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AIRCRAFT ACCELERATION SENSITIVE INERTIA REEL LOCK(U)
NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA AIRCRAFT AND
CREW SYSTEMS TECHNOLOGY DIRECTORATE T J ZENOBI

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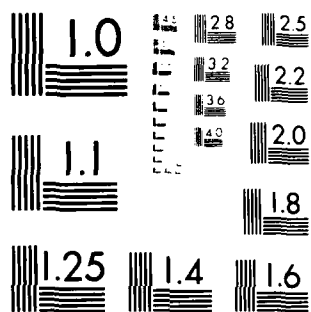
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AIRCRAFT ACCELERATION SENSITIVE INERTIA REEL LOCK

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Navy has designed, built and tested an aircraft acceleration sensitive inertia reel lock for crewmember positioning and restraint during "eyeballs out" ($-g_x$) accelerations such as during an aircraft flat spin. The design is simple and retrofittable to many ejection seats. Centrifuge tests at NADC indicate the locking device performs effectively and reliably.		

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INTRODUCTION

Summary - The Seating and Escape Branch (Code 6032) of the Aircraft and Crew Systems Technology Directorate has investigated the problem of crewmember positioning and restraint during "eyeballs out" accelerations in Navy aircraft produced, primarily, during an aircraft flat spin situation. An inertia reel locking mechanism which is sensitive to accelerations (g_x) on the aircraft (i.e. on the reel locking mechanism itself) was constructed and evaluated at Naval Air Development Center (NADC). The device is designed to be retrofittable for many ejection seats in military aircraft.

Tests with live subjects on the NADC centrifuge indicated that the inertia reel locking device operated reliably.

Background - The problem of air crewmember positioning and restraint during "eyeballs out" ($-g_x$) conditions is evident during aircraft flat spin situations where in certain aircraft the crewmember can experience $-6g_x$ to $-8g_x$. Such a spin situation is unusual and means the aircraft is in uncontrolled flight. If the pilot is not restrained properly, he may be thrown forward into the aircraft controls making it difficult or impossible to actuate the controls and regain control of the aircraft. Also, knowing he can't regain control of the aircraft and must eject, he may not be in a position where he can reach his ejection actuation handle. In the flat spin situation, the pilot must be restrained and positioned back in his seat. It is critically important that his shoulder straps (i.e. inertia reel straps) do not pay out as shown in Figure 1.

Current inertia reels have internal locking mechanisms. There is a manual lock which the crewmember must actuate via a locking handle and cable arrangement located on the left side of the ejection seat. Such an arrangement is a viable approach to solving the $-g_x$ positioning problem if the crewmember recognizes he is entering a flat spin and has the opportunity to actuate the lock handle before he is too far out of the seat. Unfortunately, the crewmember who is intent on controlling the aircraft may not have the opportunity to actuate the lock handle or may not think about using the lock handle.

There is another locking mechanism which automatically locks when the crewmember's upper torso accelerates forward at an acceleration between $2g$ to $3g$. This mechanism is actually sensitive to the rate of payout of the inertia reel straps. In a flat spin the crewmember may be able to partially resist the acceleration forces at $-3g_x$ to the point where he is forced away from the seat at a rate of less than $2g$ without having the inertia reel lock. Not only will he move out of position, he will become tired from fighting the acceleration forces.

As a solution to the problem, an Aircraft Acceleration Sensitive Inertia Reel Lock was developed by the Seating and Escape Branch of NADC. As designed, the locking mechanism is sensitive to the acceleration vector which runs from the back of the aircraft to the front of the cockpit ($-g_x$). The magnitude of this acceleration varies along the length of the aircraft fuselage. The magnitude decreases as the center of rotation is approached. If there is a $-g_x$ acceleration imposed on the aircraft and the crewmembers, then something other than controlled flight maneuvers is occurring. Either the pilot is braking upon landing or he is in uncontrolled flight such as in the flat spin. In either case, the crewmember should be restrained against the $-g_x$ force.

The following text discusses the design approach and development of the Aircraft Acceleration Sensitive Inertia Reel Lock.

