VOODOO WISDOM

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McDONNELL Aircraft Corporation

VOODOO VISDOM

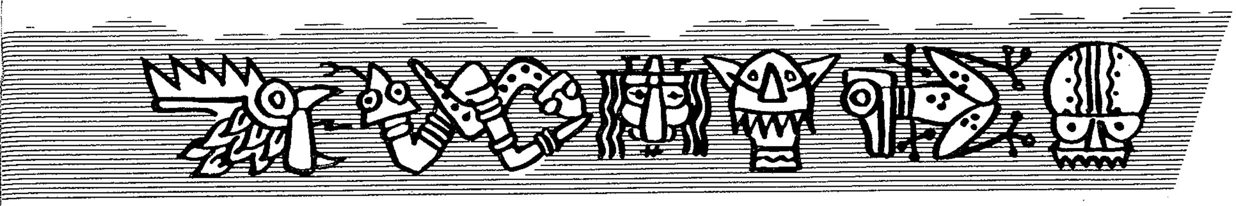


TABLE OF CONTENTS

DOUBLE FLAME OUT 2

THUNDERSTORMS-CLIMB OVER OR GO THROUGH 4

FUEL MANAGEMENT IN THE VOODOO 6

ABORT OR PRESS ON 10

COCKPIT PRESSURIZATION, AIR-CONDITIONING AND DEFROSTING 14

SAFETY AND THE VOODOO 18

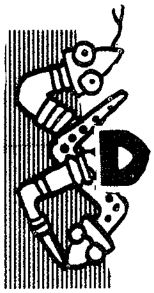
PITCH-UP 21

VOODOO-AIR DEFENSE STYLE 27

RUNNING OUT OF AIRSPEED AND IDEAS? 32

Editor's Note:

The articles appearing herein are reprints from the Field Service Digest, the section entitled "From the Flight Line" by D. H. Stuck, Experimental Test Pilot.



DOUBLE FLAME OUT

If you are a gambling man, you'd probably give pretty good odds against a double flame out in the Voodoo and you'd win. The Voodoo's engines are operated completely independently of each other and either engine will provide the pilot with every system capability.

The only way that a simultaneous double flame out can occur in the Voodoo is through fuel starvation to the engines. If you think this can only happen when the fuel gage reads "0", let's take another look at the fuel system.

Fuel for both engines is derived from a common fuel manifold. This manifold is fed by two booster pumps located in the No. 2 fuel cell. These pumps are ground checked prior to flight for proper operation and since one pump is sufficient to supply all fuel demands of the aircraft, there is no pilot check for proper operation during flight and no indication of failure of one of the pumps. With both boost pumps inoperative the engine driven pumps will "suction feed" fuel from the No. 2 tank. In general a pilot will notice no deterioration of Military or A/B performance below 25,000 feet. However, as the pilot climbs through the higher altitudes the fuel flow demands of the engines will exceed the "suction" ability of the engine driven fuel pumps and the engines will develop surge and loss of thrust. Corrective action is to reduce fuel flow requirements of the engines and descend below 25,000 feet.

If the aircraft is above 35,000 feet when both boost pumps fail a double flame out will occur since atmospheric pressure at this altitude is not enough to provide adequate "suction flow" to the engine driven pumps. Again the corrective action is to reduce fuel flow requirements to the engines and descend below 25,000 feet where normal operation can be resumed. This requirement can best be satisfied by pulling one engine directly to "stop cock" and the other to idle. As you point the nose down, depress the airstart ignition button on the "idle" throttle. (On block 35 and up the button only needs to be depressed momentarily since there is a 30 second hold relay incorporated into the circuit). By this method as soon as fuel is available the engine will start. There is little chance of a hot start since the engine is dry due to fuel starvation and windmill RPM will be high. You will notice that cockpit pressurization is slowly, but noticeably deteriorating so it wouldn't be a bad idea to go on emergency oxygen flow until you get squared away.

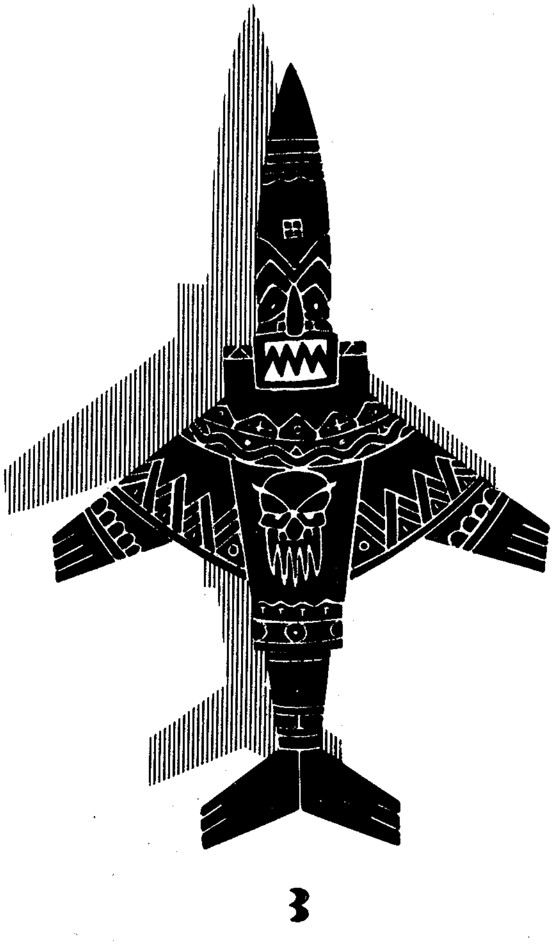
The airstarts will be characterized by rise in RPM after which TOT will rise slightly. After one engine is running at idle continue descent to 25,000 feet and increase power to ascertain it is functioning properly. After this, start the other engine and maintain altitude below 25,000 feet for the remainder of the flight.

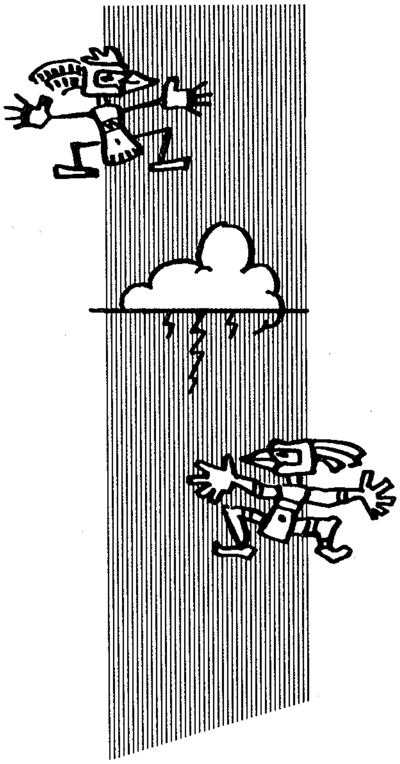
If, however, the first engine refuses to start, place the idle throttle to "stop cock". Prior to bringing the other throttle to idle ascertain that 30 seconds has elapsed from the time you released the airstart ignition button on your first attempt. This is to preclude having both airstart ignition units operating simultaneously which will overload the circuit. If the second engine also fails to start and fuel flow indicates that fuel is being delivered to the engine, the problem is probably an open ignition circuit.

The ignition circuits to both engines are protected by a single 10 amp circuit breaker and if this circuit breaker is tripped (it is not located in the cockpit) normal airstart ignition is not possible for either engine. Electrical power for ignition can still be obtained, however, through an unprotected circuit from the emergency bus. To activate this bus, both generator switches must be placed to the "off" position.

In summary you need fuel and spark to get a fire back in a dead engine. With both boost pumps inoperative you'll need to get below 35,000 feet to get enough fuel for start and below 25,000 to get enough fuel to run the engines at high RPM's. Spark can be gotten from airstart ignition through normal electrical circuitry, or, if the normal circuit is open, through the emergency bus by turning both generators off.

Chances are you'll never see a double flame out in the Voodoo, but it's nice to know the facts beforehand. It's hard to figure out what to do at the last minute, because the quiet is deafening.





THUNDERSTORMS - CLIMB OVER OR GO THROUGH

If you turn to Section IX of any pilot's handbook you'll find that one term is used in all of them concerning thunderstorms - "avoid them whenever possible".

This recommendation is not based on the assumption that the pilot or the aircraft is not capable of thunderstorm penetration, but on the philosophy "why put yourself in an uncomfortable situation if you don't have to".

The folks at WPAFB fly the all weather phase of every type aircraft delivered into the Air Force inventory. This naturally includes thunderstorm penetrations, so that the optimum penetration technique for the aircraft can be devised. However, with all the experience and data that Wright-Patterson has in thunderstorms no one will guarantee what you will find inside of one. From this fact comes the recommendation - "avoid whenever possible, but if you must penetrate here's the optimum way to do it -".

From the Handbook Section IX we can determine the optimum way to penetrate but how about the ways to avoid? Simple? You're right, - it is simple - only two alternatives: - change altitude or heading. So simple, as a matter of fact, that you may have overlooked the facts concerning just how high you can get this aircraft in order to top a thunderstorm. Your Voodoo, like any other aircraft, has an absolute ceiling. This is the point of your climb where every bit of thrust you're putting out is just maintaining level flight. There is no excess thrust available to push you any faster or higher. Since the thrust which you are commanding has to overcome the weight of the aircraft in order to "lift it" any higher, you can see that your absolute ceiling is definitely affected by your gross weight (fuel remaining).

