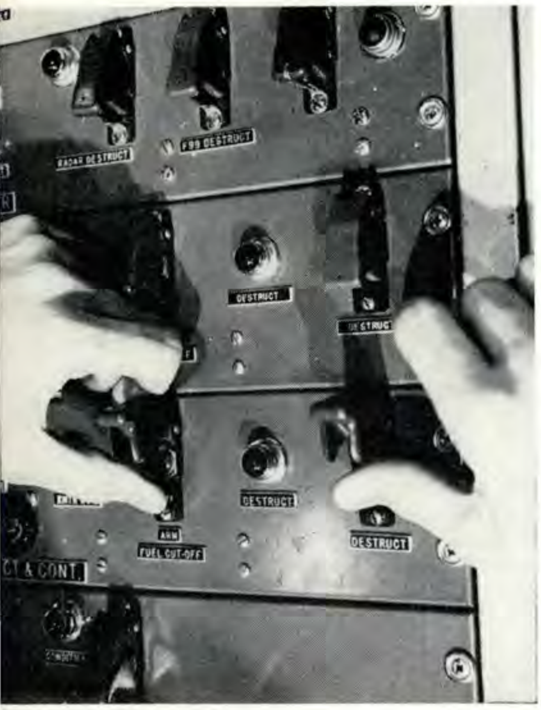
During research and development flight tests at the Atlantic Missile Range, the value of any ballistic missile flight is proportional to the time it is in the air, because valuable optical and telemetry data are accumulated as long as the "bird" flies. Therefore, destruct signals to errant missiles are sent as late as possible, within the framework of range safety criteria.

The underlying philosophy upon which missile destruct calculations are based is that a dangerous turn from a planned trajectory may occur at any time without warning during the powered flight phase of a ballistic missile. Instrumentation has been perfected which instantaneously transmits inflight information to a

BALLISTIC MISSILE SAFETY (Cont.)

Range Safety Officer, who must know at all times the exact position of a missile.

The primary safety responsibility during a missile flight at the Atlantic Missile Range rests with the Range Safety Officer. His job—to protect life and property both on and off the Atlantic Missile Range—has a direct and immediate effect on the progress and welfare of the entire ballistic missile program. Electronic and optical safety instrumentation is an important ancillary to over-all safety operations; but, ultimately, the success or failure of the inflight safety program rests with the judgment of the RSO.



Above, RSO's reaction time to destroy errant missile is 2 sec. Below, high speed digital computer automatically determines point of missile impact should thrust be terminated.

During a missile countdown, the Range Safety Officer plays an integral part in a flight test. Seated before the range safety console—the single most important piece of range safety equipment, since it contains the destruct switches — he receives a continuous flow of information throughout the countdown and during liftoff and flight.

If a missile begins to deviate from its planned trajectory, safety instrumentation records the deviation. This information is relayed by safety technicians directly to the Range Safety Officer. This is known as a dangerous or "red" condition.

The Range Safety Officer then compares and evaluates this information with other visual and auditory data which he receives, and either decides to destroy the missile or waits briefly to see if it will return to its planned trajectory. If he decides it is necessary to destroy the missile, he initiates destruct action by activating the necessary control switches on the range safety console in their proper sequence: *Arm and Destruct.* Relays close and the signal is radioed to the missile. Receivers inside the missile pick up the signal which automatically closes relays activating the destruct package, and the vehicle is destroyed.

Another procedure is to terminate its thrust by cutting off the fuel.

It is obvious that the Range Safety Officer's assignment is a most difficult one. The psychological pressures on him are tremendous and his decisions must be "perfect" if he is to avoid criticism and censure.

If he destroys a safe missile prematurely, he is open to possible criticism from missile agencies. If he destroys a safe missile because of an incorrect evaluation of the flight data, he is subject to criticism from his superiors, missile agencies, and adverse newspaper publicity. However, if he fails to destroy an erratic missile in time to prevent damage to property or injury to personnel, he is open to almost universal criticism and censure.

The Air Force ballistic missile safety program thus far has paid off important corollary dividends. For example, missile crews, while aware of the ever-present hazards involved in their work, have developed a relaxed on-the-job psychological attitude. This enables them to work more efficiently because they know that almost their every action is protected by safety procedures.

Another important corollary dividend is that we have learned that overemphasis on safety can be as detrimental as a lax attitude. Safety techniques and procedures, if too restrictive, can become stumbling blocks to effective operation and thus may adversely affect operational reliability. Therefore, in devising safety programs, safety engineers emphasize the relationship between safety and reliability, to prevent compromise of performance. In short, learning to live with the new and revolutionary ballistic missile weapon systems has been in itself a major achievement.

The attainment of a successful over-all ballistic missile safety program may be attributed to three important factors:

First, and perhaps of greatest significance, is that safety guidelines have been developed long before a missile is flight tested for the first time. Safety, in effect, is built into the over-all weapons system.

Second, special emphasis has been placed on devising simplified handling procedures in all phases of missile development from the assembly line to the launching pad.

Third, carefully implemented, realistic inflight safety techniques have meant a level of reliability which initially was thought to be impossible.

For the future, as our ballistic missiles become more sophisticated, we must continue to insure the continuation of safety programs and safety records comparable to—if not better than—those of today. We have already begun to anticipate problems inherent in these newer, bigger, faster and more powerful vehicles. We expect solutions to the problems of handling greater weights and much more bulky rockets. Moreover, as new and more energetic propellants are introduced, we will also be faced with greater handling problems to prevent premature detonation during storage and prelaunch phases.

I am sure that none of these new problems will be too complex to defy solution. However, to a large degree, the new safety techniques that they bring about will have an even more important effect on the objective of conserving our missile capability and making it, ultimately, a keystone in our military strength. ▲

Too much to do in too short a time? Not enough hands or perhaps too many instruments? Maybe you're a victim of N + 1 = TROUBLE.

The "N" Factors

William P. Lear, Sr., Santa Monica, Calif.

The author is Chairman of the Board, Lear, Inc. The theories and opinions expressed were developed by him through years of active investigation in areas of aircraft instrumentation.

If man is to satisfy his primal urge to stay alive, especially in hostile or dangerous surroundings, he must depend on safety measures. Instinctively, he tries to defer an untimely end for as long as possible by protecting himself with safeguards in which he personally believes.

Safety lies in anticipating trouble and preparing for the unexpected. One always has to be on the defensive to achieve high performance with safety of operation. One always has to be two or three jumps ahead in his thinking. It isn't enough just to know what to do next, but rather one must have imprinted indelibly on his subconscious and conscious mind what to do after that and then even beyond.

Man's basic survival equipment—his brain—is credited with the capability of holding some 15 trillion units of information. This remarkable statistic to the contrary, it is said that a man can do no more than one thing at a time and do it well. Even those who find this axiom debatable accept its implication that there is a limit to the number of things a man can do at once with any degree of proficiency. Further, since pilots are human, they vary somewhat from man to man and it is generally agreed that not only is there a certain maximum number of things each man can do at one time but also that this number will vary from time to time, depending upon his health, condition, environment and emotions.

So, let's say that under any given set of conditions a man may be capable of doing N things (*N being a certain number of things*). Now let's examine what happens when he is given just one thing to do beyond this maximum number, which we shall call an N + 1 *(N plus one)* condition.

Does his efficiency and capability cause him merely to neglect the extra thing? Or does he do all of the N + 1 things, but with less efficiency? Or does his brain simply go into low gear and react as though it were swimming in glue?

Every pilot knows the correct answer to this question because, with even limited experience, he remembers situations when for a time he was incapable of pulling himself together—when he couldn't even read his watch, much less tell someone what was going on or where he was. He knows that he is not the panicky type and not an imbecile, yet he was unable to think and act normally during a condition of stress because he suddenly became overloaded. He had just one more thing to do than he had capacity for, and suddenly his computer (*brain*) went AWOL.

In electronic parlance this condition is called saturation. A computer or amplifier will handle just so much information or inputs. After that, it bogs down and fails to function until the inputs are reduced in numbers, when it again goes to work as though it had not experienced the overload.

A man's mind is not unlike such an amplifier. A mind can accept and function very well with N + 0 inputs. But when one more input is added, making N + 1, the mind may temporarily cease to function. At least it reduces output to only a fraction of its usual ability to supply answers and directives to the muscles. When this condition prevails, the human brain acts as if it were aswim in glue.

But the factor N is not only variable between men; it varies from time to time in a particular man. For instance, a well-adjusted, physically fit fellow doing exactly what he likes can do much more than the same man when tired and harassed.

A major factor in providing safety in the air derives from meeting the overloading potential head on and protecting the pilot from saturation by providing him with equipment designed to circumvent human limitations. Ideally, the pilot should have almost nothing to do except manage the over-all performance of the airplane. For the things he must do, it is necessary to provide inputs to his brain that cause instinctive reactions, rather than inputs that force him to think. This does not mean he isn't capable of thinking; it simply means that his God-given quality to deduce cause and effect is being reserved for more important requirements.

The number of things he has to do are reduced to keep them as far as possible below the N + 1 condition. The closer to nothing that the pilot must do, the better he can manage the flight, and the safer the operation. Obviously, it is not possible to reach the zero level of action for the pilot; and equally obvious that if it were, he would be left out of the aircraft. The effort, however, to provide him with efficient working conditions by reducing the things he has to do, offers the nearest approach to absolute safety through better flight management.

With this in mind, Lear, Inc., became intensely interested in the cause and cure for many private aircraft accidents which occurred due to inability of the average man to read and understand the instruments on his panel. Some 28 per cent of the private aircraft fatal or serious injury accidents in 1958 reportedly resulted from weather penetration by VFR pilots, which certainly suggests that eventually instrument training will become mandatory, as it is and has been in the military services. Meantime, it was thought that many accidents could be prevented by reducing the number of things a man had to do or learn in order to fly his small business aircraft when he got caught in the clouds or fog.

A study indicated that practically none of these accidents was the result of intentional penetration of clouds or fog. They were the result of the pilot's continuing on in the hope that the ceilings would improve or that he might find an open canyon in the clouds. All too often the canyon turned out to be blind and before the pilot could reverse his course, he was on instruments. Not infrequently, a pilot has been forced to fly instrument conditions for the rest of his life—which ended dramatically only a

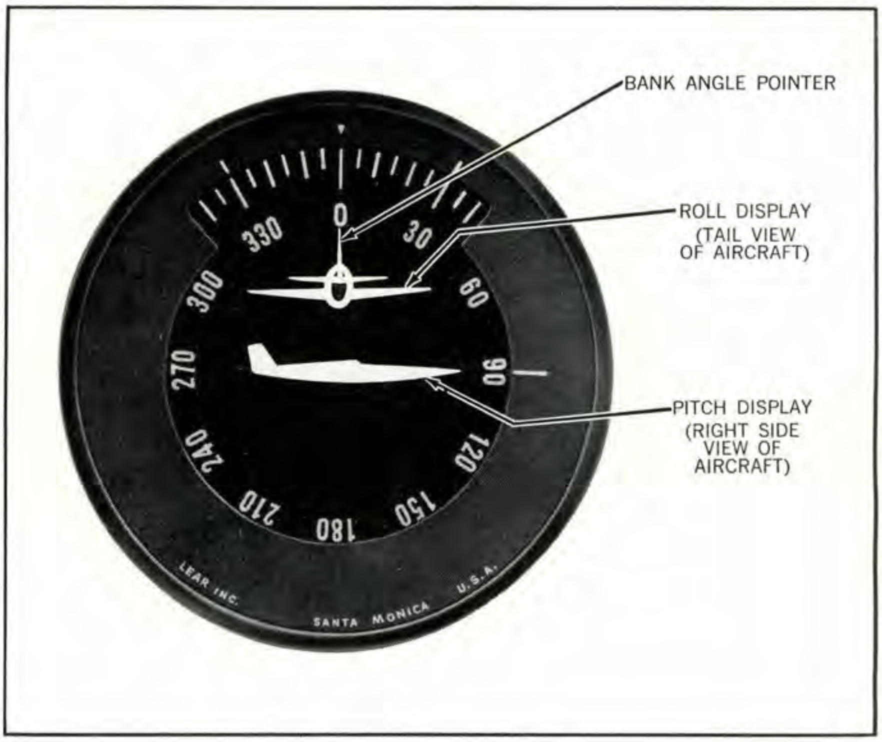
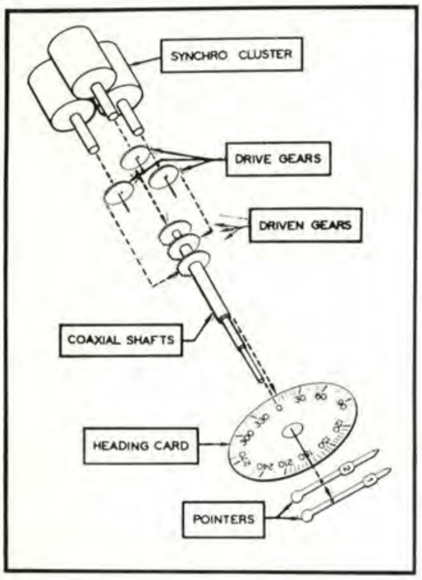


Fig. 1, above, aircraft silhouette attached to TURN NEEDLE; ball is obscured. Fig. 2, right, converted RMI. Fig. 3, below, standard RMI converted to present pitch, roll and heading.



few minutes later because he didn't know how to read his instruments when he couldn't see the ground or the horizon.

The prevalence of this type of accident indicated the need for two things: first, automatic stability for the aircraft which would free the pilot of such demands, i.e.,

- Operating the wheel, stick, rudder and trim tabs.
- Reading his old-fashioned, hard-to-understand instruments.

This freedom would leave his mind clear to initiate and complete a turn on autopilot and get out of the clouds, thereby living to fly another day or go another way.

Alternatively, if the plane had no autopilot, provide an instrument so easy to read that the pilot just had to obey his God-implanted instincts to fly the ship equally as well in the clouds as under visual flight rules.