DESIGN CRITERIA

The Aircraft Acceleration Sensitive Inertia Reel Lock is designed to satisfy the following requirements:

- The locking mechanism locks the inertia reel when an acceleration in the range of $-0.5g_x$ to $-1.5g_x$ is applied. The mechanism can be set to lock at a precise $-g_x$ level within this range.
- The locking mechanism automatically unlocks when the negative g_x returns to zero or to positive g_x .
- The locking mechanism shall withstand a pull load on the inertia reel straps of 400 pounds. This approximates a $-8g_x$ load on the crewmember.
- The locking mechanism will not lock inadvertently when $+g_z$ loads up to $3g_z$ are imposed on it. This requirement allows for crewmember movement of his head and upper torso during certain air combat maneuvers.
- The locking mechanism is designed to be easily retrofitted on existing ejection seats. There is no need to integrate or alter any ejection seat components other than the inertia reel itself.
- Because of the locking mechanism simplicity and retrofittability, costs for installing modified inertia reels will be minimal.

PROTOTYPE DESIGN

A prototype aircraft acceleration ($-g_x$) sensitive inertia reel locking mechanism was developed under NADC contract (Contract No. N62269-81-C-0707) to Pacific Scientific Co., Anaheim, CA. The locking mechanism is a modification to an existing inertia reel currently used on ejection seats in some military aircraft. All the previous functions of the basic inertia reel were maintained. Figure 2 illustrates the locking mechanism. The mechanism consists of a throw weight (locking weight), pivot arm, locking dog, and positioning spring. All of these parts are "add-on" hardware to the original inertia reel. The positioning spring functions as a buckling column when the load from the locking weight during acceleration becomes too large. When the spring buckles, the locking weight moves in the $-g_x$ direction (See Figures 2 and 3) and via the pivot arm, causes the locking dog to rotate into the ratchet wheel as shown in Figure 3. With the dog engaged on the ratchet wheel, the inertia reel cannot rotate in the direction of strap payout. The reel remains locked until acceleration in the $-g_x$ direction returns to zero allowing the spring to return the locking weight back to the unlock position.

To prevent inadvertent locking, the lock weight which is a small drum is filled with lead beads to dampen vibration effects. Also, the location of the locking weight relative to the pivot nullifies the effects of the $\pm g_z$ loads.

The $-g_x$ level at which the reel locks can be altered by changing the spring or the locking weight. For the prototype tests the locking weight was changed to obtain locking at various $-g_x$ levels.

TEST RESULTS

For the purpose of validating the design of the locking mechanism, the inertia reel lock was set to actuate at $-1.35g_x$. The NADC centrifuge was used to test the prototype inertia reel. Human test subjects were used in these tests.

For each test run, the $-g_x$ profile was brought from zero to a given level and held at that level for 10 seconds before being brought back to zero. The rise time from zero to the desired $-g_x$ level was two seconds. The test subjects were asked to resist the acceleration loads and keep their shoulders against the seat back until the desired $-g_x$ level was reached. After reaching this level the test subjects were told to let the acceleration forces pull them out of the seat. Nine runs were conducted where the acceleration level was $-1.30g_x$. In every run, the inertia reel remained unlocked and the test subject came fully out of the seat (i.e. the inertia reel straps payed out to the maximum limit). For all nine runs where the acceleration level was $-1.40g_x$, the inertia reel locked and the subject's shoulders could not move away from the seat.

After each $-1.40g_x$ test run when the acceleration was returned to zero, the test subject was asked to move his shoulders away from the seat. This verified that the reel would unlock after conditions returned to normal.

Through all of the centrifuge testing there were no indications that the inertia reel lock was not operating as intended.

COMMENTS AND CONCLUSION

One important issue which needs to be settled is at what $-g_x$ level should the lock actuate. Based on the centrifuge tests, a $-1.35g_x$ level may be too high. If the crewmember offers no resistance to acceleration forces, he will come out of the seat before this level is reached and before the lock actuates. If the crewmember must concentrate on resisting the $-g_x$ forces just to stay back in his seat, he may be distracted and unable to operate the aircraft controls. Of course, the acceleration onset rates play an important part in the time it takes for the crewmember to restrain himself against acceleration forces before the inertia reel locks his shoulder straps. For this reason, the inertia reel lock was also tested with a lock actuation setting at $-0.65g_x$. Again, there were no indications during the centrifuge testing that the inertia reel lock was not performing as intended. Therefore, the current design can be set for actuation of the lock at a wide range of $-g_x$ levels.