Another factor we must consider is the critical angle of attack of the wing. As you know, angle of attack on the wing is a function of gross weight and IAS for 1g flight. You also know that as you climb at a given mach number IAS is falling off with increasing altitude. Therefore, angle of attack is increasing as we make a constant mach number climb.

Because of this it is possible under afterburning conditions to climb on the climb schedule to a point where the critical angle of attack on the aircraft is reached before the absolute ceiling. Under military power climb at recommended mach number, you will reach the absolute ceiling before reaching this critical angle of attack.

Since it would be impractical to work up and carry charts or plots expanded from the above example to tell you minimum IAS to fly at each altitude at each gross weight, it is best to use a rule of thumb that you can easily keep in your head for reference when you need it. The procedure outlined below will automatically round the aircraft out at the highest possible altitude that it can attain for the fuel you have remaining, commensurate with your flying comfort.

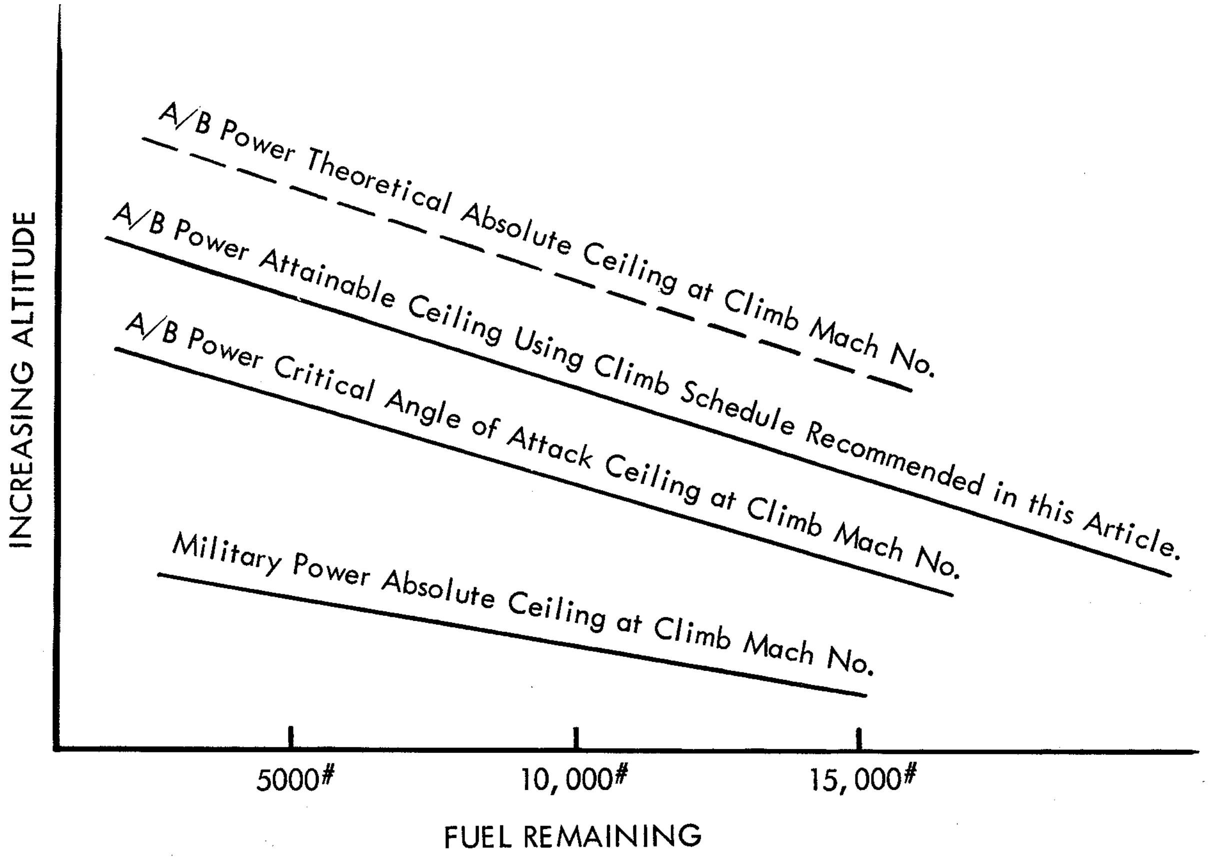
1. Hold recommended climb schedule mach number for the power setting you have selected.
2. Climb at this mach number until the IAS drops to 240 knots. From this point hold 240 knots IAS for the remainder of the climb. As you continue to climb at 240 knots IAS your mach number will start increasing and you will automatically be holding angle of attack constant and slowly rounding out to your maximum altitude.
3. If, after reaching maximum altitude in afterburner, you reduce to military power, hold 240 knots IAS until mach number drops to the climb mach number for your new power setting. This will automatically let you down to the absolute altitude for this new power setting.

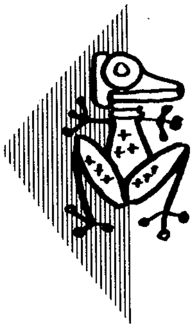
Next time you want to top a thunderstorm and you're forced to climb higher than your cruise climb altitude keep these few points in mind and climb away.

1. Don't ever let mach drop below recommended climb.
2. Don't ever let IAS drop below 240 knots.
3. If turbulence is encountered or expected, increase IAS to compensate for gust loads.

*4 If a decision is made to go higher or slower than dictated by 1, 2, or 3, above place the left hand on the drag chute handle after selecting maximum power - you'll probably be needing it.

*This last statement contains more truth than comedy.





FUEL MANAGEMENT IN THE VOODOO

The Voodoos in operational use today hold over 2000 gallons of internal fuel - with this amount of fuel you are flying not only the fastest tactical aircraft in the inventory, but also the one that can carry you the farthest, without support, to accomplish your mission. Fuel management, more than any other single item, can spell success or failure in any maximum effort mission:

Good fuel management falls into two general categories:

1. Knowledge and proper monitoring of the fuel transfer system, including emergency transfer techniques.
2. Proper operational utilization of aircraft performance.

Your job as a professional pilot with the Air Force includes knowing the aircraft systems that you are flying. In addition to getting the most out of your airplane for Uncle Sam, it is also good life insurance for you.

There are slight differences in the fuel systems between blocks of aircraft which represent improvements that you, the operating pilots, have indicated a need or desire for. These slight differences should be studied in technical publications so that you will thoroughly know the system you are flying. Basically the F/RF-101A, B, and C aircraft feed and transfer fuel in the same manner, with the following exceptions:

1. The A model aircraft utilize the common refueling manifold for transfer of wing and external fuel. This requires that transfer pumps be off during this transfer since internal fuselage transfer of fuel also utilizes this same manifold.
2. The Band C model aircraft transfer wing and external fuel directly into the bottom of No. 2 tank, thereby leaving the normal fuel transfer manifold available for normal fuselage transfer. This is accomplished by a dual float level switch in the No. 2 tank which allows external and internal wing fuel to feed into No. 2 tank before any internal fuselage fuel is used.

If fuel consumption is so high that wing and external tanks cannot sustain the full level in No. 2, the fuselage transfer pumps will supplement this feed through the normal fuselage transfer manifold. What this means to you as a pilot is this:

"A" MODEL AIRCRAFT

During normal fuselage transfer, No. 2 tank level will be maintained at 2800 pounds by normal transfer pump action. No. 1 and No. 5 tank will feed together until No. 5 tank goes empty. At this point No. 5 pump will automatically turn off and No. 4 tank will start feeding.

During transfer from external or wing tanks, the fuselage transfer pumps are automatically turned off and fuel is forced under air pressure into the overhead fuel manifold and will fill any of the fuselage tanks that will accept fuel. When wing tanks are empty the fuselage system will remain on gravity transfer until the fuel selector switch is returned to "fuselage" which brings the transfer pumps back into normal operation.

"B" and "C" MODEL AIRCRAFT

With the fuselage, external and wing tank fuel switches in "normal" position, fuel will feed from the external and wing tanks to hold a level of approximately 3000 pounds (B Model) or 2800 pounds (C Model) in No. 2 tank. The fuselage transfer pumps, although running, will not transfer any fuel unless the level of No. 2 drops to 2600 pounds (B model) or 2300 pounds (C Model).

When wing and external fuel is exhausted the fuel level of No. 2 will drop to 2600 (B Model) or 2300 pounds (C Model) where the fuselage fuel transfer system will take over and maintain it. In general all fuel switches will be placed in "normal" after engine start so that external and ungaged fuel will be used first.

If for any reason you find yourself with external and wing tanks "off" and a partially depleted fuselage fuel supply which you would like to refill, proceed as follows:

(a) External and wing tanks to "normal".
(b) Fuselage switch to "gravity".

The external and wing tanks will feed only into the bottom of No. 2 tank until it is full. At this point, a valve opens into the normal fuel transfer manifold and allows fuel in excess of that required to keep No. 2 tank full to refill any fuselage tank that will accept it. This valve will then stay open unless the #2 fuel level drops below 2600 pounds (B Model) or 2300 pounds (C Model), or until the fuselage fuel switch is returned to normal.