This takes into consideration the quantity of things a pilot has to do, as well as the quality or degree of complexity of each of these things, which in turn further reduces the N *(number of things)* capacity. If an instrument is hard to read, then the number of things a pilot has to do is increased by some factor. For instance, when the pilot looks at a horizon indicator bar, he has to remember:

- that the bar represents the horizon, not the attitude of his aircraft in roll;
- that he must turn the wheel *(aileron control)* opposite to the direction he wants the horizon bar to move;
- that if he wants to fly a certain heading, he must keep turning until he reaches that heading;
- that he must level the aircraft.

However, he knows that if he waits until he reaches that heading before leveling the aircraft he will not roll out on the desired heading but beyond it, depending upon his direction of bank. So he must remember still another thing:

- that he has to begin leveling out his wings as he nears the desired heading to avoid overshooting. If he levels out too soon, there is the hazard of undershooting.

A pilot is plagued by all these considerations merely in flying the heading and roll on aileron controls. This leaves many more things to be done, such as control the aircraft in pitch or elevation, watch the airspeed, altitude, rate-of-climb or dive, perform the navigation, communications and so on.

Based on the need to reduce the number of things required in reading the instruments or combination of instruments, it was decided to approach the problem simultaneously in three different ways.

The first approach was to design the simplest possible instrument that anyone could buy and use, one that would be easy to master and readily available at low cost.

This instrument was suggested by Bill Jones at the FAA Training Center in Oklahoma City, who asked me to try it and see for myself how easy it is to use and how quickly others could be taught to use it. Such an instrument was built and installed in two of our Bonanzas, and we found Bill Jones' enthusiasm entirely justified. *(Figure 1)*

In using the instrument, you do not use the rudders. You keep your feet on the floor, off the rudder pedals, and "fly" the aircraft attached to the turn needle, just as if you were steering an aircraft directly ahead of

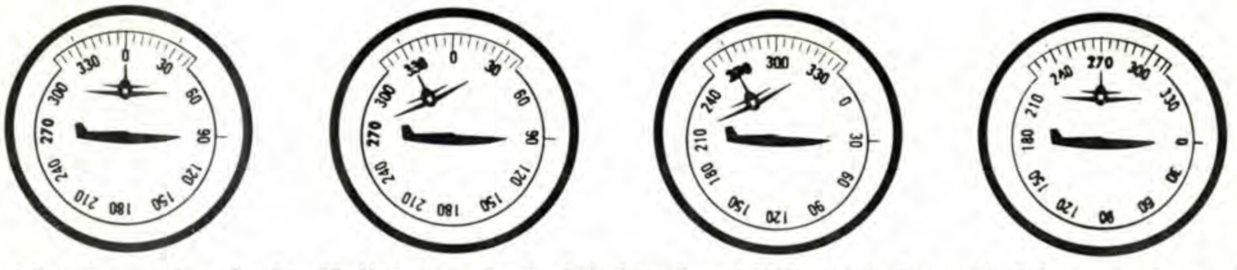


Fig. 4, left, instrument shows heading 0°. Next, in turning to desired heading of 270°, pilot banks toward 270°. As aircraft turns (third instrument), heading card rotates, bringing 270° mark up to bank pointer. Far right, pilot holds bank pointer on 270° mark, and rolls out with it.

you. There is some lag in all of these instruments, but a little practice enables almost anyone to quickly master the art of keeping the aircraft from turning. The principle upon which it works is this: If any aircraft is in a bank, it is turning in the direction of the bank. Conversely, if the wings are level the aircraft is not turning. Therefore, keep the wings level on the turn-and-bank indicator and you're not turning. Simple!

The second approach to the problem of a simplified, easy-to-read flight instrument was really triggered by the ease of learning to fly the roll axis display on the turn-and-bank indicator. The reasoning behind this was that if the moving aircraft resulted in *instinctive* reactions on the part of relatively untrained pilots, why not eliminate the damping delay attendant to rate-of-turn indicators and drive the roll axis display on the indicator from the roll axis of the vertical gyro?

Surely this would have been done on the very first gyro horizon had it not been impractical due to the gyro's roll axis remaining fixed with respect to the earth while the aircraft moves about it, making a moving airplane impractical as it would have moved in reverse. In other words, if the ship's wings dipped left, the aircraft would have rolled right. At that point someone said, "Okay, let's forget about moving the aircraft display. Let's use a long bar instead, and call it the horizon."

And that's how the hard-to-read, reversed reading artificial or gyro horizon was born! Ever since, it has been necessary to train, retrain and refresh all users of this instrument to keep them from reverting to their natural instincts and move the wheel clockwise to make the *bar* move anticlockwise instead of the reverse.

Once we decided to connect the aircraft roll display to the vertical gyro roll axis it was clear that we would have to *servo* the indicator, because a direct gyro connection was possible only through use of gears to reverse the motion so that a right aircraft roll would produce a right roll motion of the display on the indicator.

And once we decided to picture the aircraft in silhouette and to literally fly the moving aircraft display, we reasoned that the pitch axis should also be displayed in the same way, to make it possible to watch what the airplane is doing by viewing it from the side as though the pilot were looking at it from the outside. This is just what he was doing in the case of the roll axis, i.e., looking at his airplane as if he were directly in back of it and could see if the wings were level or banked.

This could easily be done, it was discovered, by simply using the internal works of an RMI as the repeater or servo for repeating the angular motions of the pitch and roll axis of the vertical gyro. *(Figure 2)*

The RMI has three synchros arranged so that they drive three coaxial shafts with a card on the external or outer shaft, which is generally connected as a compass or heading repeater for the directional gyro. By placing the roll silhouette on the middle shaft and the pitch or elevation silhouette on the inner shaft, we now had a relatively low cost, easy-to-assemble three-axis flight instrument all in a standard AN $3\frac{1}{4}$ inch case. Although it presented heading, roll and pitch attitude simultaneously to the pilot, *(Figure 3)* the instrument proved very easy to read and use. Moreover, some unexpected yet desirable effects resulted from combining these three bits of information in one instrument.

First, it was found that, despite our fears, reading the pitch axis by viewing the aircraft display from the side produced no confusion at all. It was equally as instinctive to push the nose down from a nose-high attitude as it was to roll right from a left wing low attitude in roll.

Second, it was found that by using an angle bank indicator line or mark directly above the roll display and by holding this mark directly over the desired heading on the directional card, no lubber line was required on the indicator case above the card. As a matter of fact, a lubber line only confuses the pilot as he uses the indicator.

Third, the findings enumerated above prompted further investigation and it was found that, due to the relationship of the roll index and the heading card, we had a turn computer for free.

In other words, *(Figure 4)* by glancing at the card the pilot turns toward the desired heading instantly, without thinking. Instinctively, he banks the right way to get there in the nearest direction, even though the new heading being sought may be 179 degrees away from the heading he has been flying.

Fourth, it was found that by banking in the correct direction and holding a reasonable bank (as indicated on the bank index marks on the glass) until the card turns, bringing the heading selected up under the bank indicator line, and then holding the bank indicator mark directly over the selected heading on the moving card, the pilot invariably came out on the heading selected in level flight with no over or undershooting of the heading.

This meant that we had a heading indicator and a bank indicator so related to each other as to produce, without any extra black boxes or electronic gear, a "turn to and hold" heading computer.

Fifth, it was found that the instrument required practically no training time and could be used by tyro or expert. Its commands were all sensed right and the pilot's instinct forced him to believe it and do the right thing the first time he used it.

Sixth, it was found that flying this new presentation produced no strain, despite the narrowed cone of vision the pilot was required to observe in order to use all of the instrument's capabilities. His eyes did not have to move very far, either left-right or up and down. And all of the command, attitude and direction indicators were so close together that the pilot could actually see both the bank and pitch information at the same time, eliminating excessive eye movement.

The instrument, we feel, greatly contributes to safety through decreasing the quantity of things a pilot has to do. At the same time, it eliminates the need to train him to remember to do some things backward.

At the outset of this article, reference was made to the "N" capability of the pilot and the desirability of staying as far as possible under the N + 1 condition in order to insure safety. The simplifications here described obviously result in lessening both the number of things required and the difficulty of doing them. This is particularly significant when the pilot is making very low approaches in bad weather and is all too aware that a single wrong decision can cause a bad landing. The instrument frees him so that he can watch everything that is going on, allowing him to have several N's in reserve.

Designing the instrument to compensate for the pilot's human limitations, as related above, still required using the pilot as a servo to push and pull the wheel and occasionally turn it, although this means that he expends some N reserves that he might need in an emergency.

One of our pilots successfully fought and conquered an aircraft nacelle fire while the autopilot and approach coupler brought the ship down to the runway, leaving the pilot free to fight the fire.

As a result, we still have our pilot, our ship and the military personnel who were aboard, all of whom might have been lost if flying the plane had kept the pilot so busy that he'd used up all his N factors. In that case, with the additional chore of fire fighting, he would have reached the condition of N + 1, or Trouble, and this can be fatal.

To achieve maximum safety, N factors must be kept available to the pilot, instead of being used up for the "chores" that instruments can do for him. ▲

★ ★ ★

✓List

Your FSOs who attended the recent World-Wide Flying Safety Conference in Riverside, Calif., can take a bow for the compliments bestowed on them by the management of the Mission Inn. Mr. Brett, the General Manager, wrote General Caldara that never, in his years of experience, had he observed such an orderly, efficient and competent group of men conducting the affairs of a conference. General Caldara passes along his thanks for the exemplary conduct displayed by those attending which made this one of the finest conferences on record.

✓

Winter is upon us and already the spine chilling reports are coming in. A KC-97 successfully aborted a takeoff attempt after becoming airborne 8000 feet down a 14,000-ft. runway; airspeed was 130 knots. The aircraft was not responding to elevator control. Isopropyl was used but even so, slush ice ¼-inch thick was found on tail surfaces. Have you checked your base deicing procedures lately? See article "Deicing Materials and Procedures," published in Aircraft Accident & Maintenance REVIEW, September 1959.

✓

This one first appeared in SAC's magazine, "Combat Crew." So far as is known now, the method works only on B-47s. It is good info, however, and is passed on to you.

"Major Kenneth E. Heller, Director of Safety, 96th Bomb Wing, has an answer to bug-splattered aircraft windshields that wins him a $25 Savings Bond.

"On low-level operation, pilots of the 96th found that bugs hitting the windshield were becoming a serious problem, so Major Heller came up with a kit consisting of a large battery syringe and a plastic quart bottle. The bottle may contain either plain water, or water and a mild soap not harmful to the canopy. The navigator fills the syringe, opens his periscopic port and squirts the liquid up into the airstream toward the windshield. Windblast blows the liquid against the windshield and cleans it. If you don't have a syringe, put an opened water bottle against the port and suction will do the rest."

✓

There is nothing like realism and actual practice to teach emergency procedures, but it can be carried *too far*, namely, stopcocking the T-33 in order to teach and practice airstart procedures. There is good reason to suspect that there are *still* some instructors who are using this technique. If you've thought about it—don't! If you are doing it—stop! Sooner or later, you'll find the one "sick" bird that won't re-light.

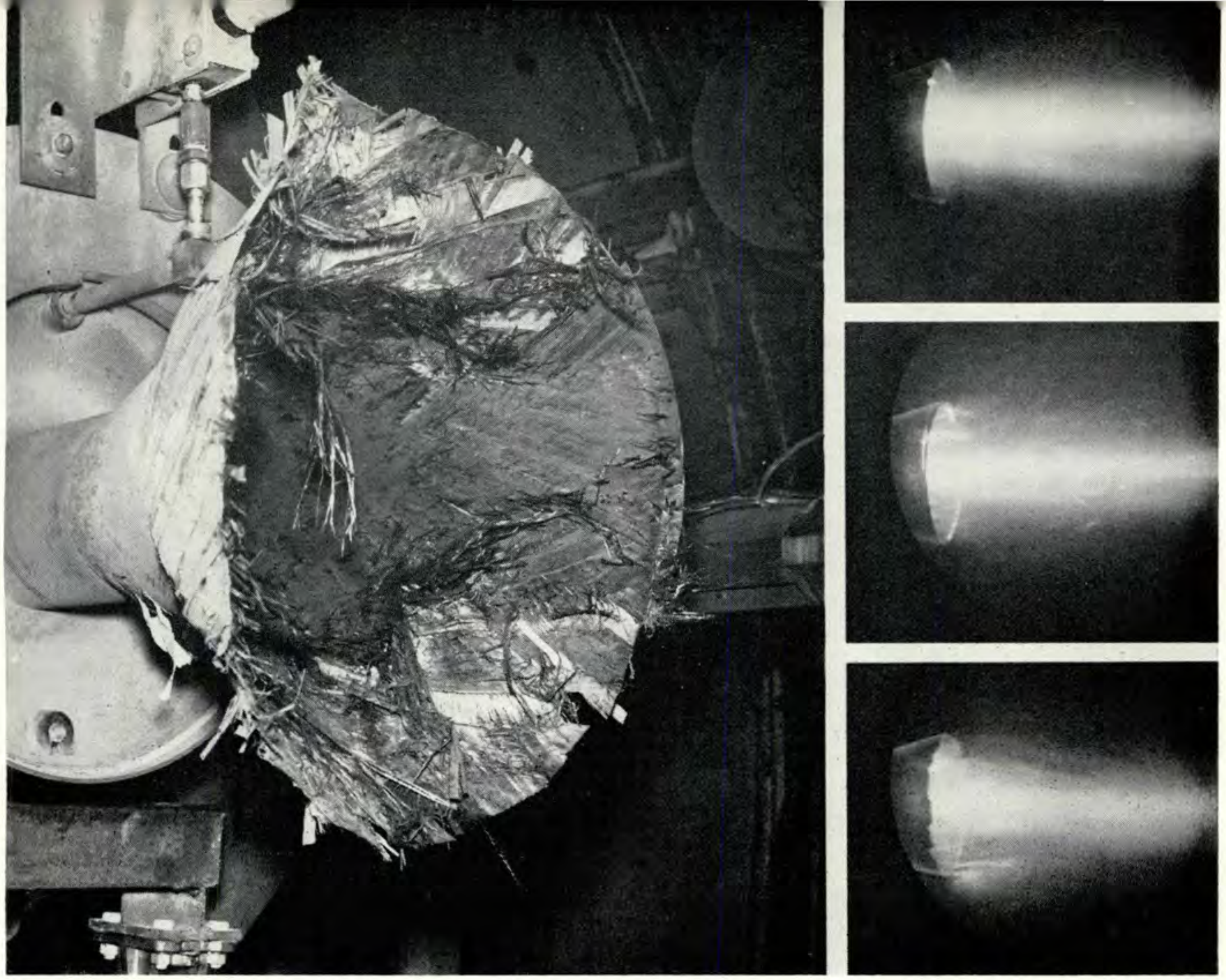
✓

Take another look at "Operation Hotfoot" on page 29 of the October 1959 issue. The sections of T. O. 4B-1-1 quoted are in conflict with instructions contained in the latest Tech Order dated 28 July 1959.