The Aircraft Acceleration Sensitive Inertia Reel Lock has been tested and found to be an effective and reliable device. Incorporation of this device into existing inertia reels should be simple and relatively inexpensive. If the inertia reel lock proves to be a viable solution to the crewmember displacement problem, then a program will be planned to conduct the necessary tests to qualify it for use in operational inertia reels.

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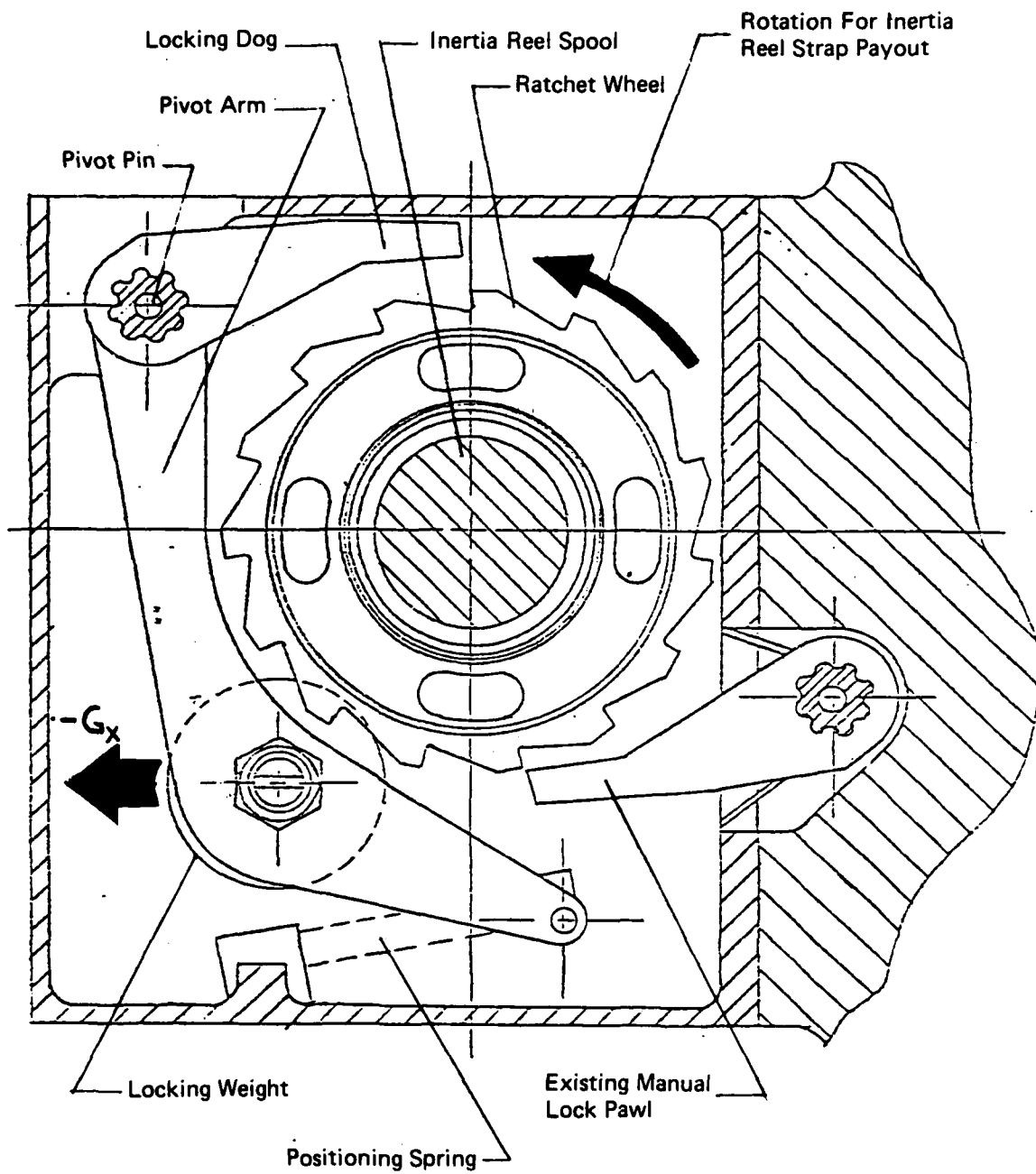