After external and internal wing fuel is exhausted, the fuselage transfer system functions the same as in the "A" with the exception that the fuselage transfer fuel level for No. 2 tank will be 2600 pounds for the "B" and 2300 pounds in the "C". Transfer sequencing of the fuselage tanks is No. 1 and No. 5 until No. 5 goes empty, when #5 automatically shuts off and #4 is automatically turned on. A change shows up in Block 55 aircraft (56-199 and up) which will eliminate fuselage fuel sequencing altogether. With the fuselage switch in "normal" on these aircraft, #1, #4, and #5 pumps will all transfer simultaneously until any one tank goes dry, at which time its pump will automatically shut off.

Under gravity flow conditions fuel will flow between fuselage tanks through interconnect pipes. Under these conditions a lower level will be maintained in #2 tank, so fuel consumption should be kept at the normal cruise levels. Under gravity conditions, very little fuel will be trapped if the flight is planned properly and CG conditions will be normal. The five fuselage cells, under gravity flow conditions can flow only toward the No. 2 cell. For this reason #1 tank fuel feed can be assisted by acceleration, climb or nose high attitudes, and #3, #4, and #5 tank feed can be assisted by deceleration, dive, or nose down attitude.

Let's take for example a complete gravity transfer flight in an F-101A aircraft. After thirty minutes of flight at 35,000 feet cruise altitude, your tanks would have dropped fairly equally and would read as in Table A.

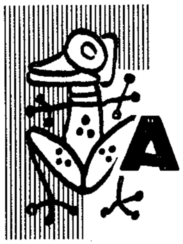
At the end of sixty minutes all tanks would have dropped another incremental amount if altitude and attitude were maintained. However, by making a climb to 38,000 feet toward the end of this period, fuel flow out of #1 will be accelerated with the resultant fuel readings shown in Table B.

If during the latter part of the third 30 minute period a low cruise power descent is established this will assist flow of fuel from the rear tanks with the result that at the end of 90 minutes of flight the fuel readings would look like Table C as you passed through 10,000 feet on your letdown.

TABLE A		TABLE B		TABLE C	
#1	3200 pounds	#1	1800 pounds	#1	1700 pounds
#2	1200 pounds	#2	1300 pounds	#2	900 pounds
#3	1000 pounds	#3	500 pounds	#3	250 pounds
#4	1700 pounds	#4	1200 pounds	#4	250 pounds
#5	1600 pounds	#5	1300 pounds	#5	50 pounds

During the letdown fuel has been kept from transferring out of #1 tank because of attitude and deceleration. After level out in the pattern the nose high attitude at pattern speeds will increase this #1 flow such that #2 level will rise about another 200 pounds in the pattern. If a go around were required #2 tank level would rise still higher due to the acceleration of go around further assisting flow from #1 tank. This example is for the "A" model aircraft. The "C" model with its increased gravity transfer capability would show higher levels in #2 tank for all conditions.

The example given is indeed extreme, but does represent a case which was actually flown and recorded. Run this case and any other possible failure cases through your discussion groups to determine which techniques would be best suited for any given failure condition. There might be a time when you'll need to use some of these procedures to spell the difference between success and failure of your mission.



ABORT OR PRESS ON

The big decision - go on or no go. Can this problem turn into something worse? - - Know the systems and let your decision be influenced by facts, not guesswork or pride.

This article is presented to clarify the seriousness of certain malfunctions and their contributing effect on other components of your mission. In many cases operating policy spells out what the "head shed" expects you to do. This automatically dictates your action but even under these circumstances it's best to know the reasons behind the prescribed action.

Very often when compounding abnormal situations arise you will have to know more than just what to do - you'll also have to know "why" if you expect to make it safely.

HYDRAULICS

A pump or entire system failure by itself does not necessarily constitute an emergency situation. The failure of one pump only knocks out a portion of your insurance but none of your capability. The loss of a system can, in the case of the utility system, limit your capability but in any case don't rush yourself into an accident by making too much of an emergency out of the situation. Play it slow and cool and set yourself up for landing the way the "dash one" spells it out. Experience has shown that abnormally high hydraulic system pressure (36 - 3800 PSI) will be followed in about thirty minutes to an hour of operation by a pump failure, followed shortly thereafter by that system failure. This type of failure originates with an indication of malfunction in the pressure regulating ability of one pump. The affected pump wears itself to pieces in very short order and these pieces are in turn carried through the system knocking out the other pump.

If you crank up and find a system reading abnormally high you might find that actuation of the controls or some hydraulic unit might bring it back to normal, however reject it anyway. The pump is on its last leg and you'll be saving the medicine men a lot of work: A single pump change as compared to a dual pump change, flushing a complete hydraulic system and possibly changing some actuating cylinders.

OIL PRESSURE

Oil pressure limits are established at minimum 30 PSI and maximum 50 PSI. However, keep in mind that minimum continuous oil pressure reading is 40 PSI. If the reading is low, relieve the thrust and maneuvering loads on the engine as much as possible and bring it home. But once again don't rush yourself into trouble - that ole J-57 won't let you down before you can get home just because the oil pressure is a little low. The reason for reducing power and not pulling a lot of load factor is to relieve the strain on the engine bearings as much as possible while they are being undernourished.

High oil pressure is a slightly different matter - it can mean a malfunction in the regulating and relief portion of the system or it can mean a restriction in the system. A restriction could result in complete lack of lubrication to one or more bearings. In any case, reduce power and try to bring the readings down to normal while heading home. Give the engine the same gentle care that we outlined before. If idle power won't bring the pressure down, shut down the affected engine and see what the lower windmill RPM will do. If, even at windmill RPM, the pressure is above the limits then there is nothing further you can do except keep windmill speed as low as possible and land as soon as practical - commensurate with other mission and safety requirements.

When I get back to the base on single engine I normally start the affected engine again and leave it at a low power setting for the base leg and final approach - if the condition hasn't become any worse and windmill RPM appears normal.

If pressure is high due to a restriction in the system there is a possibility of failure of the mal-lubricated part unless you take recommended action. If the pressure is high due to pressure regulating deficiencies, the bearing seals will fail if action isn't taken. In either case it's a good chunk of money you save for Uncle Sam if you can nurse it home without further damage. However, never favor the engine so much that you compromise the whole aircraft and yourself.

There has been some confusion as to the association of generator warning lights and low oil pressure indications. The following should help to clarify this association. The engine oil system and the Sunstrand constant speed generator drive unit have a common oil supply. Since the Sunstrand is very sensitive to proper oil supply, a generator warning light could be the first indication of engine oil starvation. If a generator warning light comes on, the oil pressure indicator for that engine should be immediately checked and closely monitored for evidence of oil starvation.

However, monitoring the generator warning lights should not be considered a substitute for monitoring the oil pressure indicators. The generator drive unit has its own boost pump and accumulator, upstream of the engine pressure pump and pressure transmitter. In case of an engine oil pump failure or some other malfunction, the Sunstrand could continue to run even though pressure in the engine oil system fell below the critical limit. Therefore, an engine which indicates low oil pressure should be operated in accordance with the procedures outlined in the flight handbook under "oil system failure", whether the generator warning light is on or not. (Block 20 & Subsequent)

FUEL SYSTEM

Fuel transfer and management has already been covered in the article entitled "Fuel Management in the Voodoo" and boost pump action and lack of it is covered in the article entitled "Double Flame Out".

TAKE-OFF ENGINE CHECK

The Handbook spells out what EPR reading you should have for a given temperature. This gage must be used because it is the only indication you have of engine power. Now the question arises how much discrepancy should you accept before aborting? Theoretically you should accept none in excess of the allowable bracket in the handbook. But this is theoretically - let's look into what happens in actual practice. First off the handbook figures are good but they are set up for static (no ram input) conditions per an exact temperature after the engine has stabilized at full Military Power for a few minutes.

If you don't let the engine "cook" for a couple of minutes under static conditions your reading will be slightly higher than normal. Also, if you take your reading with ram affect the reading will be slightly high. Since we can't sit in take-off position under a full Military Power head of steam because of tire slippage problems, we must take our reading on the roll and with a non-stabilized engine. It would appear from this that the reading will always be slightly high. This would be true if the temperature information were correct. The temperature we need is the temperature of the air that actually goes in the scoop - not the temperature from the last hourly sequence, not the temperature in the tower, and not the temperature of the runway surface.

Normally you will expect the reading of both engines to be slightly high, however, if both engines are very slightly low by the same amount you probably got some erroneous temperature information. If one engine only reads low, it's sick and won't get better with time.

In the air the EPR gage can tell you if an A/B nozzle hangs open after A/B shutdown. If this condition is encountered it can normally be corrected by reducing the affected engine to about 80%, then re-advancing the throttle. This condition occurs when the actuating pistons, through some malfunction, just don't have enough poop to close the eyelids against the force of the exhaust exit gases. By reducing the power on the engine the pistons have less exhaust pressure to work against and consequently the nozzles close.

The deterioration of the A/B nozzle actuating system is usually gradual so there are very few times that you won't be able to get one closed by working at it. If, however, through some other type malfunction the eyelids are hung open and can't be closed remember that you are dumping about 40% of your thrust from that engine. No sweat with both engines operating but it could get tight if you lost your full power engine.