This new Tech Order was not received until after the magazine was printed and distributed. You might take out the new one, dated 28 July 1959, and give it a real good, long look. Won't hurt a bit!

✓

From January through September 1959 the success rate in ejections from below 1000 feet was as follows: from Century fighters, 79 per cent; from other jet fighters, 88 per cent; from jet bombers, 67 per cent. This is the best rate yet, with the exception of the T-33. Of 8 ejections below 1000 feet, only 2 *(25 per cent)* were successful. These 6 fatalities could very likely have been prevented had proper ejection procedures been used. Two men delayed ejection until too low for parachute deployment. The third man failed to connect his zero lanyard and the fourth kept a death grip on the seat handle after his restraining equipment released. The fifth and sixth fatalities were caused by a combination of the above three errors.



Left, nozzle fails during altitude test. Right series, hot spots start at nozzle exit; burn-through starts at rim; burns off, cone disintegrating.

Tunnel Talk

Lt. Col. Frank D. Campbell, Jr., Hqs Arnold Engineering Development Center, Tullahoma, Tenn.

The class reunion was in full swing. Steins were filled and emptied with clocklike regularity as old grads swapped tales both tall and short. Two Air Force officers, holding a corner table in the Student Union, were comparing notes on their careers since leaving the ivy-covered towers of old P. U.

"Yes, I'm in the wind tunnel business down at Headquarters Arnold Engineering Development Center now. I hear you're flying Starfighters out of Hamilton," Major Slipstick said.

"Yes sir! It's the hottest thing ever and that cockpit fits like a glove," said Major Jockey, loosening his belt from the bulge at his waistline and ordering another round of brew.

Slipstick grinned. "Guess you feel mighty proud, kicking around in what may be one of our last combat airplanes. Now that the space age is here, what's going to happen to all you old aerial combat types?"

"Hey!" Jockey straightened in his chair. "We're just getting started! Didn't you notice that the Astronauts were chosen from the cream of the throttle benders? And the 'way-out-there' stuff like Dyna Soar is scheduled to be a manned beast," continued Jockey, punching home his point with a flourish of his half-spent cigar.

"All this guided missile and remote-control space junketing that's on the track now is because you science sisters haven't figured a way to make the aerospace planes liveable.

"Doubt you not, as soon as you can figure a way to feed him, cool him, heat him and let him breathe, the trusty old pilot type will be driving in place of all those squirrely black boxes that blow fuses and short circuit the mission for no apparent reason."

He poured another beer and continued, "And just where does a back-to-the-drawing-board type like you get off knocking us highly skilled aerial drivers?"

"Not so, Jock," grinned Slipstick. "My needle hit home. I've been up to my gazeetus in wind tunnel work for so long that I like to relax by touching the torch to you operational types.

"Actually, I'm with you. This 'last-manned-aircraft' song is just an interim deal. Future flight will require lots in the way of black boxes to help the pilot react—and fast—but I'm sure the goal is to get the only 'reasoning' autopilot back into the act as soon as possible. And we're working towards that in wind tunnels."

Jockey fumbled for a fresh cigar. "What's with this wind tunnel bit, anyway? You're at the AEDC in Tennessee, that much I know. But since there is nothing out in space, how can you test a space ship in a wind tunnel? And another thing, if old Professor Updyke was right, when we were burning our midnight oil, these rocket engines not only don't need air, but they run better in a vacuum, so what's the angle with engine test cells?"

Slipstick frowned. "Hold it! I've got news for you. We're busier than ever trying to keep up with this space hardware workload in our old air-blowing facilities. And most of this work is of vital interest to you potential space troops."

"Hm-m-m. Tell me more."

Slipstick fumbled beneath the table and drew out a battered old brief case.

"I'm right glad you asked me that. It just so happens I'm homeward bound after a little presentation we had to make on the coast. I've got a couple of pictures here you might like to see."

"Yow!" growled Jock. "Looks like I stepped into a sales pitch."

Slipstick pulled out a folder, fumbled through it and drew out a chart. The caption identified it as "Trends of AF Systems Requiring Research and Development."

"This came out of a publication from the Wright Air Development Center. It will give you a buckshot perspective of what to look for in the next 20 years."

"By that time I'll be flying the space age equivalent of the gooney bird," interrupted Jockey.

Major Slipstick traced the curves of the chart. "Notice that this estimated Research and Development activity for new aircraft continues throughout the 20 years. But the important thing is the tremendous amount of additional R and D work that is going to be needed to generate these boost-glide vehicles, satellites and lunar and interplanetary vehicles.

"And a lot of that R and D work is going to be done in ground facilities that can simulate the high altitude, near-space and high mach number environment that these future birds are going to have to live through."

Slipstick pulled a photograph from the folder in his hand. It showed a battered nozzle of a rocket motor and a series of frames enlarged from motion pictures taken as the nozzle failed its high altitude tests.

"Okay. Let's take a few main points. Did you ever think of how the rockets are going to run when you're orbiting around at the top of the stairs? You'll want dependable push not only to get way-out-there, but to slow you down so that you can be drawn back to earth by the force of gravity.

"Look at this photo here. It shows what happened to one rocket nozzle which had checked out perfectly at sea level. But, when we tested it at near-space pressure conditions, the nozzle came unhooked at the seams. The test data permitted the manufacturer of this job to redesign the nozzle. He beefed it up and then it checked out as a reliable piece of hardware for operation in the dark black yonder.

"Sure, Updyke was right about rockets producing more thrust in a vacuum but we've learned that they don't behave better in all respects. Sometimes they won't start. When they do start, they may have unstable combustion. Thrust control may not function—and this surprised everyone—they don't necessarily quit running when they are shut off!

A Mercury man-in-space capsule enveloped in luminescent airflow during Mach 20 test run in Arnold Engineering's tunnel Hotshot Number Two.

"We've been testing rockets for more than a year now at simulated altitudes of 100,000 feet and higher in our engine test cells. These cells, originally designed to test jet engines, have proved to be suitable for rockets and their pump-down capability gives pressure of less than one per cent of sea level! You can't get much better simulation of the space vacuum for rocket testing than that."

Jockey chuckled. "All very interesting," he said, "for an egghead. But don't you ever miss that whine of the turbine?"

"Okay, so I'm over-enthusiastic about wind tunnel testing. But look at it this way: One of the rockets tested at AEDC was to be used in an ICBM launch. During the testing program in our cells, we discovered that the rocket had a bad 'chuffing' characteristic. In other words, it would fire and burn its normal life span, then go out. Seconds later, residual fuel within the rocket would reignite and burn for several seconds. This was repeated many times. Sometimes it potted along for more than three minutes. From this, it was calculated that upon separation from the payload of the missile, a 'chuffing' rocket could re-ignite, surge through space and collide with the payload, either destroying it or throwing it out of its planned orbit."

"Hey, that's pretty good." Jockey sipped his beer and edged forward on his chair.

"I know that I sound like Updyke at his worst, but the stuff we're discovering in our facilities at AEDC is going to make life a lot easier for you space troops when you start wandering around the universe."

"Okay, you've convinced me about rockets, but how about these wind tunnels? Don't tell me that you pump them empty and blow nothing through them at orbital speed!"

Slipstick snorted and took a pull at his brew. "No," he said, "it's a lot simpler than that. It boils down to this: You jokers not only want to get way-out-there, you want to get back! This means these high flying space birds have to start from zero speed on the ground, climb out through the atmosphere and return to the 'rest' position again without frying the pilot.

"The bird must be controlled over a speed range from zero to about 24,000 miles an hour, almost 20 times the speed of your F-104. And believe me, the answers are not obvious!

"Ever start a penetration at Mach 20 from 200,000 feet?

"We've been running the National Aeronautics and Space Administration Mercury capsule under these conditions in our Hotshot 2 Tunnel at AEDC. It's a real hotrod. The airflow reaches a velocity of Mach 20 and becomes highly ionized, which means its flow characteristics are changed.

"You can bet the Astronauts are interested in the heat transfer and pressure data we're getting on this model. When they take off on the big shoot, they'll know the capsule can take it.

"Another interesting aerodynamic test we've run on the NASA Mercury capsule is strictly subsonic. Sitting on the poop deck of an ICBM, sweating out the countdown, is rough on the nerves. But if the Astronaut knows that a device was tested in our AEDC wind tunnels to get him safely up and away from the missile in the event of a misfire, he can leave his tranquilizers at home.

"This gadget will lob the capsule for a few thousand feet up and away from the missile and permit it to parachute to earth safely. It's one of those facts that are nice to know."

Jockey finished his brew. "It sounds like you guys are really in there pitching for the space weapon system program. And it's a comfort to characters like me. Who knows? Today the F-104, tomorrow a space platform."

As Slipstick started to place the photos back into his briefcase, he pulled one out and placed it in front of Jockey.

"With all this Buck Rogers talk, I don't want to neglect the work we're doing on the present flight hardware. Here is a recent test setup we did on the escape capsule for the B-58. Purpose was to check the drogue parachute which pops open shortly after you supersonic types are wrapped shut in this capsule and blasted out of a distressed Hustler."

Jockey studied the photo for a long moment. He handed it back to Slipstick with one hand while he pushed back the stein with mock solemnity.

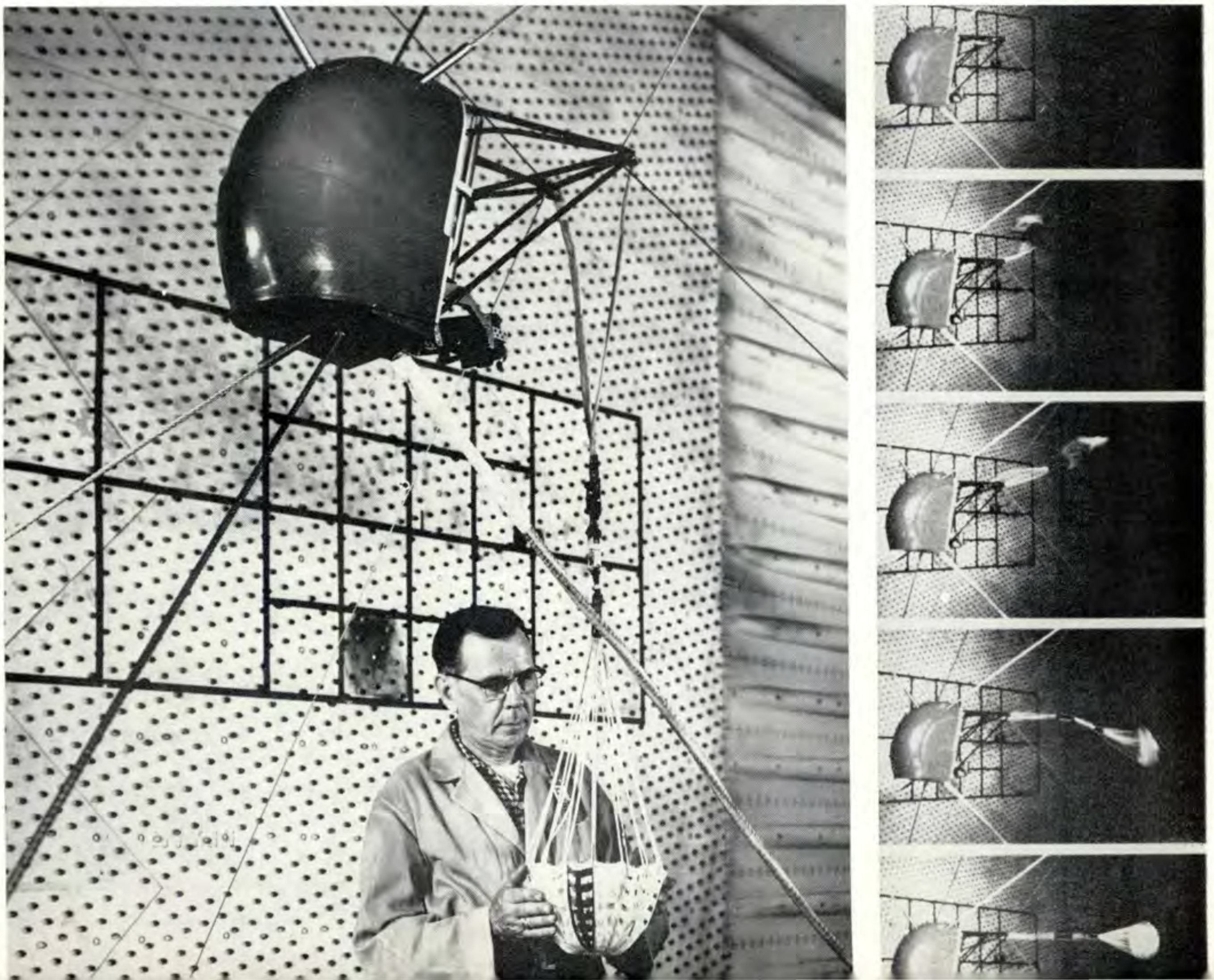
"My head hurts. And I know it's not this beer. It's just that it takes too much cranial exercise to keep that picture you're painting in focus. I thought I knew a little about wind tunnels, but I didn't think they'd be used for this job of tunneling us towards space."

Slipstick grinned as he buckled the briefcase. "I didn't mean to get wound up, Jock. Our work in ground facilities isn't spectacular. No flaming launches, high vapor trails or sonic booms from low level passes. But it's a must if we're going to get our people a place in space."

