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AD-P005 381

MULLER MIXER FIRE  
"LESSONS LEARNED"

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1967

The purpose of this paper is to share some of the actions taken by Morton Thiokol, Inc. to enhance safety in pyrotechnic muller mixing operations at Longhorn Army Ammunition Plant. These initiatives resulted from the investigation of a muller mixer fire which occurred on October 30, 1985. It is the safety management philosophy of Morton Thiokol Ordnance Operations that all explosive accidents and significant near miss incidents be thoroughly investigated, by the Engineering and Safety Committee, utilizing a safety systems approach. This committee, which is chaired by the Director of Engineering, B. V. Diercks at the Longhorn Division, was charged with identifying the causative deficiencies and ancillary procedural, equipment design and human engineering changes required to enhance the overall system. To assist Mr. Diercks in this investigation, the following personnel were key contributors in the safety initiatives developed from the analysis of this incident:

J. E. Hawley	Safety & Security Manager
T. R. McClellan	Chief Safety Engineer
M. L. Naron	Technical Specialist
F. J. Russell	Mechanical Engineer
W. M. Teague	Safety Engineer

On October 30, 1985 at approximately 0830 hours a flash fire occurred in Bay D of Building B-11 while mixing M22 flash composition. This was a remote video camera monitored operation. The fire initiated in a size 05 dual wheel National Engineering stainless steel Special Simpson Porto Muller equipped with two-200 pound muller wheels plus an inside and outside plow. Both plows were fitted with nylon wipers positioned in direct contact with the bowl surface.

Longhorn AAP has used this blade to bowl contact mulling procedure since the mid-60's. The mixer wheels/plows revolve at approximately 18 RPM and are driven by an 1800 RPM 3 H.P. motor through a double belt sheave and gear box. The bowl diameter is approximately 39 inches and 12 inches deep with the mulling wheels/plows geared to move in a counterclockwise rotation. All bays are equipped with closed circuit TV monitors, Backrack explosive vapor alarms, Detronics UV rapid acting deluge and fusible link wet pipe fire protection systems with electrically interlocked emergency exit doors, fire door and vapor alarms to remote controls. Also provided is 100 percent make up air with temperature and humidity control, vapor/dust removal systems connected to an external wet type Rotoclone dust collector that is electrically interlocked to the control panel. Walls between bays and control room are substantial dividing walls of 12 inch thick reinforced concrete with three feet of sand fill between bay and control station walls. (Figure 1 illustrates B11 configuration)

At the time of the incident, Bays A and B were inactive while Bay C was in same mix cycle as Bay D. The pyrotechnic being manufactured was a M22 flash composition mix which is composed of Magnesium (93.75 lbs.), Teflon (12.5 lbs.), and Viton Binder (18.76 lbs.) dissolved in Methyl Ethyl Ketone (44 lbs.). This was the first mix of the day with bowls in both Bays C and D being charged with only the Magnesium and the dissolved Binder. No Teflon had been added. The remote mix operation had run approximately 7 of the 10 minutes when the flash fire occurred. The fire caused superficial damage to Bay D and equipment with most of the production material either being consumed or tossed out of the bowl by deluge system. No personnel injuries were incurred. The fire ball did not propagate to Bay C due to the rapid acting deluge system but was

forced into the back corridor and out the emergency exit nearest Bay D. The fire ball also vented over the top edge of the sliding corridor fire door igniting contaminated surface along the fire door track and ceiling. In interviewing the operator who was supposed to have been watching the TV monitors, there was no indication of a problem before she heard a boom and looked up and to see Bay D engulfed in flames on the TV monitor. (Figure 2 shows damage in Bay D)

In conducting this investigation a local and worldwide canvassing of industry incidents failed to identify a similar accident that occurred in the production cycle experienced. Not having a comparative data base to draw on, a complete equipment and supporting systems tear down and analysis was conducted. This evaluation included component design, production material quality control and sensitivity testing, electro-mechanical interfaces, manufacturing processes and procedural adequacy. Without belaboring all the causative possibilities considered the following four were considered the most probable in order of priority:

- ⑤ Friction due to Mechanically Damaged Lip Seal in Muller Wheel
- ④ Friction Between Material Contamination in Bearings
- ③ Friction Between Plow Blades and Bowl
- ② Exothermic Moisture Reaction

The above scenarios were selected as most probable since a man/machine interface was not evident at the time of the incident coupled with mechanical damage, contamination and fire being identified inside a muller wheel. This was also supported by no unusual observations noted prior to the incident or during post production material screening, chemical analysis, and sensitivity testing. Electro Static Discharge (ESD) was not indicated as all electrical continuity systems checked. The investigation of this incident centered primarily on friction/spark ignition, e.g., ignition temperature of MEK is 960°F with a flash point of 70°F while M22 composition is 752°F. The frictional heat levels indicated were considered achievable in the scenarios hypothesized.