Incidentally even with the eyelids jammed open full maximum power will normally be avilable although only 60% of full Military Power is available.

GENERATORS

The generators are held to a close frequency tolerance beyond which they cannot operate together. If you find yourself with a generator which won't stay on the line, try operating it by itself. If it operates with normal voltage singly continuation of your mission will not be compromised. One generator is sufficient to carry the entire aircraft load so the other could be left in the "off" position for use as a spare thereby still giving you twin generator reliability.

These are only a few examples to be sure but they do point out that today's pilot must be proficient at diagnosis and prognosis of aircraft problems. It's not enough to know just the handbook emergency procedures - in many cases mission accomplishment and your personal safety will depend on your knowing all the reasons and answers concerning small malfunctions which if not handled properly could grow into a full grown emergency.

COCKPIT PRESSURIZATION, AIR-CONDITIONING AND DEFROSTING

The environment in which you sit while flying is something that you take pretty much for granted as long as everything is kept at comfortable levels.

The origin of the conditioning, pressurizing and defrosting air is the engine itself. This air is bled from the 16th stage of compression. Since this air is delivered at temperatures which can reach 850° F it is necessary, of course, to cool it prior to introducing it to the cockpit. This cooling is accomplished by a primary heat exchanger and a refrigeration package. The refrigeration package is a pretty startling little unit in itself, turning at over 80,000 RPM and delivering air to the cockpit at temperatures as low as -40° F. The refrigeration system of the Voodoo can deliver volumes of cold air which would be sufficient to fully air condition 27 average size homes.

There are slight differences of course in the systems of the A, B, and C aircraft which lead to different pilot techniques in the various aircraft.

Pressurization: Pressurization in the cockpit is obtained by restricting the outflow of conditioned air from the cockpit. This is accomplished through the cockpit air pressure regulator and the cockpit air safety valve. The pilot exercises no control over the cockpit air pressure regulator which automatically maintains a 5 PSI differential from 8000 feet aircraft altitude on up. (On early aircraft, through block 35, the pilot could select 5 PSI or 2.75 PSI). From the cockpit we see no pressurization until we reach 8000 feet. Then continuing the climb the cockpit stays at 8000 feet until the aircraft reaches 22,000 feet. When the aircraft reaches 30,000 the cockpit will read 13,000 and at 45,000 the cockpit will read between 19,000 and 20,000. The cockpit safety valve functions as a pressure and vacuum relief and as a dump valve. The pilot has no direct control over this valve although it is actuated in conjunction with other components when the pilot selects "Ram and Dump". In the A and C model aircraft the pilot either selects pressurization or Ram and Dump, however, the B model aircraft is fitted with a three-way switch so that pressurization inflow of air can be terminated without dumping cockpit pressure.

Loss of adequate cockpit pressurization is a pretty rare occurrence in the Voodoo because of the large volume of air delivered to the cockpit, which is more than adequate to cope with normal leakage. There is also a hazard potential involved here in that with certain possible malfunctions of the pressure regulating devices it is possible to overpressurize the cockpit. Without proper pressure regulation the cockpit can theoretically attain internal pressures in flight which can push the canopy off the aircraft. Pilots should have a rough idea of what cockpit altitudes should be for various aircraft altitudes. If the cockpit altitude is lower than scheduled this means the force acting against the canopy is higher than normal and could result in canopy failure. Go to "Ram and Dump" and get a write-up in the maintenance forms.

Normally you would think that once on the ground pressurization shouldn't be a concern anymore. However, a couple of Voodoo canopies are lying shattered in the boneyard because of this premise. If, through a malfunction of pressure regulating devices, the cockpit is pressurized to below sea level on the ground there can be sufficient force to throw the canopy off the aircraft or damage it severely when the locks are opened. After landing it is a good idea to check the cockpit altimeter before opening the canopy. If it's reading is well below "O" best go to "Ram and Dump" before opening the hatch and of course, write it up.

There is, of course, a difference between models because of difference in canopy size and mechanisms. Because of the added size of the "B" canopy and a shear mechanism installed in the actuating assembly only 1.2 PSI pressurization (cockpit reading of approximately -2250 feet) on the ground will cause the canopy to be thrown off the aircraft if it is actuated up. Although 1.2 PSI doesn't sound like much pressure remember that this represents over three tons of force acting on the canopy. The A and C model aircraft don't have the shear mechanism and also don't have the physical size of the "B" canopy. Although the canopy probably won't leave the aircraft if opened while pressurized, substantial damage can be done to the locks, hinges and seals if the canopy is opened with about 2 1/2 PSI pressurization working on it.

Heat and Vent - All models have the capability of automatic or manual heat control in the cockpit. Mention might be made about the inherent lag present in the automatic system. After a temperature change is commanded the cockpit thermal by-pass valve actuates almost immediately, causing temperature of the incoming air to change within a matter of a few seconds, however, it will take a minute or so to bring the entire cockpit to the new tamperature. The A & C model aircraft take their hot air for mixing before it goes through the primary heat exchanger, therefore there is always an adequate supply of hot air for the cockpit. The B model is configured differently in that all air for the cockpit goes through the primary heat exchanger. In addition, the B model is also equipped with an "iris" valve which controls the flow of ram air through the primary heat exchanger. Cockpit indications of a failed closed iris valve are abnormally warm cockpit temperatures at high Mach numbers. If these cockpit conditions are noted hold Mach numbers below 1. 1 for the remainder of the flight and request an inspection of the subject valve. So much for the hot side of the picture. With the iris valve open, conditions of high altitude, low power cruise conditions might provide fairly cool cockpit temperatures.

The reason for insufficient heat is that engine bleed air flow through the primary heat exchanger is of very low volume under cruise conditions. With the iris valve at its maximum flow (open) position the primary heat exchanger can cool the air going through it to very low values. Under these conditions the only way to get more heat to the cockpit is to provide more flow through the primary heat exchanger. If the equipment cooling switch is in "ram" placing the switch to "normal" will provide more flow through the primary heat exchanger. Of course, increase of engine RPM will also increase flow. This abnormally cool cockpit condition again warrants an inspection of the iris valve.

Defrost - All models of the Voodoo have electrically heated windshields. This heating element should be operating at all times during flight to keep the windshield warm. The unit is designed to prevent windshield fogging, not remove it.

The A and C canopy and windshield defrosting is accomplished by manually positioning valves that alter the ratio of air going into the defrosting tubes and the cockpit distribution manifold. With the defrost valve regulating handle in the "normal" position the majority of incoming cockpit air is directed to the cockpit distribution manifold with only a very small percentage going to the defrost manifold. With the defrost handle in the "defrost" position the majority of incoming cockpit air is directed through the defrosters, thus increasing the volume and velocity of defrost air considerably. This is good for removing fogging from the canopy or windshield but can also prove a detriment to safety if the pilot is not prepared for a hurricane blowing in his face such as can happen if the take-off run is started with the defrost handle inadvertently placed in the "defrost" position.

It is nice to have this much defrosting potential available in case you need it but here again the "ounce of prevention - - -". The entire flight, or at least the last fifteen minutes prior to let-down should be flown with some warm air flowing across the windshield and canopy. Except under extreme conditions this action will prevent fogging of the transparent areas so elimination of condensation will not be a problem.

The B model aircraft has a slightly different set-up for air defrosting. The take-off for defrosting air is between the primary heat exchanger and the refrigeration package, therefore the pilot has no control of the temperature of the defrost air. The defog system is automatic so the pilot has only indirect control in that he can position a switch either "off" or "normal" (automatic). Defrost air flow is regulated by a signal from a windshield heat sensor in conjunction with a sensor monitoring primary heat exchange air. The system is designed to keep the transparent areas at a temperature of 65°F. There were some design problems with the early systems which have been corrected for retrofit and in addition some potential operational and maintenance problems have been uncovered which should be fully understood.

The system is designed to prevent fogging by keeping glass temperatures high. Therefore, it is necessary that the system be in "normal" at all times. One design malfunction is that the system is noisy particularly if some malfunction allows the flow valve to go full open. Another is that there is no emergency override of the automatic system. This lack of positive valve control can also work itself into an operational problem in that if the system is left in the "off" position until fogging actually occurs the system, when turned on, will automatically bring the glass temperature up to 65° and then shut off. This action is adequate for preventing fogging but it is not adequate for "burning off" condensation that has formed.

On the maintenance side there are three prevalent malfunctions to look for:

1. The valve stays closed all the time or open all the time, when the system is actuated to normal (automatic).
2. Maintains the glass at the wrong temperature.
3. Valve action is extreme during cycling. Except under conditions where the system is turned on with glass temperature very low, valve action should be smooth and slight. No abrupt valve action or abnormally high noise or flow levels should be apparent to the pilot during normal operation.

This article is just meant to be a rough rundown on the system and how it applies to you, the pilots. The -2 Handbook covers it in pretty good detail for your edification as well as the "medicine men's". For your comfort and safety know the operation and deficiencies of this system, even though we do tend to take it for granted.

SAFETY AND THE VOODOO

During its first year of operational service, the Voodoo enjoyed the distinction of having the best first year safety record of any fighter aircraft ever introduced into the Air Force inventory. From the end of the first year to almost the close of the second, this excellent record has slipped to something just a little better than mediocre.