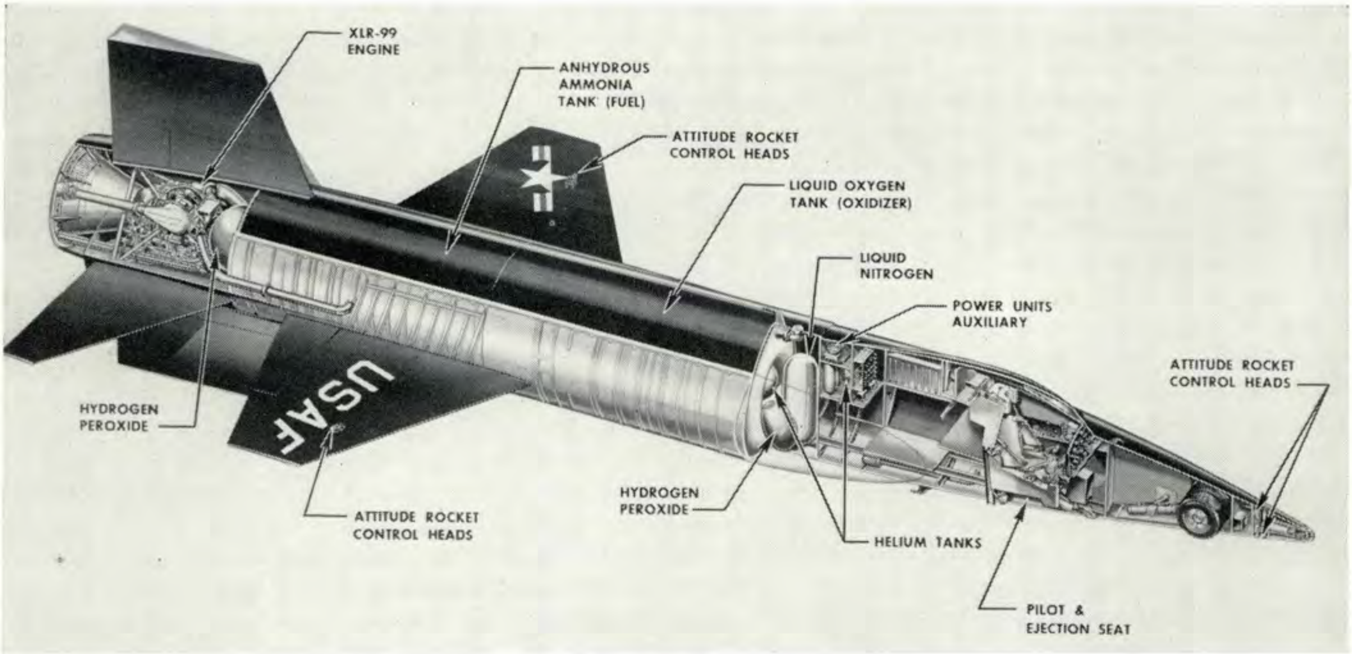
The two rose and shook hands.

"Got to run along and get back to the base," said Jockey. "But somehow that '104 is going to seem awful antiquated after this session. See you in space." ▲

Below left, proposed B-58 escape capsule in 16-ft. transonic wind tunnel. Drogue chute offers maximum drag and stabilization. Right, strip from motion picture footage during test opening at simulated speed of 505 knots.



A STEP To The STARS



The first powered flight of the X-15 *(17 September 1959)* is now history. This, in the radio chatter of Scott Crossfield, is how history sounded while being made:

0731 The mighty B-52 mother craft, with the X-15 securely nestled under its wing, lifted off the runway into the early morning sky. Scott's comment at this point was, "I have first class fare and a private compartment."

0750 The hitch-hiking X-15 is at 35,000 feet and most of the hundreds of pre-launch items have been checked. Crossfield, comfortable in his MC-2 full pressure suit, observes "Cockpit temperature is minus 20."

0758 Top-off of the X-15's oxygen tanks is completed. "Let's not spill too much overboard," cautions Scott.

0800 "Starting liquid now," says Berkowitz, NAA's launch panel operator. Scott answers, "Hydraulic temperature minus 38."

0806 "One minute," comes word from the B-52. "Engine master on," says Crossfield. Then, "LOX light on."

0807 The X-15 drops away from the mother craft at 38,000 feet. Crossfield has two of his eight rocket chambers burning before he clears the fuselage of the '52. Then he says, quietly, "I'm running. Eight of 'em on. Heading uphill at 33,000."

0810 "At 50, level," says Crossfield. "Left turn." Then, "I hear a funny noise." (It was his helmet against the windshield picking up engine vibration.)

0812 Scott announces "Burnout." Ground observers see puffs of smoke exploding in the contrail as the eight rocket chambers burn out, one by one. Crossfield, in a sweeping turn, says to Major White in the chase plane, "Very powerful rudders on this little baby."

0816 Scott has been deadsticking down and now, at 1500 feet, he blows the ventral fin off the X-15 to keep it from protruding below the landing skids.

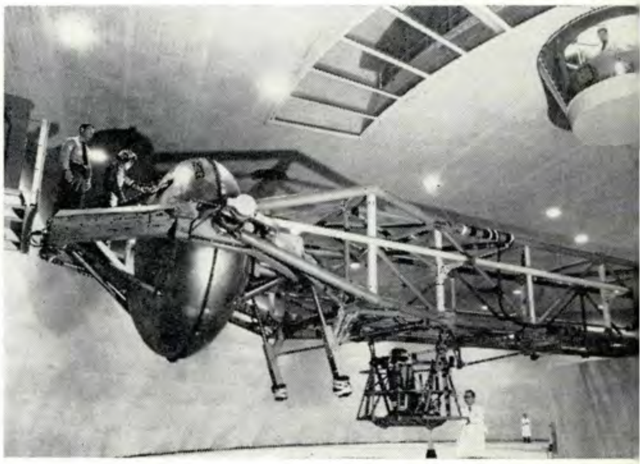
0817 Major White calls out the airspeeds and coaxes Crossfield down. "Doing 260, 250, 240, nice and easy, daddy, still 240, looks good, very fine." As the X-15 alights, "VERY FINE, very good, dad!" Scott answers, laughing, "I'm an old pro, daddyo." ▲

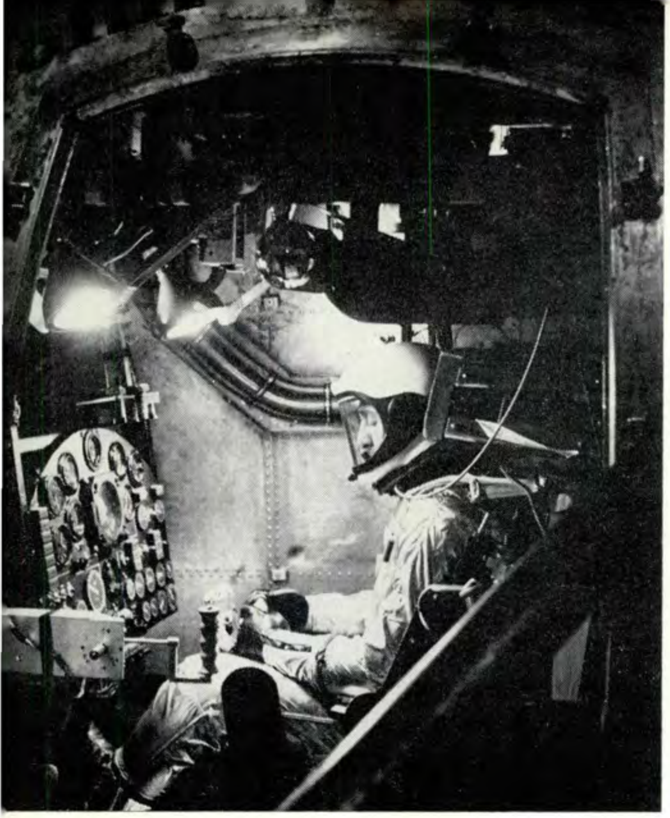
Top left, Scott Crossfield is shown in cockpit prior to a test flight. Lower left, a pilot's eye view of cockpit with canopy in place. Note simplicity of instrumentation. Top right, one of the pilots is measured for adequate cockpit clearance. Each X-15 pilot has an individually tailored seat which, when used with full pressure suit, insures safe ejection at ground level and aerodynamic stability at supersonic airspeed.

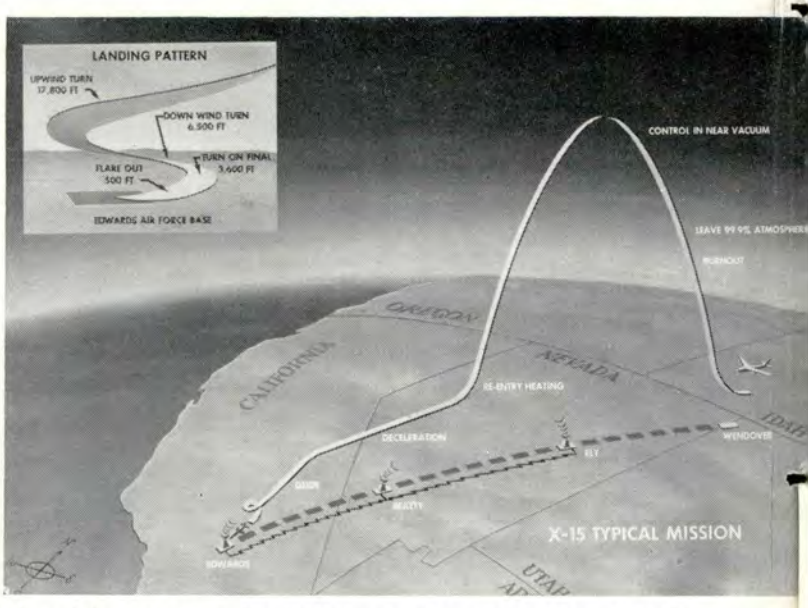
Below, the MC-2 full pressure suit worn by pilots of the X-15 is a miniature pressurized cabin, tailored to the individual's measurements.

Four of the select few who will fly the X-15. L-R: Scott Crossfield, Joseph Walker, NASA; Capt. Bob Rushworth and Maj. Robert White.

The Navy's powerful centrifuge at Johnsville, Pa., where the X-15 pilots were conditioned by exposure to enormous G forces.



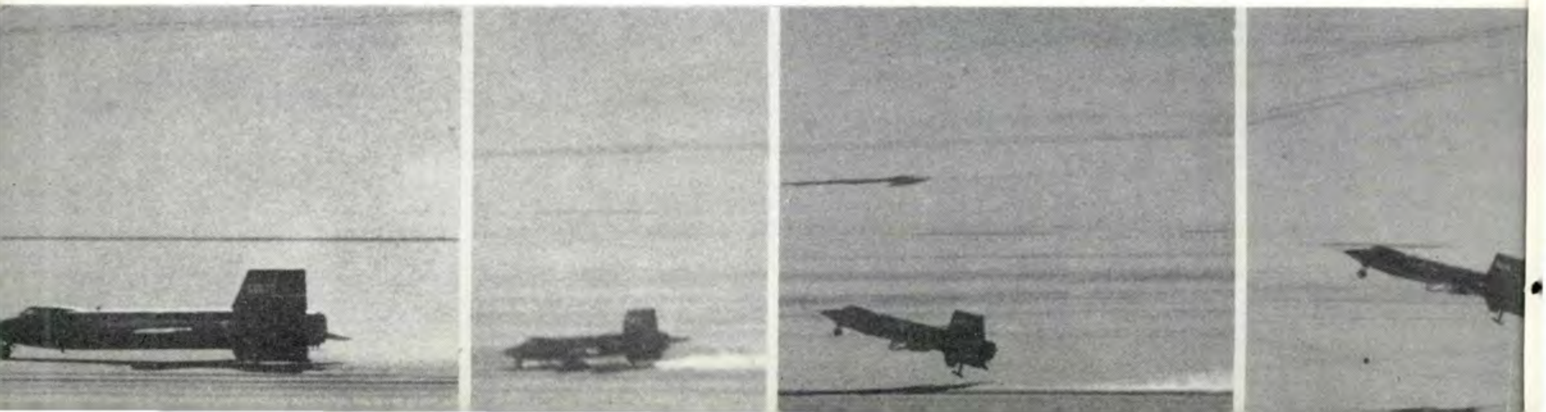




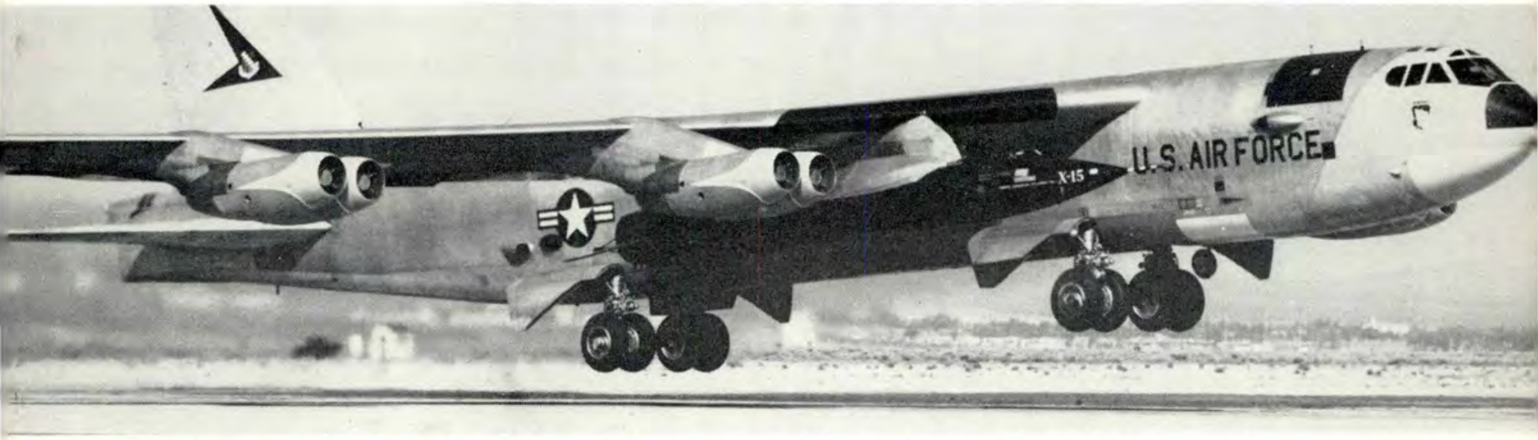
Above left, the X-15 cockpit built into centrifuge to simulate the violent tumbling and whirling which pilots might encounter through more than 7G in test maneuvers. Right, proposed powered flightpath, drop to landing.