Figure 2 – Layout Of Aircraft Accelerating Sensitive Inertia Reel Lock Components

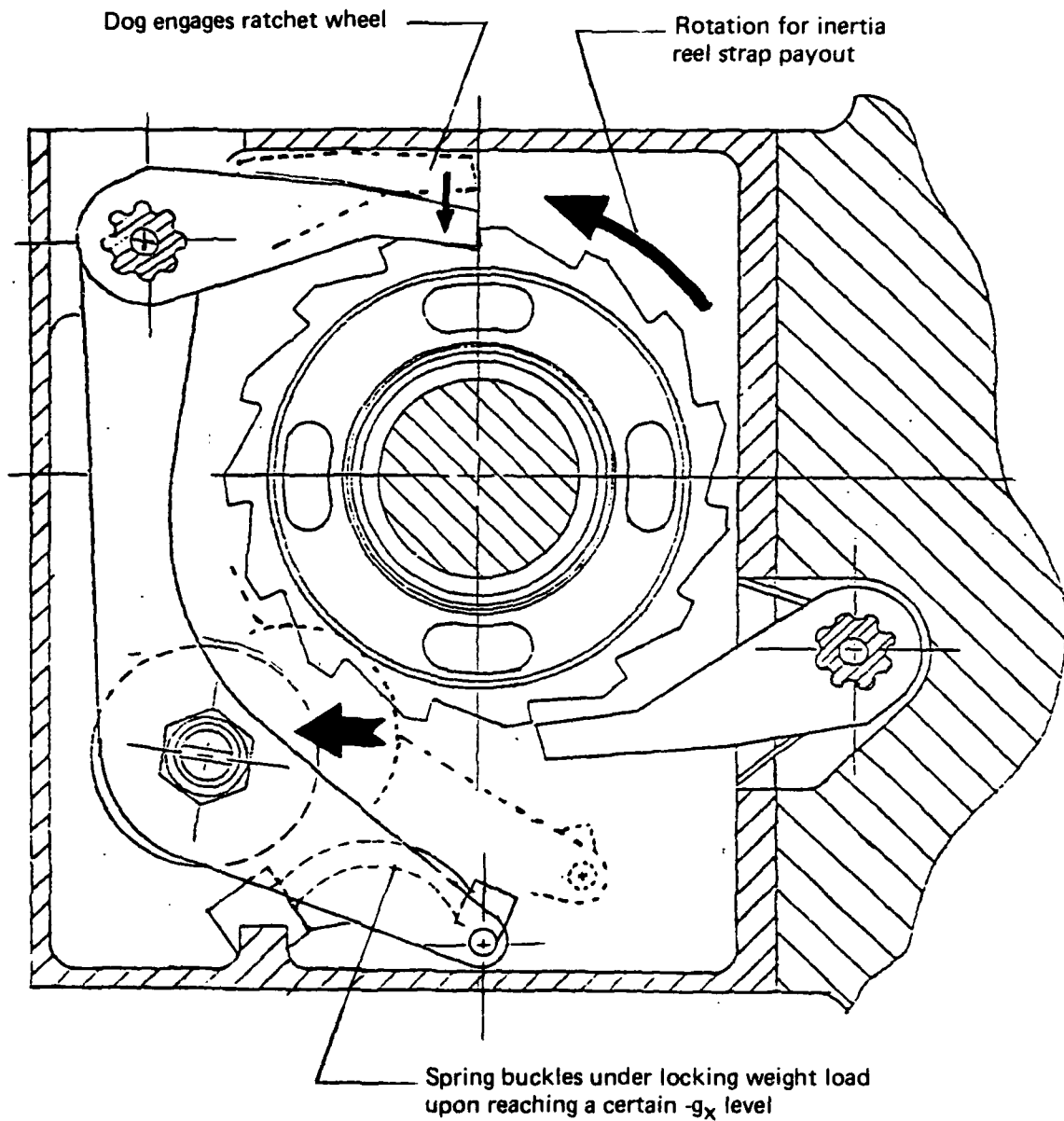


Figure 3 – Locking Of Inertia Reel

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