I do not intend to set myself up as a judge on F-101 accidents. I do, however, compile those reported to McDonnell and analyze them separately and together to try to obtain isolated and trend information which will be of value to McDonnell in carrying out company responsibilities as concerns flying safety.

In this light, I have access to information which you, the pilot in tactical organization, might not have an opportunity to see compiled into one list. I would like to acquaint you with some of these facts for your analysis.

1. First year - F/RF-101's flew 14,335 operational hours.
   Second year - (to date) these same aircraft flew 32,007 operational hours.
2. First year - 2 "class 26" accidents, no injuries or fatalities.
   Second year - 9 "class 26" accidents, no injuries, 3 fatalities.
3. First year - 4 substantial damage accidents, no injuries or fatalities.
   Second year - 6 substantial damage accidents, no injuries or fatalities.
4. First year - of the 6 total accidents -
   (1) 2 were unquestionably aircraft malfunction.
   (2) 2 were unquestionably caused by human factors.
   (3) 2 showed possible human factor influence.
   Second year - of the 15 total accidents -
   (1) 5 were unquestionably aircraft malfunctions.
   (2) 7 were unquestionably caused by human factors.
   (3) 3 showed possible human factor influence.
5. A comparison shows that in this second year to date -
   (1) We have flown approximately 2.2 times as much.
   (2) We have had 4.5 times as many class 26 accidents.
   (3) We have had 1.5 times as many substantial damage accidents.
   (4) We have gone from 0 to 3 fatalities.
   (5) Known human factor accidents have increased 3.5 times.

The ratios look like we've increased the human factors accidents rate more than the law allows. Also, we're damaging fewer aircraft, but we're class 26'ing them instead which is a losing game any way you look at it.

The one most interesting fact is that in the first three quarters of 1958 you One-O-Wonders had an exceptionally low accident rate of about 14. In the last 3 months of 1958 this rate rose to a startling 33. Now don't stop reading in disgust, I'm not going to get on the soap box. But let's see what we as pilots can do to help get that rate back where it belongs.

Aircraft Malfunction - What can a pilot do about aircraft malfunctions other than call on his skill and cunning to minimize the hazard potential? He can work toward eliminating malfunction potential. The only way the maintenance crew can know about an in-flight discrepancy is through the pilot. Don't let things "ride" till the next flight, or think you're doing someone a favor by telling the crew instead of writing up your discrepancy.

If the item is written up, it has to be corrected or "carried". Either way the next pilot knows what the score is from reading the form prior to flight. Another type of write-up is equally important. If a piece of equipment is working as designed, but still is not giving you satisfactory performance, then UR channels are the ones to use. If the design discrepancy is one which affects safety of operation, Norton will be glad to help you expedite corrective action.

In these ways pilots can help the malfunction problem. It's very often that a minor malfunction compounded with certain other conditions can cause a major or even fatal accident.

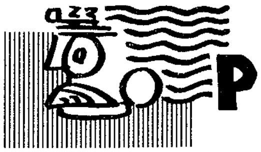
Human Factors - Here we talk about a lot of things, but most of them fall under the heading of Supervision and Discipline - not only that meted out by the Commander, the Ops Officer, and the Maintenance Officer, but as important, that shown all the way down the chain of command - the IP's, the Flight Commanders, and element leaders, the Maintenance NCO, the Crew Chief - right down to the individual who exercises supervision and discipline over his own actions in accomplishment of his job.

Human error within the tactical squadron can be divided roughly between maintenance and pilots. You, the pilot, are in the best position to evaluate the maintenance on the aircraft you fly. If its not up to snuff, do something about it through normal write-ups or through normal chain of command if necessary. Eliminate the accident potential before it has a chance, through the law of averages, to get to you.

The pilot error accident is a dirty word, but you must admit it is one potential over which you, and only you, have direct control. No pilot purposely goes out to tear up an airplane or kill himself; therefore this type accident has to be a result of poor planning or lack of forethought. My recommendations here, for what they are worth, are:

1. If you think you're operating over your head, work hard at getting yourself up to par - it's your life that's at stake.
2. If you think you're operating at par - work hard to elevate yourself to above standard. Rehash the little points that the experienced pilot often can forget.
3. If you think you're sharp - watch out - ego can easily put you in a position where you're operating over your head. Remember the majority of pilot error accidents occur at about the time a pilot is getting a good feel for the aircraft.
4. If you know you're sharp - work hard at staying there and help those in the other three catagories.

I don't doubt that a lot of people will have criticism of this article. My figures might not agree exactly with those of Flying Safety at Norton and my classification of accidents might not coincide with your feelings. As I stated previously, I do not set myself up as judge - I don't even claim I'm right. But I am studying the situation to try to improve the F-101 safety record from every angle I know of - are you???



PITCH-UP

The term pitch up has become widely spread in Air Force circles with the advent of century series fighters. The only problem is that the complete story of pitch up has not kept pace with the wild rumors, and this has resulted in some pretty weird interpretations of this phenomena, even among some pilots flying aircraft that have this characteristic.

Let's start by saying that pitch up is definitely an undesirable trait, and anyone who tries to shrug it off as "no sweat" is just plain crazy. I say this as pilot to pilot with this reservation: The operational analyst is right when he says that pitch up does not reduce the tactical capability of the weapons system since the pitch up boundary is no more limiting than the stall boundary would be if pitch up were not there. Also the design engineer is right when he states that, aerodynamically, pitch up is a small price to pay for the advantages gained in weight saving, performance, maneuvering capability, and trim free flying qualities which come from the same configuration that causes pitch up as you know it in the 101. These points are true and are interesting as background information, but the responsibility for getting the most out of the bird without getting into trouble still lies with you, the pilot. Therefore it is up to you to know about pitch up so it can't "bite you".

Pitch up is a characteristic that can be pinned down cold. Let's first look into why the aircraft pitches up.

1. When any swept wing aircraft approaches stall, the center of lift (the position of the imaginary lift vector which represents the sum of all the lift vectors acting on the aircraft) moves forward as the tips stall out. This action causes a nose up pitching moment.
2. By bringing the aircraft to the condition of Paragraph 1, we have also increased the lift co-efficient (and angle of attack) of the wing, which has increased the wing downwash effect on the tail. This also produces a nose up pitching moment.

You have felt these first two items in any swept wing aircraft you have flown (F-86, F-84F, etc.). The terms I have heard in squadron useage describing the phenomena have been "tucking", "stick lightening", "dig-in", or "stick reversal". No matter what the term, it's still nose up pitching moment, and it affects the F-101 like any other swept wing bird.

3. As the wing tips on the 101 stall out at high angles of attack, the vortex action from the wings moves in from the tips, increasing in intensity as it progresses. When this vortex action reaches that portion of the wing which influences the tail at high angles of attack, it imparts such a strong downwash component on the high horizontal stabilator that it not only helps the aircraft to pitch up but also renders the stabilator ineffective as an immediate recovery device.

From a practical standpoint, everything your aircraft does is based on angle of attack. It takes off at a given angle of attack, it flys final approach at another given angle of attack, it cruises at still another given angle of attack, and it pitches up at a known angle of attack. The angle of attack of the aircraft is that angle formed between the relative wind vector (the direction in which the aircraft is moving) and the longitudinal axis (the direction in which the aircraft is pointing). Angle of attack is a function of gross weight, indicated airspeed and G loading. Altitude is divorced from the picture altogether since we are interested in indicated airspeed, not true. The easiest way to visualize how we affect angle of attack is to vary one parameter leaving the other two constant.

1. Let's first vary weight, holding 1 G, 250 knot flight. The aircraft requires enough lift to offset its weight and since lift is a function of angle of attack the aircraft will be flying at a certain angle of attack to sustain stabilized flight. When the aircraft has burned down 5000 lbs. of fuel, 5000 lbs. less lift is required, which means the angle of attack is reduced. Conversely we can theoretically start adding weight to our example aircraft. For each pound added another pound of lift is required, and this means angle of attack must be increased. We can continue to add weight (and increase angle of attack to give us a commensurate increase in lift) until we reach a point where we stall the aircraft in 250 knot, 1 G flight. The practical application here is that under heavy weight conditions at a given airspeed we are flying at a high basic angle of attack to begin with, leaving us with a smaller margin for maneuvering. A handbook example is shown by take off speeds given in the handbook. Regardless of gross weight the aircraft should leave the ground at the same angle of attack. This is accomplished on take off charts by increasing recommended take off IAS as gross weight increases.

2. Now let's vary IAS, leaving gross weight and G constant. Lift is also a function of IAS. As the aircraft is slowed down, lift is decreased and the only way to get it back is to increase angle of attack. This is apparent on an acceleration from V min. to V max. at constant altitude. At the start of the run the aircraft is in a fairly nose high (high angle of attack) attitude. As speed increases the nose high attitude decreases which shows that less angle of attack is needed to produce the same lift as speed increases.

3. Now let's vary G loading. In reality we are right back to changing weight. A 40,000 pound aircraft requires 40,000 pounds of lift to keep it airborne in 1 G flight. If we go into a 3 G turn the 40,000 pound airplane now requires 120,000 pounds of lift, and angle of attack must be increased to obtain it at a constant IAS. This increase is shown to the pilot by the back pressure required to hold constant altitude in a turn.