Careful ground checkout of all operating equipment, including engines, precedes each flight of the X-15 from Edwards Air Force Base, Calif.

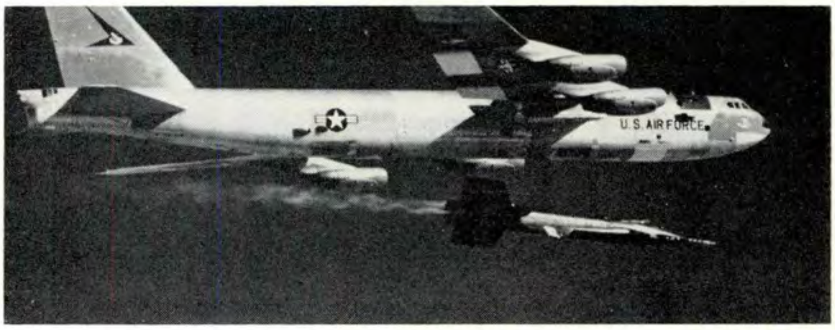
Film strip shows Scott coming in for first landing. Major White, in chase F-104, calls out airspeeds during approach and touchown.

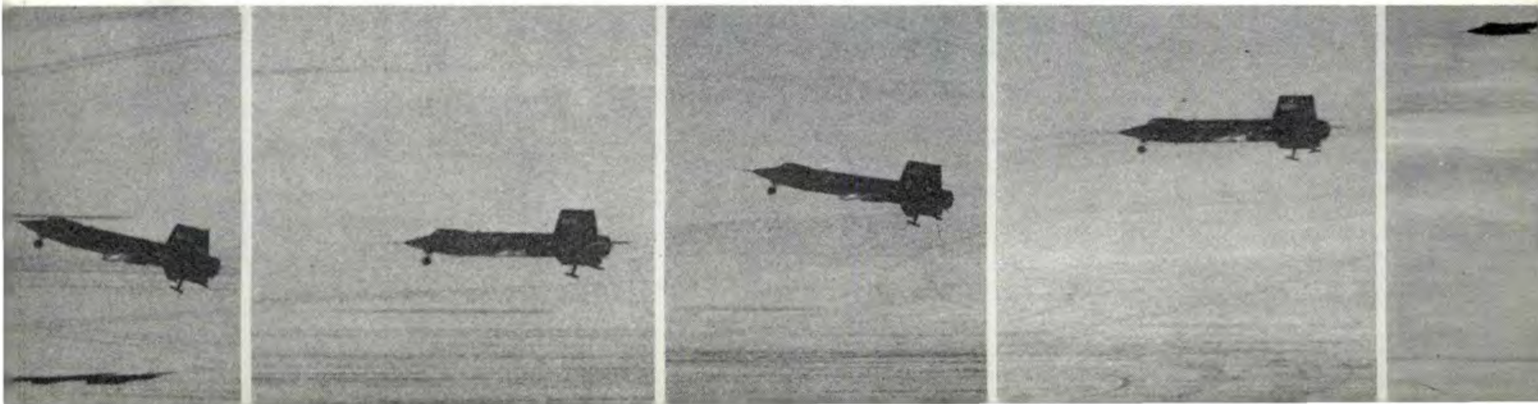


Left, X-15 mated to the B-52. Above, chilled helium is pumped into the X-15 causing ground fog. Chilling the gas makes it possible to increase fuel load.



Above, B-52, with X-15 tucked under wing, lifts off. Lower left, specially designed pylon carries the X-15. Lower right, the payoff: with full rocket power, speeds in excess of 3600 mph are expected to be reached.





the hound

The HOUND DOG is an air-to-surface missile for use with the B-52 bomber. Following successful free-flight launchings preceded by an extensive captive flight program, deliveries are set for an early date to the Strategic Air Command.

Robert E. Brown, Missile Division, North American Aviation, Inc.

"Weapon System Integration" is a matter of major concern to us in the HOUND DOG missile program. "Integration" means, for the most part, designing and developing a missile system in all elements which can phase into the operations of the existing B-52 system. This must be accomplished without diminishing the continued utility of the B-52 as a separate system.

Our responsibility in this program has been to provide not only a missile and its control equipment in the aircraft but also the ground support equipment, facilities criteria, personnel requirements, a training program, and details of the operational and maintenance planning for the missile on an operating B-52 base.

Safety considerations arise in each of these areas and are of paramount importance in weapon system integration. The HOUND DOG has been confronted with most of the safety problems of other types of missile systems as well as those associated with manned aircraft operations.

First, it will be desirable to review the characteristics of the HOUND DOG weapon system. The Boeing B-52 intercontinental bomber will carry two HOUND DOG strategic missiles, each mounted under the wing between the inboard engine nacelles and the fuselage. The missile will be air-launched outside or inside enemy territory. It will fly at supersonic speed for several hundred miles in one of several possible modes of flight programming and strike prime enemy targets with a nuclear warhead payload. The missile is relatively small; its engine is a Pratt & Whitney J-52 turbojet of about 7500-pounds thrust. It burns the same fuel as the B-52 and is fed from the aircraft during captive flight. The engine pod is mounted on the underside of the body.

The body has several compartments, divided to accommodate the nose cone, forward equipment, autonavigator-warhead, integral fuel tank and the aft equipment. The nose cone contains elements of the arming and fuzing systems. Most of the other missile subsystem assemblies and components are located in the forward equipment compartment mounted on a structural beam. The missile nose cone is removable for maintenance access. With the nose cone off, the entire forward equipment compartment skin shell is removable, thus providing 360 degrees free access to the components mounted on the structural beam.

Fuel for launched flight is carried in the single integral tank over the engine. An equipment compartment aft of the fuel tank houses the missile hydraulic system reservoir and the electrical generator. The electrical generator and the missile control surfaces are driven by hydraulic power from a pump mounted in the accessory cowling below the engine.

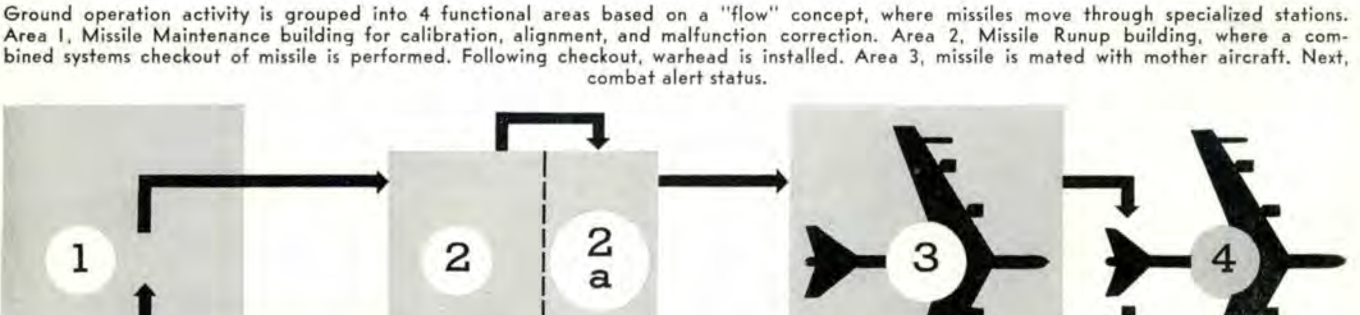
The pylon is attached to the missile at all times, except *after* the missile is launched. Autonavigator alignment equipment is mounted in the pylon just above the stable platform. The pylon contains an ammonia tank to provide coolant capacity for extended captive flight operation.

There are two important points relative to HOUND DOG design:

First, from its inception, the HOUND DOG has been designed as the *operational* version. The research and development version will not be redesigned into an operational version. The flight test activity is working with essentially an operational article and simulates as much as possible the operational environment and procedures.

Second, the HOUND DOG program is an accelerated one. This is one of the reasons why the design is predicated upon the maximum use of developed and proven components. Likewise, because high assurance of meeting the operational date with a safe, reliable missile was paramount, the design has not been based upon extremely close margins, load factors, or allowables. Structurally, it is not a marginal design.

Ground operation activity is grouped into 4 functional areas based on a "flow" concept, where missiles move through specialized stations. Area 1, Missile Maintenance building for calibration, alignment, and malfunction correction. Area 2, Missile Runup building, where a combined systems checkout of missile is performed. Following checkout, warhead is installed. Area 3, missile is mated with mother aircraft. Next, combat alert status.



dog

The missile equipment in the B-52 has been held to a minimum. It includes a starting and control panel for the engines at the copilot's station. A second panel, located at the bombardier-navigator's station, provides for autonavigator alignment, warhead, and arming and fuzing controls. Several modes of jettison and emergency missile release are provided at each of these stations.

Ground operation activity is grouped into four functional areas.

- One area includes a maintenance building where inspections, troubleshooting, and general maintenance can be performed on the missile subsystems and components.
- The second area is the missile runup building with provisions for an automatically controlled combined systems checkout of the missile.
- After satisfactory combined systems checkout, the missile is moved to the preparation (or third) area. Here the missile is mated with the B-52 bomber. The aircraft is loaded, inspected, serviced and otherwise prepared for alert status or for a training flight.
- The fourth area is the alert area, where bombers and missiles are held on continuous alert status, ready for a combat mission.

The identification of these areas is related to the maintenance concept. It is distinctly a "flow" concept, in which the missiles move through specialized stations.

Missiles normally move from the maintenance hangar to the combined systems checkout station. If they malfunction during the checkout, they are returned to the hangar for corrective action and are subsequently put through combined systems checkout again. Corrective maintenance will not be performed in the combined systems checkout, because missiles in this position are closed and in as nearly a ready-for-flight condition as possible.

After completion of the combined systems checkout, warheads are installed in the missiles which are then delivered either to ready storage or to the preparation area for installation on bombers.

Missiles which are removed from a bomber because of an indicated malfunction or are due for periodic maintenance, will be returned to the maintenance building for troubleshooting and correction. Missiles which are *not* due for periodic maintenance and which do *not* have malfunctions will be returned to alert status on another bomber or placed in ready storage.

When a missile has been repaired and inspected, it is moved into the combined systems checkout building which has three sections. The building is constructed with a blast and fire wall between the control room and the missile area, and has a "blow-off" roof. The control room contains the automatic checkout equipment.

The missile is placed in the center bay of the building on a flight attitude positioner which is our rock-and-roll device to simulate flight conditions. The unit to the left of the missile is a cooling unit which provides cool air for the equipment compartment.

When the checkout has been completed, the missile is moved into the warhead installation room where the warhead is installed. The warhead is not in the missile during the combined systems check, as a safety precaution. Warhead installation will take place when the combined systems position is being readied for another missile. The missile is then moved either into ready storage or out to the preparation area.

Ground transportation is accomplished by sliding the adapter and missile onto the rails of an Air-Log positioning trailer. With the adjustable feature of the Air-Log trailer, the missile can be transferred to fixed position work stand rails, as is the case in the maintenance area.

There is a fire detecting system between the engine and the nacelle. Its purpose is for inflight safety. There is no accompanying extinguishing system, but operating procedures have been developed for use in case a fire is detected. If these procedures fail, the HOUND DOG can be jettisoned. Perhaps one of the *most* significant facts with respect to HOUND DOG inflight safety is that *the missile can be jettisoned*. Most of the crewmembers have ready access to jettison buttons, in the event a hazardous situation arises in which the missile could endanger the bomber.

However, even though being able to jettison a missile provides a measure of additional safety to the B-52 and its crew, it poses a whole series of safety problems. These include:

- Insuring a safe separation with adequate clearance of the missile from the aircraft;
- Prevention of inadvertent release, and
- Safety from disaster by detonation of the warhead in the event of a willful emergency release.

Since jettisoning cannot be used on the ground, other methods are required. In the event a fire occurs when the missile is in the combined systems position and the missile is buttoned up, a manually operated foam system would be used. The knockout panels permit entry of the foam into the annular space.

Another ground operation problem concerns the fuel tanks. Whenever the HOUND DOG is removed from the aircraft, the fuel tanks are made safe regardless of fuel ullage (amount used or lost) by an inerting unit on the missile handling adapter. This unit puts nitrogen gas over the fuel under low pressure.

Aerodynamic studies have shown that if the missile control surfaces were hard over at the time of launching, the missile could be driven into the B-52 structure. The first and most obvious solution to this problem was to lock the control surfaces until *after* the missile was launched. However, the control surfaces were required almost at the moment of launch for recovery and stabilization into a free flight condition. In addition, it was desired to operate and monitor all systems including the surfaces for proper operation during captive flight and a requirement existed that in the event of a malfunction, the missile could be dropped as a bomb.

The North American Aviation-Boeing Safety Committee and the aerodynamic and flight control system engineers solved these problems after much study and coordination.

The control surfaces were ultimately locked during the captive flight and a sequence of unlocking was employed at the time of normal missile launching. The ailerons and rudder are unlocked just after release, and the forward elevator is unlocked three seconds after release. The locked control surfaces provided for a safe release and free drop under any condition, except for the normal launching. The unlocking sequence provided for recovery and control of the missile in stabilized flight for the normal launching.

An interesting side light to the problem of locking the control surfaces was that of employing the missile as a free fall bomb. A winged vehicle would normally have a very unpredictable trajectory. Locking the control surfaces in a slightly canted position causes the missile to spin as it falls. This provides stabilization in free fall and greatly improves predictability of the trajectory. Safety-wise, this is significant because the crew can *ascertain quite accurately* where a jettisoned missile will hit.

The second problem associated with missile release is the prevention of inadvertent release. Two possibilities have had to be dealt with.

The first was human error, and the second was breakdown or malfunction of equipment.