The pitch up and spin program at MAC consisted of over 200 fully instrumented, intentional pitch ups and spins. Full scale pitch ups and successful recoveries have been demonstrated and fully recorded by instrumentation in speed ranges from low subsonic to supersonic speeds and at altitudes ranging from combat ceiling to as low as 10,000 feet. Early in the program recovery techniques were developed which were proved 100% successful. Further verification was obtained in the many subsequent pitch ups resulting from flight test development programs which required flight near and through the pitch up boundary. Basically the following can be derived from a study of the data.

The aircraft demonstrates three basic modes of stall performance after the critical angle of attack is exceeded.

1. Pitch Up. The aircraft must pitch up before it can enter any type of stall or spin gyration. Recovery from pitch up is 100% effective with or without a chute. However, without a chute the aircraft will undoubtedly progress into the next step prior to recovery.

2. Incipient Spin. I do not personally agree with this term, since the mode in question is not a spin mode of the aircraft, but is rather a post stall, or pre-spin gyration. It is characterized by its highly oscillatory nature about all axes providing a pretty wild looking ride from the cockpit. The ride is not violent, however, and no abnormal forces will be felt. If proper control action is used, and held, recovery from this invigorating ride is also 100% effective. As before, the chute speeds up recovery time. If the chute is used for pitch up recovery, chances are excellent that you'll never reach this stage. However without chute deployment at pitch up the aircraft will go through some post stall gyrations prior to recovery.

3. Steady State Spin. This is the true spin mode of the aircraft. It is easily recognized by its flat spinning characteristic which is non-oscillatory - just a slow, wings level, 360° look at the horizon. The chances of recovery from steady state spin are less than 1 in 5. Not very good odds, but the odds don't actually apply since the aircraft must go through Step No. 1 and No. 2, both of which are fully recoverable, before it can reach Step No. 3 and then it can only get into steady state spin if it is put there - with improper use of rudder and aileron. Incidentally a program was run in which the aircraft in normal trim for various flight conditions was placed in full scale pitch up at which time all controls were released and a "hands off" recovery was effected. The fact that in every case the aircraft recovered completely "on its own" proved the conviction that the 101 does not inherently "seek" steady state spin after pitch up but rather will recover on its own.

Now let's talk recovery controls. The only recovery control is full forward stick, neutral ailerons, neutral rudders. (Remember those ailerons and rudder.) As soon as you feel that nose start up, don't hesitate to drive that stick forward to the instrument panel - now. Chances are you'll still have stabilator effectiveness and you'll get immediate recovery. (If you can get negative G's by pushing the stick forward you didn't actually pitch up. You just came mighty close to it.) If the nose continues up (or you can't obtain negative G) even with full forward stick wait till the peak of the pitch up, which will guarantee that speed is below the 200 knot chute limit, and deploy the chute. During the pitch up or subsequent recovery, don't try to control yaw or roll - remember, neutral aileron and rudder. Recovery with the chute will be almost immediate (about 4 seconds), however, if the aircraft is in a slight yaw as recovery is effected, one wing will recover slightly ahead of the other producing a roll, which again, should not be countered with control action. When the full forward stick starts producing negative G's you've recovered and you can slowly release forward pressure so as to hold a 1 G dive to build up airspeed. Treat that stick mighty tenderly at this point; you are still critical until speed builds up, so don't try to pull any G until you've built up sufficient airspeed to do so. At above 200 knots in a dive, with definite stabilator effectiveness, you can release the chute, but don't worry about it as it will tear free on its own at about 230 with no damage to the aircraft.

Once you're in full scale pitch up, don't hesitate to use the chute. You can't tell from aircraft action how far you are from recovery, so don't get fooled into thinking "It looks like it's just about to recover, so I'll just save my chute".

If for some reason you can't, or don't, use the chute the same control action still applies, however the out of control time will be extended considerably. The vast majority of no chute recoveries resulted in an out of control time ranging from 8 - 14 seconds.

If the chute is not utilized the aircraft will go through post stall gyration (incipient spin). After the aircraft reaches peak of pitch up, (which can result in angles of attack in excess of 50°) the aircraft will probably yaw strongly in either direction as the nose falls through the horizon, followed by rolls (fast, slow, or snap type). The yaw will change direction, the rolls will change direction and type and during it all the nose will oscillate from above to below the horizon. Through all of this you will sit, steel nerved and remembering "neutral ailerons and neutral rudder". It's a wild ride in anyone's language, but I'm in hopes that knowledge of what's coming up next and the ultimate outcome will be of some comfort during your few seconds of need.

There is no aircraft configuration which will help recovery from pitch up or post stall gyration. Therefore it is advisable that recovery be effected with a clean aircraft. (Gear, flaps, and speed brakes retracted.) External tanks should not affect recovery potential one way or the other. Engines will probably stall on initial pitch up and remain stalled until recovery. No action is necessary with the throttles as engine RPM will recover (to throttle position) as soon as the high angle of attack is broken, and no damage or overheat will result during the stalled condition. In the test programs flown by McDonnell there is no record of an engine ever flaming out during pitch up spin. If afterburner was in use upon pitch up, terminate it as soon as possible. Also, do not attempt to use afterburner as a recovery device since it will not deliver power, but is likely to "torch" behind the aircraft, burning off the drag chute.

Altitude loss is a difficult thing to state, since there are so many variables, but let's look at some fundamentals.

1. During post stall gyration your aircraft is dropping like a chicken wire submarine to the tune of about 18,000 ft/min.
2. Average out of control time with chute recovery is four seconds.
3. Average out of control time without chute is 8 - 14 seconds.
4. Control will be regained in a dive. Altitude required for dive recovery must also be considered.
5. Dive recovery charts show that from a 90° dive at 200 knots (worst possible condition) it will take 6000 feet to achieve straight and level starting at 10,000 ft., 9,000 feet to recover starting at 20,000 and 12,000 feet to recover starting at 30,000.
6. A study of all the pitch ups recorded shows that drag chute recoveries average the following loss of altitude to bring the aircraft to level flight.

Pitch Up Altitude	Altitude Lost in Recovery
40,000	10,000
30,000	8,000
20,000	6,000
10,000	4,000

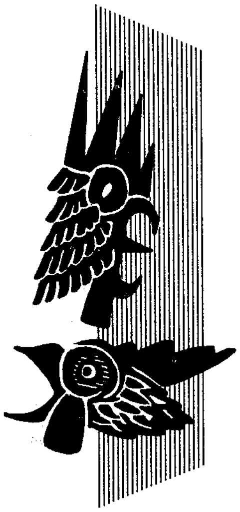
So much for recovery from pitch up. How do we stay away from it?

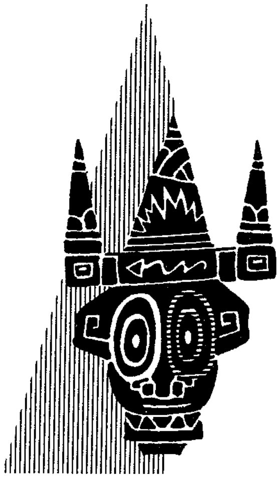
All the rules boil down to what we discussed earlier about angle of attack. The heavier the aircraft is, the less G you can pull for a given indicated airspeed. In addition, the slower the IAS the less G you can pull for a given gross weight. Disregarding inhibitor systems, the aircraft itself gives more than adequate buffet warning below .9 IMN telling of approach to critical angles of attack. Supersonically where no buffet warning is available, the knee pad cards show the number of G's you can pull for any given IAS. It's an easy rule of thumb to remember - know it well.

One other important thing which the pilot must take into consideration (the inhibitor system does it for you if its operating) is pitch rate. Your aircraft represents a lot of mass and when you start that nose moving upward you must take inertia into consideration. The faster you rotate the greater the inertial overshoot tendency will be. Smooth control action will prevent any problem here - don't "horse" the aircraft, fly it.

One last item is airspeed bleed off. When you glance at your indicated airspeed to determine how many G you can pull in a turn remember that the added induced drag of the turn will start that airspeed upwinding unless power is added or altitude is lost to compensate for it. As the IAS bleeds off so does your G potential so don't back yourself into trouble.

In order to extract the most operational capability from his aircraft, a pilot must know all characteristics, good and bad. If you study and understand all of the aircraft's characteristics you will know and respect pitch up, and it will never cause you trouble.





VOODOO-AIR DEFENSE STYLE

Reprint from INTERCEPTOR - May Issue '59

Before and during checkout in a new aircraft we pay a lot of attention to the aircraft's characteristics in the takeoff and landing phases, because we realize that these two phases of flight contain a lot of danger potential if we don't know what we're doing.

After the checkout and transition phase we start paying more attention to in-flight performance, range, mission profiles, and other tactical applications. We pay less and less attention to take off and landing until soon they represent only a method of getting the aircraft off the ground so that we can accomplish our mission objective and getting it back on the ground when we're through.

If you have a pilot-error accident coming up in the future, chances are better than four to one that it will be during landing. A surprising fact is that the average pilot who has a pilot-error accident during landing is not the newly checked out pilot; he is the one with over 100 hours in the aircraft.

TAKEOFF: Simple?--Sure it is, but that high performance can turn around and bite, if you let it get ahead of you.

The thoroughness you use in pre-takeoff checks on your first few rides should continue throughout your career with the aircraft. Make sure that everything checks out and that all cockpit controls and switches are in the proper position before lining up for takeoff. After those burners light off there isn't much time left in the takeoff phase.

Another technique that should not change with experience is the way you fly the aircraft off the ground--light, easy control force at the recommended speed to command and then hold the nose gear off the runway about seven degrees higher than three-point attitude. From here on out the aircraft will accelerate to its flying speed and leave the ground all on its own. The time element between nose lift-off and becoming airborne naturally varies with ambient conditions and selected thrust; but one thing is certain--this 20-to-25-ton machine isn't going to fly until it's ready, <u>regardless of the experience level of the pilot.</u> As for the use of military power for takeoff, a good rule of thumb is if the computed roll for a military power takeoff is 5000 feet or over, use A/B.

LANDING: The landing phase of flight accounts for over 25 per cent of all Air Force accidents. With the present state of the art of high-speed aircraft design we don't get something for nothing. When we try to reduce the high speed drag, we do it at a sacrifice to the low speed portion of the envelope.

The benefit of a low aspect ratio wing (span to chord ratio) is that the induced drag is comparatively low at high speed. This is the reason that the hot aircraft of today all sport stubby looking wings. However, when we buy this decrease in drag at the high speed end we also buy a greater drag at the low speed end, which includes our pattern work and landing. As pilots, we see this as higher recommended final approach speeds with more critical tolerances to avoid high rates of sink.

Another price we pay for low aspect ratio wings is in maneuvering drag. Under normal maneuvering flight conditions, the Voodoo is better equipped than any other fighter to combat this high maneuvering drag situation by the raw thrust it can deliver to counteract it. But under final approach and flareout conditions only a small amount of engine power is being utilized, so if high "g" loadings are demanded, airspeed bleed-off will be very rapid. This requires shallow final approach angles so that flareout will not be abrupt or demand high "g" forces. We must maintain power on during the flareout to keep that airspeed from bleeding off too rapidly.

Fly shallow final approach angles. This is accomplished by flying the aircraft on a two and one-half to three per cent glide slope.

If our final approach angle is steeper than this, more "g" loading is required over a longer period of time to flare the aircraft so the airspeed indicator unwinds more rapidly and for a longer period. This situation can increase in severity to the point where the aircraft will stall before the flareout is accomplished. You will be in the right landing attitude, and you will indeed land--but you will not fully break the rate of descent and the landing could result in the main landing gear struts sticking up through the wings.

The basic approach and landing rules are these:

1. Fly proper indicated airspeeds.
2. Flare from mild rates of descent and shallow final approach angles not to exceed three degrees.
3. Do not "chop" power until after flareout.

LANDING ROLL: Well, you're safely on the ground now, but your job is far from finished--you're sitting on 15 tons of weight steaming down the runway at 150 knots or so, which represents a lot of energy and it's up to you to get it stopped safely. According to one of Newton's laws the aircraft will continue to roll forever unless some decelerating forces are applied. This overall decelerating force is an additive function of:

1. Basic airplane drag including flaps and speed brakes.
2. Rolling friction drag of wheels on runway.
3. Induced drag (caused by lift).
4. Parabrake.
5. Wheel braking.

Working against the decelerating forces is the combined thrust output of the two idling engines, so this, too, has to be included in our analysis. Looking at all of these factors, let's first see which we have control over:

1. Ascertaining that you have speed brakes out and flaps down is about as much as a pilot can do to create as much basic airplane drag as possible.

2. Rolling friction (the drag caused by the wheels free rolling on the runway) does not come under pilot control.
3. The pilot has absolute control over induced drag by holding the nose off during landing roll.
4. The pilot of course has full control over deployment of the parabrake, use of wheel brakes and the thrust output of the engine.

Now let's set up a problem of a no-drag-chute landing with a 33,000 pound gross weight airplane, touchdown with flaps and speed brakes out at 155 knots with the throttles idle. In case "A" we hold the nose to 10-11 degree fuselage attitude until 110 knots, then lower the nose and use maximum possible wheel braking to stop.

In case "B" we place the nose gear on the runway immediately and utilize maximum possible wheel braking to stop. For case "A" we find that the decelerating force of aerodynamic braking from 155 knots to 115 knots averages 8900 pounds as opposed to case "B" where average wheel braking decelerating force over this same speed range is 4800 pounds. This would indicate that the decelerating ability of this aircraft can be maximized by holding the nose gear off the runway in this speed range where wheel braking effectiveness is low and chances of skidding a wheel are high.

This wheel braking effectiveness, which is not too good at the higher speed ranges, is getting better, however, as speed decreases. Conversely the effect of aerodynamic drag decreases as the aircraft slows down. The effective decelerating force of aerodynamic braking in case "A" and maximum wheel braking in case "B" are equal at 109 knots. This means that from this speed on down it is more advantageous to use wheel braking than to further employ aerodynamic braking. In addition, the stabilator is fast losing its effectiveness at this speed, so it is best to start the nose down to the runway at about 115 knots so that it can be eased onto the runway.

From this point to stop, use wheel braking to the extent desired. For shortest possible rolls use maximum braking from this point without skidding the wheel. (A skidding wheel loses much of its decelerating capability.) As the aircraft reaches about 30-40 knots, slight landing gear chatter might set in, increasing the possibility of skidding the wheel, so easing off on the pedals is in order from this speed down to stop. Now let's add the drag chute to our airplane. The decelerating force of the drag chute is proportional to the speed at which it is moving through the air.

If we take our basic test aircraft again and, after landing at 155 knots, place the nose gear on the runway and just let it roll, it will take 6500 feet of runway for it to slow down to about 100 knots. If, however, we hold the nose off at about 10 degrees fuselage angle, the high induced drag alone will shorten this distance to 3200 feet to slow the aircraft to about 100 knots.

When we add the chute to both examples it can be seen that the decelerating effect of the chute will be felt more and over a longer period of time on the 6500-foot roll. Therefore, it can be concluded that we will rely more on the drag chute to slow us down if we don't employ aerodynamic drag. Qualitative data shows that by using recommended techniques for landing roll the absence of a drag chute will only add 500-750 feet to the landing roll.

Now let's set the stage for another comparison--this time we'll wet down the runway. A wet runway provides a lower coefficient of friction than does a dry one. This manifests itself to the pilot as less wheel braking effectiveness and increased skid potential. This lower braking effectiveness will only affect the landing roll during that portion where wheel brakes are needed.

If we use the same nose-high technique, which we have already shown to be superior, to get the aircraft slowed down to about 100 knots, the runway required to this point will not increase since wheel brakes have not even entered into the picture yet.

As a matter of fact, on a heavily puddled runway the distance required to slow to about 100 knots will even be slightly less than for the dry conditions because of the added decelerating force imparted when the wheels run through the water puddles. If, on the other hand, we immediately place the nose gear on the runway, we are relying on wheel brakes and parabrake to get us slowed down to this 100-knot point. Wheel braking effectiveness is low in the high speed ranges even for a dry runway and is almost nil under wet conditions. This means we are relying almost 100 per cent on the parabrake to slow us down.

In the event of drag chute failure, the nose-high landing roll distance to the 100-knot point will only increase a couple of hundred feet because the chute represents only a portion of the overall decelerating force, as we stated previously. However, in the three-point attitude the drag chute represents almost all of our decelerating ability to the 100-knot point, and with its loss and the lack of a wet runway braking effectiveness at high speeds, our roll-out distance for slowing down to 100 knots can easily double and then some.

From 100 knots down to stop we rely mainly on wheel brakes to stop us, regardless of airplane configuration or runway conditions. From 100 knots on down, where braking effectiveness is excellent on a dry runway, it is also surprisingly good on a wet runway. Again bear in mind that brakes are most effective up to but not at the skid point, so play the pedals with an educated toe. The skid potential from 40 knots on down is also aggravated by wet runway conditions so this, too, has to be handled a little more carefully.

We've introduced just about all of the variables now, with the exception of engine shut-down to shorten landing rolls--DON'T. The effect of this technique on landing roll distance is so slight it can't even be measured. When we shut down the one engine at touchdown, we are talking about less than 200 pounds of accelerating force in the face of decelerating forces from aerodynamic braking alone of 11,000 pounds, and wheel braking forces up to 7500 and 8000 pounds. Why play around with a piddling hundred or so pounds at the high risk potential involved with engine shut-down at this critical point?

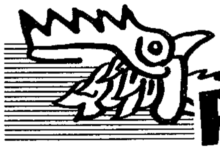
Let's sum everything up in a few sentences.

> Follow recommended final approach speeds.
> Fly mild final approach angles and maintain power until after flareout.
> After touchdown, deploy drag chute and hold nose-off--slightly higher than takeoff--attitude until approximately 115 knots.

CAUTION: The parabrake compartment of the A&C or the afterburner of the B model will drag the runway at about 15 degrees of fuselage pitch angle.