The initial design proposed explosive bolts for attachment of the missile to the bomber. This design was simple, efficient and inexpensive. It became apparent, however, that there was danger of accidental firing of the squibs by erroneous connection, worn insulation resulting in shorts to a power source, and stray currents. It was not a foolproof system. It was determined that there should be a physically actuated attachment of the missile to the bomber which could be mechanically locked against inadvertent actuation. This resulted in what we call the "collet release system." It consists of large structural bolt heads attached to the missile, one fore and one aft, which are held by grasping collets attached to the pylon. The collets are opened by actuator rods driven by solid propellant cartridges. A separate motor-driven locking pin actuated by a completely independent circuit locks the collet in closed position so that it cannot be opened by inadvertent firing of the cartridge actuator.

To us at the Missile Division, the weapon system includes everything that enters into the make-up or operational employment of the flight article that strikes the enemy. This takes in the missile, the aircraft, ground facilities, ground support equipment, checkout and maintenance equipment, air and ground personnel, airborne and ground procedures, training and logistics supply.

The weapon system approach adds specialists in the areas of looking at the whole system to find and help correct incompatibilities. These are the so-called big-picture people who have experience and knowledge in nearly all the areas and elements of the weapon system integration activity. Their major problem is not in uncovering a wrong or incompatible solution but with the attitude expressed by some of the desk mottos we've all seen, such as, "Don't confuse me with the facts, my mind is made up," and "Be reasonable, do it my way."

However, once these big-picture specialists get working closely with the functional group's designers, the bene-

Upper left, flight attitude positioner is rock-and-roll device to simulate flight conditions. Lower left, Air-Log positioning trailer is rolled under wing, preparatory to mating the missile to its carrier. Lower right installation nears completion.

Above left, B-52 bomber and HOUND DOG missile sit on alert status.
Above right, B-52 takes off on alert mission with two HOUND DOGS in launching position.

fits derived from a more efficient, compatible, and safer system are soon evidenced.

One of the first steps taken by the specialists in HOUND DOG development was the generation of a Weapon System Specification. In fact, contractual negotiations were contingent upon the WSPO's receiving and approving a weapon system specification which delineated the whole of the WS-131B characteristics, components, performance and operating procedures. In so doing, practically every part of the weapon system was investigated, analyzed and conceptually detailed before major design activity was underway. This activity made every functional group aware of where and how it fitted in.

When the WSPO accepted the specification, the requirement for it to guide the whole research and development program was adamantly stated. This was and still is concurred in by the Missile Division management.

Although the Missile Division is responsible for revising the Weapon System Specification, it has not yet had to make any major revision. Basically, the specification stands today as it did at the start of the program.

Another step taken early in the program originated when the question of "How many missiles should be assigned to a squadron?" had to be answered in order to do realistic planning and provide data for procuring long-lead-time articles. To satisfy these data requirements, an analytical model of the weapon system was developed, before any of the hardware existed.

This process was basically an operations research approach, that of setting up an analytical model of the system and using Monte Carlo techniques, simulating the day-by-day operating characteristics of the weapon system. This approach gave us much valuable planning data at an early date. It was a rather unique approach and it paid off in many ways. In addition to establishing general weapon system operating procedures, it provided a basis for identifying the squadron missile quantities and the nature of missile workload requirements and movements on the ground. It also provided a basis for estimates of manpower, facilities and equipment.

Human factors considerations also have entered into the problem. The Missile Division has conducted an extensive human factors analysis of the entire man-machine system.

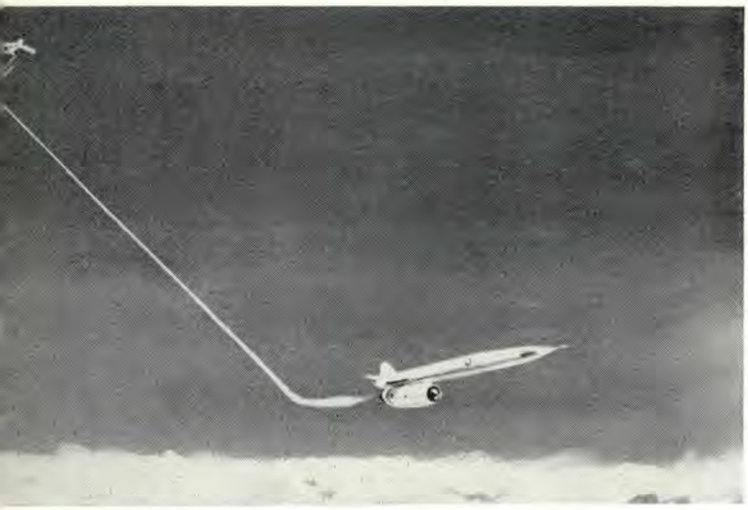
The basic purpose of this analysis was to maximize reliability and safety by minimizing the possibility of human error. Specific objectives were:

- To facilitate rapid and efficient inspection and checkout of all equipment during ground activities and to simplify maintenance requirements.
- To permit safe and efficient handling of the warhead.
- To maximize the probability that operators would be aware of any unsafe conditions and that means would be available for rapid and proper action to eliminate potentially dangerous conditions.
- To insure error-free inflight monitor and control activities by providing continuous indications of equipment conditions.

Results of this analysis consisted mainly of the identification of error-likely or potentially unsafe conditions and specific recommendations for the modification of equipment or changes in tentative procedures for the operation, handling and maintenance of the system.

From the very beginning, safety has been a continuing major consideration and, because of that fact, it is difficult to ascertain those safety precautions which were the direct result of the man-machine analysis. We do know, however, that there are many.

Another method used to design safety into the weapon system is called Weapon System Problem Reports (*abbreviated WSPR, and called "whisper"*). It goes much deeper than the Unsatisfactory Report or UR system. Design deficiencies and unsatisfactory conditions, not just equipment malfunctions, are the subjects of WSPR's. A better way of accomplishing a task or design ob-



THE HOUND DOG (Cont.)

●

jective may be suggested for even a satisfactory way; potentially dangerous situations are reported before an accident happens. A recent check by WSPR showed that only 30 per cent would have been the subject of URs. In another check, 4.7 per cent were found to have uncovered direct safety problems. Many more had safety implications.

Throughout the HOUND DOG development, there has been an active reliability program. It involves record keeping of component malfunctions, and the Weapon System Problem Report is the mechanism for documenting any trouble. Estimates and predictions are made of system reliability and as data are received from tests, these predictions are verified or re-evaluated. They have pinpointed troublesome areas and contributed materially to resolving them. The reliability predictions and measurements are concerned with a component successfully operating when it should, and not operating when it should not. Thus, the reliability program encompasses both success and safety.

So far, we have covered the HOUND DOG weapon system description, some of its safety problems, and the methods by which we feel we have designed safety into the weapon system. This is not to say that everything has been a bed of roses; far from it. The fact that real safety problems have not been evidenced by repeated accidents or malfunctions does not in itself prove that the methods have been totally responsible for the success. One can only speculate what might have happened if things had been done differently. To date, we have experienced no major malfunction in flight test which resulted in an unsafe situation. There has been one inplant accident in which a man's finger was injured when a fuel tank bulkhead gave way in a pressurization test.

The HOUND DOG differs from other weapon systems in several ways which perhaps increase its safety problems, and at the same time materially help to solve others. Many weapon systems are designed for essentially a one-show warfare operation. But since HOUND DOG is turbojet powered, it is capable of operating on the ground and during captive flight. Certainly the environment of these two conditions does not exactly duplicate the free flight environment. But many thousands of hours of complete systems operation will be realized and it will accrue at a rapid rate. A single squadron equipped with less than 20 missiles could build up systems operating time at the rate of 300 hours per month.

This day-in-day-out continuous operation will uncover practically all the bugs, safety and otherwise, not uncovered during the flight test phase. Flight testing also has the same opportunity of running systems on the ground and in captive flight to thoroughly checkout and de-bug the system. Couple this fact with the use of already developed and proven components and a great step forward has been taken safety-wise!

However, this operating time benefit is realized at a certain risk. Operating the weapon system at such a high rate increases the opportunity for even the most improbable event to happen. With aircraft and missile combinations fully armed, providing a strike-ready force or conducting simulated missions—takeoff, flying, refueling and landing—the hazards could be extremely great; therefore, the solutions and procedures for malfunctions or accidents must be as foolproof and fail-safe as they can be. One can rationalize this problem by pointing to the fact that this mode of operation is really not different from today's operations with aircraft that do not now employ missiles. This *is* true, but the chances of hazardous malfunctions have been greatly increased.

Even for that one awful time when HOUND DOG would be used in an all-out war, provisions must be made to insure safety to friendly and neutral nations. These provisions add complexity and weight to the system. Those of you who are familiar with the warhead safety problem will appreciate its ramifications. It is of such magnitude that I am sure you will consider these provisions in detail, along with a more detailed approach to some that have been mentioned. ▲

Left, sleek and supersonic, the F-105 presents an imposing appearance. Advance design includes swept-forward air intake ducts. Lower left, unique cloverleaf speed brakes are shown partially open.

"THUNDERCHIEF"

Rusty Roth, Experimental Test Pilot, Republic Aviation Corporation.

"**The world's most powerful fighter-bomber**" is a phrase that was contained in a statement by General Otto P. Weyland, Commander, Tactical Air Command, during acceptance of the first F-105 aircraft for that command's "Category III" tests at Eglin Air Force Base.

I'd like to add that the F-105 is also the world's most potent fighter-bomber. I've grown up with it, from the drawing board through the F-105A, the B, and soon to hit the field, the F-105D. This is an easy airplane for a pilot to like, in fact, it would be difficult for a pilot not to like the "Chief." It has been designed to *do the job* that TAC requires of it and then some. A pilot can fly the mission as comfortably as is possible for a Century Series bird. The safety features built into the airplane give you your best chance yet of retiring from advanced age rather than from collision with the ground.

Your first impression of the "Chief" is that it is a big airplane. Compared to WW II fighters and subsonic types, it *is* big. Compared to some of the other Century Series, however, it is not so big. Actually, it is four feet shorter than the F-101 and its wing span is four feet less than the F-100's.

As you walk up to the airplane, you'll see quickly why you don't have to worry about walking into the leading or trailing edge of the wing. It is seven feet from the ground to the wing. Our engineers have thoughtfully designed a landing gear that would reach from the ground to the wing, and this gear is strong enough to survive the worst treatment!

You have to get above the bird or watch it in flight to see the coke bottle shape of the fuselage, which is in conformance with the area rule design theory. The next eye catchers on the walk-around are the air intake ducts located at the wing roots. You won't have any trouble identifying the '105, once you see the ducts. They are completely different, but they're functional! The design is such that the engine gets all the air it needs at supersonic speeds. Adjustable plugs in the ducts that slide back and forth, prevent "choking up" on supersonic shock waves when over mach 1. Movement of the plugs is automatic and no additional action by the pilot is required.

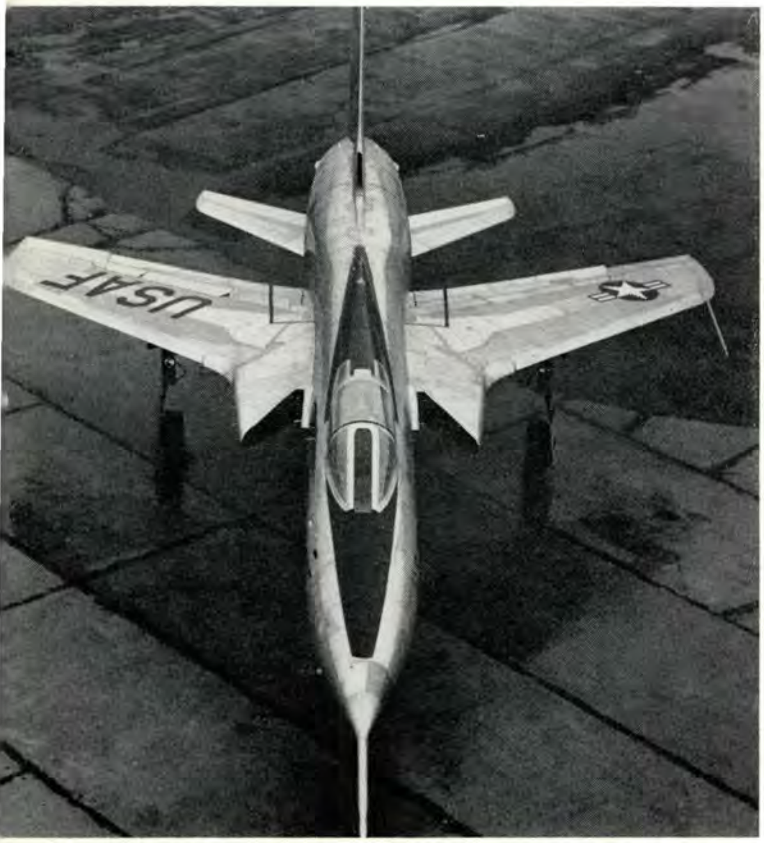
On the aft end of the fuselage is another new wrinkle—the speed brakes. The four boards actually form the tail cone. When used as speed brakes they present an area of 29 square feet. When the boards are fully open they will increase your drag 390 per cent at mach .8 and 300 per cent at mach 1.2. They will go full open in 3 seconds, at any speed. During flight all four brakes extend at the same time and may be held at any intermediate position from closed to full open *(50 degrees angle to fuselage)*. As the landing gear extends, the top and bottom boards automatically retract. This permits operation of the drag chute and insures that the pilot won't scrape the bottom speed brake on the runway as the airplane touches down.

A fin scoop slot in the base of the vertical stabilizer feeds cooling ram air to the aft section fuselage between the tail pipe and shroud. By being heated and accelerated, 800 pounds of additional thrust is gained as the ram air is passed through the exit.

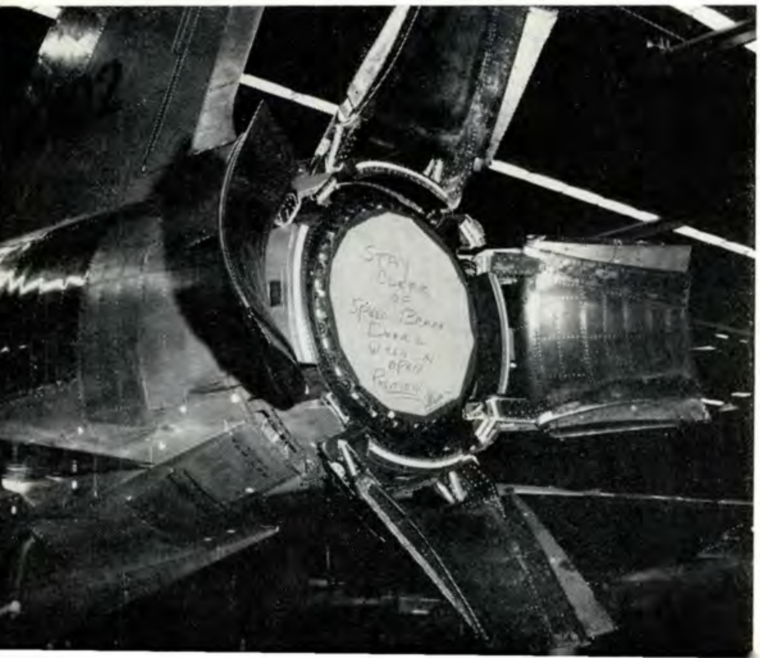
That's about it, for the exterior, so let's get in the cockpit and see what we have there.

The layout of the cockpit of the "A" and "B" series isn't much different from any late model fighter except that the cockpit has more room for the pilot than any other fighter I've flown. With the extra space you are more comfortable, therefore less fatigued on long missions. The cockpit of the "D" series aircraft is another breed of cat—although still spacious.

This is as good a time as any to give the whys and wherefores of the "D." It was recognized early in the life of the F-105 that for TAC to achieve a world-wide mobility and strike capability under all conditions, it would be necessary to add navigational and attack capabilities under adverse weather conditions. To increase navigational capability, the APN 105 Doppler Navigator was put in the F-105. This equipment permits automatic navigation over long distances with a *maximum* error of ½ of one per cent of the distance traveled between check points. Target location in weather is done by means of the radar ground map.



Above, the fin scoop is shown at the base of the vertical stabilizer. Below, the enormous speed brakes are pictured in full open position.



For letdown through weather the terrain avoidance or contour map mode is used. The entire system incorporates an air-to-air search, track and lock-on capability as well as air-to-air, air-to-ground radar ranging for all types of armament carried by the airplane. Very simply, the F-105D has an all-weather fighter-bomber capability beyond equal. The pilot has displayed before him a ground map, terrain avoidance and contour map. Coupling the radar to the Doppler automatic navigator in conjunction with a sophisticated fire control system enables the pilot to locate and accurately deliver a store on any target under any kind of weather conditions. Also, in any kind of weather a pilot is able to perform:

- Level flight bombing from any altitude,
- Low level blind LABS maneuvers,
- Blind dive bombing, and,
- New lay-down techniques.

With the use of this equipment, a fighter pilot can now perform missions previously relegated to large bombers with large crews.

As you sit down in the cockpit of the "D" the first major change you'll notice is the instrument panel. The top is sloped *(toward the nose)* at a 10-degree angle to give the pilot an improved view. This view includes the new integrated flight panel for which we've all been waiting. The F-105D is one of the first production line aircraft to be equipped with this new instrument presentation. Centered below the instrument group is the video display for the R-14A radar.

Next, you'll probably notice that the console surfaces have a 20-degree slope in lateral elevation. The forward portion slopes upward to an intersection with the auxiliary instrument panels at a height equal to the lower edge of the main instrument panel. The surface of the right hand console is extended outboard between the cockpit frames. *All major controls are forward of the armrests.* The forward slope of the instrument panel, console inclination, and forward controls give the pilot visibility, readability and accessibility that he has long wanted but hasn't had.

Left and just forward of the windshield is the air-to-air refueling probe. With the probe extended, it is simple enough to eyeball the probe and tanker at the same time. This makes air refueling easier and a lot safer than when the probe is located in the wing. Fuel is distributed through the manifold to all internal and external tanks. The F-105 may also be fitted with an interchangeable package "buddy" refueling unit. The package consists of a 450-gallon tank fitted with a hydraulic powered refueling boom. With two additional 450-gallon tanks the '105 becomes a tanker for "buddy refueling," resulting in a 70 per cent increase in striking range.

Starting the "Chief" is conventional. In the late B model and the D series, Republic has put in the shotgun starter system similar to the B-57's except that it is smokeless. This eliminates the necessity for a ground power unit standing by. You can taxi the airplane with just the brakes but nosewheel steering is installed to make it easier for ground handling.

In discussing takeoff and landing distances, I am going to have to give typical distances, and so on. To give you specifics would involve liftoff, basic aircraft and fuel weights. For security reasons I can not do this. The same holds true for mission range. At a later date, maybe I can write an article on the portions that are now classified. I am able to say, however, that takeoff and landing characteristics are excellent. The average clean aircraft takeoff distance will be around 3000 feet. Most landing rolls will be approximately 3500 feet, using the 20-foot drag chute. As stated by the pilots of the 335th Fighter-Bomber Squadron, "If you can fly a T-33 from a given runway, you can also operate the '105 from the same runway." This squadron, commanded by Lt. Colonel Bob Scott, is a part of the 4th Fighter-Bomber Wing, Seymour Johnson Air Force Base, North Carolina.

The 335th was the first tactical unit to get the "Chief" and is at Eglin Air Force Base, Florida, running tests under the new "Category III" concept. Essentially, this calls for TAC and ARDC to conduct the tests jointly. Previously, such tests were carried out by the Air Proving Ground Center and other Air Force agencies and the results turned over to TAC. It is expected that the new system will save about two years from the previous time for the acceptance-to-squadron cycle.

A great deal of effort has been made to obtain maximum reliability of the drag chute. As a result, the present production drag chute has a reliability rate of 99 per cent. Planned improvements are expected to raise this rate even higher. Drag chute reliability has helped to get 60 or more landings on one set of tires during tests at Eglin.

The ease of flying the airplane has been commented on by every pilot following his initial checkout flight. Stability and control, especially during takeoff and landing, are excellent. It is a high wing loading, high performance machine. As in other similar type aircraft it requires that a power pattern be flown for landing. Normally, I use 175 knots over the fence with 160 knots at touchdown. This varies with the landing weight, so I suggest that you use the Dash One as your guide.

The Thunderchief displays exceptional stability about all axes. Unlike other Century Series high performance aircraft, the F-105 has been demonstrated throughout its flight envelope *without the aid of stability augmentation*, although we've installed stability augmentation on all axes to bive optimum control to the pilot. Therefore, should these mechanisms become inoperative, the mission can still be successfully completed.

Much has been said concerning pitchup and roll-yaw coupling in the Century Series. In well over 3500 test flights we have demonstrated the '105 to be completely free of pitchup and it will not diverge or uncork during rolls.

As far as spins go, I've spun the '105 many times and the recovery technique is straightforward; rudder against aileron with stick back, the recovery is clean and precise. Spin rotation is slow, approximately 6 to 8 seconds per turn, and can be stopped in half a turn. Altitude loss during spin is approximately 2000 feet per rotation with 8000 feet needed to pull out.

On our test aircraft we had a spin chute and another device or two *to be sure* we could get the airplane out of its spin orbit. We've never had to use any of the safeguards for recovery. As far as I'm concerned, *use the recommended spin recovery*, and you will get the '105 out of any spin you can get it into.

The speed and wheel brakes, landing gear, leading edge flaps, bomb-bay doors, M-61 gun drive, air refueling probes, nosewheel steering, engine air bleed doors, and duct plugs all obtain hydraulic pressure from the utility hydraulic pump. The only pneumatic system in the aircraft is for bomb delivery ejection. Hydraulic pressure for the tandem flight control actuators is received from *two* engine driven pumps. Each pump has an independent reservoir and is capable of operating the flight control system by itself. Just forward of the cockpit on the right side is a ram air turbine (R.A.T.) to provide a third power source for the flight controls. If all the other hydraulic pressure sources fail *(this never has happened)*, or if the engine seizes, the pilot can manually extend the ram air turbine. Speed limitation is 575 knots or mach 1.3, whichever is lower. Successful test landings have been made using this ram air turbine as the only source of hydraulic pressure.

The ejection seat is similar to that installed in late production model F-84F aircraft. This seat has a successful ejection rate of 100 per cent. During testing, two ejections were made without injury to the pilots, one in excess of 500 knots. The large speed brakes will enable a pilot to decelerate in 30 seconds from a high airspeed to a safe ejection speed. There is no restriction on the operation of the speed brakes. They can be safely opened from mach 2 at altitude or 815 knots on the deck. One word of caution, however: Make sure the shoulder harness is locked when extending the speed brakes at high speeds. No trim change is present but the rapid deceleration will put you in the shoulder straps. As Captain Bob Titus, of AFFTC at Edwards, says, "The reason my nose is pushed off to one side is that I forgot to lock the harness and I hit the instrument panel at mach 2."

As for armament, the "Chief" is as versatile an airplane as you could want. It mounts a 20 mm automatic cannon (Gatling type) capable of firing 6000 rounds a minute. It can carry clusters of rockets, guided and unguided missiles, and over 4000 pounds of conventional and napalm bombs. Various "shapes" *(THE WEAPON)* are carried in an internal bomb bay.

Normally, you can't say much about a battery but the one in the "Chief" deserves special mention. It's a Silvercel battery and a real hefty one. Should a pilot lose the DC generators, this battery is capable of supplying enough power to operate the *entire* electrical load of the aircraft for 4 to 5 hours and still have enough left to lower the trailing edge flaps twice at return to field. This time includes a 30 per cent safety factor.

If I have given you the impression that the Thunderchief is for the 100-hour-a-year, gooney bird driver, I've done wrong. The F-105 is a potent, high performance, mach 2, single-engine jet fighter. It deserves respect and requires competence. As it should be, Republic has taken advantage of the lessons learned and has built into the machine *many* safety of flight features. As of this writing, more than 3500 test flights have been completed without a fatality. Given a fair shake, the F-105 won't let you down—without your permission! ▲

When the time comes for the first American to track in orbit around this globe of ours the chances are good that he will be. . . .

TAKING THE "A" TRAIN

In October of 1958 the National Aeronautics and Space Administration initiated a program to put the first U.S. manned capsule in orbit. Called Project Mercury, this program will employ a Series D Atlas missile to power the payload into space. Much publicity has been given to the group of seven space trainees, one of whom will ride in the nose capsule for the damnedest sling shot ever. Much has also been written about the Atlas missile which will provide the boost for this pioneering flight. The point is that now with McDonnell Aircraft Corporation progressing rapidly with the development of the man-carrying capsule *(7 feet wide and 10 feet high)* some serious thought will be given to Atlas reliability by the men who will soon be perched on the pointed end of this terrific power package. In other words, there are two main problems to be considered in any earth orbiting venture. First, how to safely get the man into space, and second, how to safely recover him. This article will deal primarily with the launching phase. This is as it should be. For if the man, he don't go up, why worry about him getting back?

Just what do we know about the Atlas? It is, of course, our first intercontinental ballistic missile and the first U.S. missile to lift itself into orbit without extra rocket stages. The missile has been involved in a flight-test program that began in mid 1957 and became operational in September, 1959. Originally the Atlas was designed to deliver a thermonuclear warhead more than 6325 statute miles. It is powered by liquid propellant rockets, two large boosters, one large sustainer, and a pair of small "vernier" rockets. Takeoff weight is 260,000 pounds, but takeoff thrust is about 360,000 pounds. Though flight versions will vary the length, the Atlas is about 75 feet long and 10 feet in diameter.

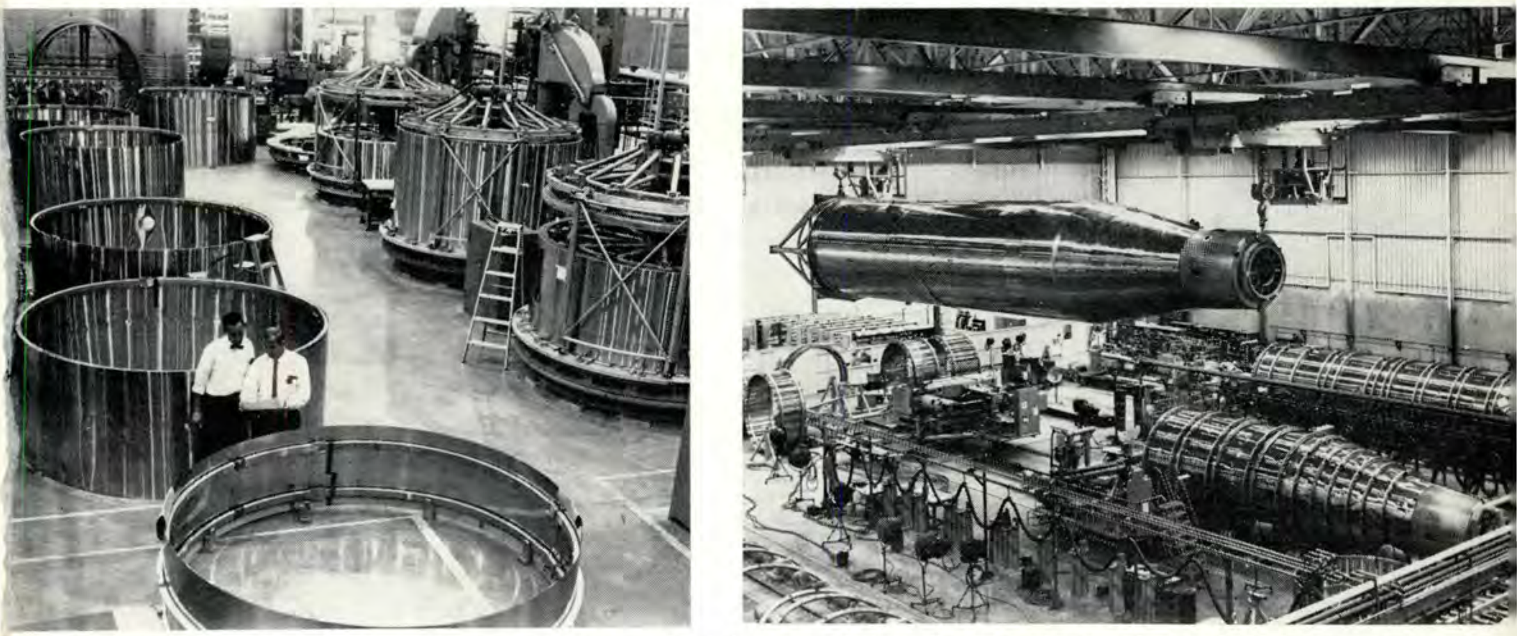
Space House—crew of the Atlas Orbital System would live and work in forward tankage of ICBM launched into a 400-mile orbit. Rotating station would give the crew an acceptable artificial gravity.