Use desired braking from 100 knots to stop, easing off brakes slightly from about 40 knots down if landing gear chatter is encountered

There is only one right way to land this aricraft, and if the proper techniques are used for each landing, wet runways or failed drag chutes will not extend the landing roll excessively. Use everything the aircraft has to offer. Don't rely on one piece of equipment (such as the drag chute) so heavily that when it fails you are automatically an accident.



RUNNING OUT OF AIRSPEED AND IDEAS ?

There you are pointed skyward in a 45° climb, 10,000 lbs. of fuel remaining and the airspeed falling through 200 knots. Can the aircraft be recovered maintaining full control throughout? The answer is yes: You'll run out of airspeed, but if you don't run out of the right ideas the situation is a no sweat (and no pitch up) proposition.

With the use of LABS and snap up delivery of armament it is not uncommon to find tactical requirements calling for some pretty healthy pitch attitudes. If we also include acrobatic training we bring all three models of the Voodoo into the picture. However, what we will discuss here does not pertain just to the Voodoos but to any aircraft from the Piper Cub on up.

As in past discussions this one too starts with angle of attack. In our last issue we explained how angle of attack is affected by gross weight, IAS, and G loading.

Let's look a little further into G loading.

The accelerometer in the instrument panel measures G loading straight down through the belly of the aircraft. This is the same G loading which affects angle of attack on the wing. When the aircraft is in straight and level flight the force of the earth's gravity is straight down through the belly of the aircraft and of course the accelerometer reads "1 G". If the aircraft is established and maintained in a climb the accelerometer reading will be something less than 1 G. The reason for this is that the force of earth's gravity is no longer working straight down through the belly, but rather midway between this position and straight out through the tail, depending on climb angle. The extreme would occur when the aircraft is climbing straight up at which time the effect of earth's gravity is working straight through the tail of the aircraft and the cockpit accelerometer will read "O G". As a matter of interest, the cockpit accelerometer in stabilized climb will read 1 times the cosine of the angle of pitch. This reading, direct from the cockpit accelerometer, is what is felt by the wings in the determining angle of attack.

We have already determined that under +2 G conditions our lift requirements have increased by a factor of the accelerometer reading times the gross weight, requiring higher angles of attack at a given IAS to produce the added lift. The same computations can be applied to an aircraft operating at less than 1 G. An aircraft operating at a given IAS and gross weight requires less angle of attack at .5 G than it does at +1.0 G. The reason being that in this case the lift required is only 1/2 of the gross weight. Under these conditions the aircraft can go to slower than normal IAS before reaching critical angles of attack. This same example can be carried further to 0 G at which time the aircraft is at 0 weight thereby requiring 0 lift. In this case the aircraft is on a true ballistic flight path and the wings are just along for the ride. Since the wings are not producing lift they do not require angle of attack and therefore can never reach critical angle of attack regardless of IAS. We have already determined that the aircraft stalls (or pitches up) at a certain value of angle of attack; therefore if the angle of attack is maintained at the 0 lift value the aircraft cannot stall at any IAS - as long as you maintain 0 G.

The ability to maintain "0" G is determined by stabilator effectiveness. There is some speed at which the stabilator is so ineffective that it will have to be fully deflected (nose down) to maintain 0 G. This occurs at approximately 90 knots IAS.

The thing to bear in mind is that at any G loading above 0 (i.e. + .2G) the wing is producing some lift. As long as the wing is producing any lift, there is some IAS at which the angle of attack will be critical to produce this required lift. The closer you approach 0 G, the slower the IAS will be when the wing angle of attack becomes critical.

An example might be an aircraft in a climb at .5 G with IAS slowly bleeding off through 155 KIAS. As the IAS reaches 150 knots slight buffet is felt indicating the wing is approaching its critical angle of attack. By slightly decreasing G further (say to .4 G) the angle of attack will be lessened and the aircraft can now fly to 135 KIAS before it reaches its critical angle of attack again. In brief, as we approach 0 G we are effectively pushing our stall speed away from us.

Putting this info in the back of your mind, let's progress to a slightly different, but associated subject. What is the best way to get an airplane which is pointed up, pointed down? Obviously the method which is safest, fastest, and most comfortable is the best. Safest - here we are thinking of staying away from critical angles of attack (pitch up) and in the case of snap up attack correcting our flight path so that we will be as far as possible from the blast of the armament we launch.

Fastest - for snap up attack recovery we are desirous of getting out of the way of the effect of our own armament as fast as possible. In the case of any slight miscalculation in acrobatics or just general flying, where we find ourselves in steep pitch attitudes with too slow an airspeed, it's a matter of "let's get out of this touchy condition as soon as possible".

Most comfortable - here we are thinking of the physiological and psychological limits of the aircrew. For the purpose of this discussion (and I doubt that I'll find anyone to argue) I am saying that an aircrew cannot and/or will not maintain sustained negative G loading in excess of -1 G. As a matter of fact anything below 0 G will start things floating around the cockpit which becomes bothersome and disconcerting. In addition, the aircraft is restricted from sustained flight at or below 0 G.

The turning radius of the aircraft is determined by G loading and true airspeed. For a given air speed condition the fastest recovery will be the one which employs the most effective G loading. Effective G loading for our purposes is that G which is getting the aircraft pointed down toward the ground. Any bank angle decreases this effective G (effective G = Aircraft G load x cosine of bank angle) therefore a wings level push over or an inverted (180° bank angle) pull through would get us the maximum corrective capability for the G load working on the aircraft. Now let's analyze these two conditions: When the aircraft is flying wings level, stabilized, the G meter reads the 1 G pull of gravity and the nose of the aircraft is stationary on the horizon. If the aircraft is pushed over to 0 G the aircraft is describing an effective 1 G turning radius toward the ground. If we push further to indicated -1 G we have an effective 2 G turning radius toward the ground. This would mean that the best turning radius we could command would be 2 G since we are working to a -1 G limit. Now let's roll the aircraft over on its back - here under 0 G conditions we are describing the same flight path as in the previous case at the same G loading and we have the same effective 1 G turning radius toward the ground.

When the aircraft is under +1 G flight while inverted it has an effective 2 G turning radius toward the ground. So here we see that by flying inverted (180° bank angle) at +1 G flight we can describe the same effective 2 G turning radius that we could by flying the uncomfortable (and restrictive) -1 G at 0° bank angle. Add to this the fact that when inverted any G you can pull in excess of +1 G helps your turning radius that much more. (i. e. if IAS allows you to pull +1.7 G you will have an effective turn radius of 2.7 G).

In addition to a best corrective turn radius the inverted position affords the additional following advantages:

1. No engine or aircraft time restrictions.
2. More comfortable - since aircraft is at all times at some positive G loading.
3. The aircraft is in the best position to receive gust loads since it can tolerate far more positive G than negative.
4. The aircraft will be shielding the crew from flash blindness.

There appear to be four common misconceptions about flying this aircraft in the low speed region. The first and most important is the erroneous impression that at some certain speed pitch up will just jump out and bite you. The aircraft can be flown near, on, and even inside of the pitch up boundary with absolutely no problems if the aircraft is flown smoothly in pitch. The closer the aircraft is to a critical angle of attack the slower you should impart pitch correction. In this way slight negative stability (nose starts up slowly on its own accord) can be felt and corrected far before it becomes strong enough that it cannot be corrected with slight forward stick pressure.

The second is that the small accelerometer with which the Air Force is equipping its present fighters is not accurate enough for use in the Voodoo. I cannot consider this a valid gripe for the following reason: The reading you obtain might well be a couple of tenths of a G in error due to instrument error and parallax, however, when you are seeking an aim G which you know to be critical, you should continually slow down your pitch rate input as you approach closer to the aim G. Therefore if you get warning signs such as horn, buffet or slight negative stability at .3 G before you reach your aim G (indicated) you know that this is the most you can tolerate and your pitch rate is slow enough that just relaxing the stick should hold what you have. From this point the accelerometer can be accurately used as a "trend" instrument to add or subtract as small a quantity as . 1 G from your loading if you require or desire it.

The third is one that can really get you into trouble. It is the mistaken idea that once an aircraft is on its back or pointed down the rules go out the window, and the stick can be "horsed back" as fast as desired.

All the aircraft knows is IAS, gross weight, and G loading (sound familiar?) which of course gives us angle of attack. The aircraft couldn't care less about its attitude as long as the proper ratios of the "basic three items" are maintained. The rules on pitch rate also apply regardless of attitude.

The fourth is the notion that the pusher can force you into pitch up by holding the aircraft in a climbing attitude if it is engaged during an inverted recovery.

If the pusher is engaged in this case it is only doing for you what has to be done --- reduce the G loading (and angle of attack) on the aircraft. Since the pusher cannot move the stabilator further than the 0° position it can be seen that it cannot possibly "hold" the aircraft in a climbing attitude. It will definitely slow down the rate at which the nose was moving toward the horizon but this original rate (G loading) was too great or the pusher wouldn't have engaged in the first place.

Although our present day aircraft are getting more and more complex, requiring more effort on the part of pilots to learn their systems and idiosyncrasies, let's not get so involved in specialized learning that we forget the basic aerodynamic laws that make all aircraft fly. Regardless of what type maneuver you elect for recovery from steep pitch attitudes remember that if you're worried about IAS get that G loading moving toward 0 while you decide what else you want to do as far as aircraft roll attitude is concerned.

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