All these figures are impressive, but the unique features of the Atlas are not its sizable dimensions. Perhaps the most surprising feature is its structure. This huge shape actually has a skin thinner than a dime, and it must be kept at about 10 psi pressure while handling and moving to keep it from collapsing like an underinflated balloon. The Atlas can be likened to a football, which maintains its familiar rigid shape and survives brutal punishment by virtue of its internal pressure. But more than that, the thin but exceedingly tough skin alone forms the container for tens of thousands of pounds of petroleum and liquid oxygen propellants. This "tank" (*minus the nose cone and rockets*) measures about 60 feet in length and has no internal framework. While this type of structure would seemingly be fragile, the Atlas actually is extremely tough. Its thinnest wall section meets a specification for minimum tensile strength of 200,000 pounds per square inch. At the forward end the tank tapers smoothly to a domed stainless steel bulkhead. A similar, larger bulkhead is located near the center of the tank to separate the two propellant storage areas, and a third bulkhead of conical shape forms the aft section of the tank. Helium, fed into the space remaining at the top of the propellant levels, does a dual job of helping force propellants to the 360,000-pound thrust Atlas engines, and keeping the balloon-like skin drum tight throughout the severe loads of launching and flight.

The structure's toughness was dramatically demonstrated during the first Atlas flight in June 1957, when propulsion was lost at an altitude of only a few thousand feet. Before it was destroyed by the range safety officer, the missile—which still contained more than half of its load of propellants—went through a series of violent gyrations, including a loop, yet remained intact.

What does this mean to the future astronaut? A more favorable mass ratio, that is the ratio of a rocket's weight at launch to its weight when all propellant has been burned, means that a greater velocity and range are possible.

An important safety factor to be considered when discussing the Atlas is its staging sequence. All five of the



Left, welded bands of thin, stainless steel make up tank sections. Note the near-surgical cleanliness of work area and material. This is imperative for safe missile operation from factory to launch. Right, the 60-ft. tank is completed. It is now pressurized to enable it to hold its shape.

rockets are ignited prior to launching. After a few minutes of flight, during which the missile is lifted well into its trajectory, the booster engines and associated equipment are jettisoned to lighten the load. No chance of misfiring of subsequent stages here. The sustainer engine continues to accelerate the Atlas until it has attained a velocity on the order of 16,000 statute miles per hour. Then the sustainer is shut off, and the small vernier rockets are used if needed to "trim" velocity to the exact value required.

The first German rockets re-entered with the complete structure intact; the Atlas has a separate nose cone feature. After vernier shutdown, when the missile is following a purely ballistic (unguided) course, the nose cone is separated from the rocket structure by firing small "retrorockets." Nose cone and tanks travel in a high arc through space until the atmosphere is re-entered, then the tank structure is destroyed by frictional heating. The problems of safe re-entry would be greatly compounded if the complete structure were involved.

A fourth feature of the Atlas which was unique at the time its immediate predecessor (the MX-774 rocket) was built is the method of directional control. The MX-774 and the Atlas pioneered the first swiveling rocket engine to maintain stability and control during launch and flight. The German V-2, for instance, used rudder-like graphite vanes placed in the jet stream. An interesting sidelight here is that during the separation of the booster engines and superstructure, the sustainer rocket swiveling action must be nulled momentarily to assure that no collision of parts is allowed. As soon as separation is complete the sustainer guidance swiveling action is resumed. This swiveling of the rocket engines is done by gyroscopic intelligence and hydraulic power.

A missile, like any vehicle, must be exhaustively tested before it is judged ready for its mission of destruction, or its mission of space exploration. From the outset of the ballistic missile program, it was apparent that the complexities and unknown factors outweighed those of any other ever attempted. The test program of the Atlas is a story in itself, but a few remarks are in order to point out the thoroughness which characterized the approach to the problem.

There are three main phases of missile testing. First is the on-ground and captive phase. Flight testing is the second phase, and operational support testing is the third. These cannot be considered separately. They must, by their nature, be conducted concurrently. While a prototype missile is being developed, the tools, machines, and the plant to manufacture and test it are being built. While launching facilities are being designed, training plans are drawn up. While operational ground equipment is being blueprinted, the logistic support is being planned, from spare parts to maintenance, from trucks to base construction.

Since the powered flight of a long-range missile is

Taking the "A" Train (cont.)

measured in minutes, without careful planning and extensive ground testing, hundreds of test flights of the sort now going on would have been required to accumulate the necessary test data and experience. In this respect, it is useful to keep in mind that the relatively primitive German V-2 of World War II required 2000 full-scale test flights to produce during 1944-45 some 6000 operational missiles, of which 3600 were launched against London, Antwerp, and other targets.

Early in the development stage of the Atlas, it was recognized that the complete operation of the missile must be as safe as humanly possible. It was decreed that men would not be exposed to any launching hazards that could be anticipated. This philosophy dictated the planning of a completely automatic, or rather a remote control automatic, procedure of missile servicing, test and launch, once the weapon was erected on the launch pad. Out of this planning came what is now known as the ladder sequence of operation. This means that every action must be correctly done before the next step can take place. If at any time during fueling or countdown, a misstep is made, or a pressure reading is found wrong, the whole operation is halted electronically until the error is corrected. There have been no injuries to personnel during test launchings since the Atlas test program began. This is indeed safety in action.

Launching climaxes the success of all previous safety operations.

There seems to be no doubt that the Atlas will be completely ready for the Mercury Project, man's first venture into space. Test pad accidents, according to the engineers, have never been of such an abrupt nature that the man in the capsule could not have been removed by appropriate emergency methods, before the missile itself was destroyed. A boom carrying emergency escape rockets will be fitted atop the space capsule during launching for just such an emergency. This boom will be jettisoned once the capsule is safely in orbit. There have been random failures of the Atlas in spite of all the exhaustive planning, but the fixes for all of these should be in before the first manned orbit is attempted. Safety will be built in for the chosen one of seven pilots now undergoing training for the first flight.

Can the average AF crew handle the Atlas operationally as safely as the engineers who built it? The answer is yes to both questions, according to John Harrison of the Field Test Support unit, who fired the first Atlas test missile. Convair has been training the selected crews for several months and they have demonstrated their complete capability to handle the job.

As the Air Force takes over the operation of its first ballistic missile, one of the prime considerations is safety. Unlike safety in aircraft operations, the bulk of safety concern and practice in missiles operation is in the design and preflight phases, and preparation for launch, and the actual launch. Once the missile is up and away there is little that man can do to affect the safety of its operation. An airplane may be in flight for many hours at the control of its crew. The missile will be airborne a matter of minutes and its ultimate goal, until man starts to go along, is destruction of its target and itself. So safety of the Atlas has been built in from the drawing board on.

According to D. R. Archibald, the Astronautics Division's Chief of Quality Control, extreme methods are being employed to assure that every part and piece of the Atlas will be delivered without flaw. For instance, microphotography is now being used to spot tiny imperfections or foreign bodies in the innards of the big weapon system. Mr. C. S. Ames, Chief Project Engineer, and Mr. K. J. "Charley" Bossart, Technical Director of Convair's Astronautics Division, sometimes called the "Father of the Atlas," are confident that they have built a missile —and ultimately a space vehicle—that will exceed all expectations of the Air Force when the time comes for that "lucky" first man to take the "A" train. ▲

a Men

Captain
David N. Leavitt
325th Fighter Wing (AD)
McChord AFB, Washington

Captain
Arthur M. Holtorf
3640th Pilot Tng Wing
Laredo AFB, Texas

Captain
Charles W. Fortney
Rome Air Develop. Center
Griffis AFB, New York

Captain
Ruey W. Blackburn
4126th Strategic Wing
Beale AFB, California

Captain
Armand J. Myers
332d FIS (AD)
England AFB, Louisiana

The men pictured are FSOs who have earned straight A's during a difficult eight-week course in aircraft accident-prevention at USC. Under the guidance of Dr. Louis Kaplan, former director, these officers grappled with the complexities of aeronautical engineering, aviation psychology, educational principles and methods. All students of classes 33, 34 and 35 merit a handshake and a well done. To the A—men who reached the pinnacle, Congratulations!

WELL DONE

1st LT. EUGENE J. O'SULLIVAN, JR.

32nd Tactical Fighter Squadron, USAFE

1st Lieutenant Eugene J. O'Sullivan, Jr., fighter pilot in the 32nd Tactical Fighter squadron stationed at Soesterberg, Holland, took off in an F-100C on an Air Defense Practice Mission. Until he rolled out on his IFR climb vector, the mission was routine. At that point, at an altitude of 1500 feet, a violent explosion in the left forward fuselage area was followed by smoke and eye-burning fumes in the cockpit. Diagnosing the difficulty as a ruptured main heat and vent line, which had caused the loss of an F-100 at the same base a year before, Lieutenant O'Sullivan called "MAYDAY," reduced power, turned off his electrical switches and prepared to jettison his drop tanks.

By this time the entire left side of the cockpit was extremely hot from the unregulated 16th stage compressor bleed air which blistered the paint and burned the insulation from the electrical wiring. Refusing to drop his tanks over land with the probability of injuring civilians, he flew over the Zuider Zee. Once he ascertained that there were no vessels below, he jettisoned his tanks. With a full internal fuel load still aboard, Lt. O'Sullivan turned back toward his home base.

Ignoring the extreme discomfort and the possibility of fire, Lt. O'Sullivan established a straight-in approach, turned on his electrical system only long enough for a final call to the tower, and landed safely with 6600 pounds of fuel.

His accurate analysis of the malfunction and his adherence to established procedures avoided the loss of an aircraft and the possibility of death or serious injury to civilians.

For his outstanding knowledge of the F-100C, his airmanship and his presence of mind under extreme stress, we extend to Lt. O'Sullivan a hearty "WELL DONE." ▲

FLIGHT SAFETY AWARDS

1 JANUARY THROUGH 30 JUNE 1959

10th Air Division
Elmendorf AFB, Alaska
AAC

54th Fighter Interceptor Squadron
Ellsworth AFB, South Dakota
ADC

•

62d Fighter Interceptor Squadron
O'Hare International Airport
Park Ridge, Illinois
ADC

•

87th Fighter Interceptor Squadron
Lockbourne AFB, Ohio
ADC

•

Air Proving Ground Center
Eglin AFB, Florida
ARDC

•

3302d Pilot Training Group
Spence Air Base, Moultrie, Georgia
ATC

•

3560th Pilot Training Wing
Webb AFB, Texas
ATC

•

3565th Navigator Training Group
James Connally AFB, Texas
ATC

•

1503d Air Transport Wing
Tachikawa Air Base, Japan
MATS

•

1607th Air Transport Group
Dover AFB, Delaware
MATS

•

45th Tactical Reconnaissance Squadron
Misawa Air Base, Japan
PACAF

•

801st Air Division
Lockbourne AFB, Ohio
SAC

57th Air Division
Westover AFB, Massachusetts
SAC

•

303d Bombardment Wing
Davis-Monthan AFB, Arizona
SAC

•

436th Tactical Fighter Squadron
George AFB, California
TAC

•

27th Tactical Fighter Wing
Cannon AFB, New Mexico
TAC

•

7625th Operations Squadron
Lowry AFB, Colorado
USAFA

•

49th Tactical Fighter Wing
Etain Air Base, France
USAFE

•

526th Fighter Interceptor Squadron
Ramstein Air Base, Germany
USAFE

•

322d Air Division
Evreux Air Base, France
USAFE

•

131st Tactical Fighter Squadron
Barnes Field, Westfield, Mass.
ANG

•

196th Fighter Interceptor Squadron
Ontario ANG Base
Ontario, California
ANG

•

512th Troop Carrier Wing
Willow Grove NAS, Pennsylvania
CONAC

WIRE
and
WAIT

RON MESSAGE		DATE 5 Jan 1948
1. BASE TO WHICH MESSAGE IS TO BE DELIVERED *(Name and location identifier)* Castle AFB	2. OTHER ADDRESSES AT THE BASE OF DELIVERY Commanding Officer 350th Bomb Sqdn	
3. AIRCRAFT IDENTIFICATION *(Serial No.)* 42-22695	4. TYPE OF AIRCRAFT C-47	5. PILOT'S LAST NAME Parker
6. TERM "RON"	7. NAME OF BASE WHERE AIRCRAFT WILL RON *(Location identifier)* Jacksonville	8. DATE(S) 5 Jan 1948

9. REMARKS *(KEEP TO AN ABSOLUTE MINIMUM)*

YOU WERE SO RIGHT. HAVE BATTLED COURAGEOUSLY AND VALIANTLY EARTHQUAKES, RAIN, SLEET, HAIL, SNOW, BLIZZARDS, TORNADOES, CYCLONES, THIRTY HOURS FLYING TIME IN DAUNTLESS DOUGLAS C47 VIA OGDEN PHOENIX SAN ANTONIO NEW ORLEANS AND AT LAST TO JACKSONVILLE FLORIDA WHERE TEMPORARILY GROUNDED (WEATHER) STILL ONE THOUSAND MILES FROM DESTINATION. WEARY BUT SPIRIT UNBROKEN FACE THE MORROW WITH SMILE ON COUNTENANCE. WITH LUCK REPEAT LUCK HOME BY MONDAY TEN JANUARY=

Van R. Parker, Major
(Signature and Grade)

FOR USE OF DISPATCH PERSONNEL ONLY

☐ TRANSMITTED ☐ RECEIVED BY *(Signature)*	DATE	TIME

SAVE the CRATE

IDEA SUBMITTED BY
MSGT RUSSELL C. SMITH, JR., HQ USAF

*U.S. GOVERNMENT PRINTING OFFICE 520961