The most probable cause was identified during detailed disassembly of the muller wheels which found a damaged Garlock Klosure Lip Seal. Under microscopic examination it was apparent that the metal spring fingers in the lip seal had made metal to metal contact with the axle plus there was indication of fire in the area. Small amounts of explosive contamination were also found past the lip seals in bearings of both the muller wheel and center support post. To correct this deficiency the muller wheel assembly (Figures 3 and 4) has been redesigned with a redundant Ethylene Propylene "O" ring seal plus potting the void in lip seal with solvent resistant Epon 828 and Versamid 125 filler. The lip seal filler prevents explosive product entrapment and build up at the edge of the lip seal, protects finger springs, and aids in cleaning of center support post lip seal. The effectiveness of this lip seal configuration was tested in inert and live prove out mixes which established a twenty (20) shift replacement schedule of all lip seals and bearings. This preventive maintenance baseline may be extended as future experience warrants. Eight months of continuous operations has seen no migration of product past lip seals. (See Figure 5)

The third alternative focused on friction between pyrotechnic composition entrapped in the rough bowl surface and rubbed by direct contact wipers and plow blades causing hot spots. As indicated at the beginning of this paper, the

Longhorn Division has used nylon wiper/plow blades in "Zero" clearance with bowl surfaces for over ten (10) years without incident. The rough condition of bowl surface was due to years of continuous multi-product use without an adequate program to periodically reface bowl and wheel surfaces. The result was a badly worn bowl and muller wheel surface. In addition, it was also discovered that the Total Indicated Runout (TIR) of the bowl was excessive and that the bowl flexed when torque was applied from drive belts. To correct these deficiencies the bowl and wheels were refaced to remove all scratches, scores and gouges, the high points of the mixer wall and bottom were identified and marked on the bowl plus a drive belt tension stabilizer support was added to drive shaft. The muller wheels were also slightly crowned to push possible foreign material out from under wheel. The nylon blades were replaced with ultra high molecular weight conductive polyethylene blades which are installed with a minimum .030 clearance. This blade to bowl clearance is verified daily by production foreman. The last two initiatives were felt necessary to increase our safety margin by eliminating the possibility of static charge generation buildup on nylon blades. The .030 standoff also reduces the potential for blade/bowl friction points. In addition, a nylon bolt was added between rocker arm and crosshead to prevent metal to metal contact and pinching of material. (See Figure 6)

The last scenario involves the possible introduction of moisture with magnesium causing an exothermic chemical reaction with the release of hydrogen. Due to the rain the night before and morning of the incident, the introduction of moisture was a consideration but could not be substantiated. Post testing of magnesium, MEK and binder lots found no moisture specification discrepancies. Operators interviewed had not noticed any water dripping or condensate forming on the Rotoclone duct. Taking an ultra conservative safety approach, action was taken to preclude this possibility happening by requiring all magnesium, teflon and MEK binder solutions to be preconditioned prior to use at 60°F for sixteen hours (16 hours). Daily moisture samples of MEK are taken plus the Rotoclone duct system has been modified with an internal condensate flange trap with take off piping. Temperature and Relative Humidity Recorders have also been installed in all weigh up and muller mixing operations to accurately document the temperature/humidity conditions at the time of weigh up, mixing and mulling.

In addition to the direct causative refinements discussed, the detailed analysis of operating, maintenance, documentation procedures and equipment design surfaced a number of ancillary initiatives which have enhanced the safety of our muller mixing operations. The following is a summary of those observations with improvements made.

- ° Crew Leader failed to observe ignition point on TV monitor. Video and audio VCRs have been installed in all remote muller mixing and granulating operations.
- ° High pressure water used to clean bowls dispersed atomized composition particles which became airborne or floated in run off water becoming attached to walls, ceilings, underside of bowl, drive system compartment and dump door trunnion housing. High pressure water cleaning is no longer used, periodic washing of bay and corridor walls and ceiling is required, drive system compartment has been encapsulized with clear lexan cover to eliminate

motor compartment contamination plus the capability to observe motor and drive belt operations. The dump door has also been modified with "O" ring seal and a product containment chute.

- ° Millwrights were manually lifting and positioning 200 pound muller wheels in bowls. A large number of dents were caused by dropping or positioning wheels in bowls. A portable lifting device and bracket have been installed on the mixer drive compartment to assist when performing special and preventative maintenance operations.
- ° During the initial mixing cycle of inert and live testing, pockets of unacceptably high explosive vapor levels were not detected by the Backrack Vapor Alarm mounted just outside bowl lip. To correct this deficiency, the air exhaust system was rebalanced plus an air purge capability installed. In addition, the wiper blade was redesigned to improve mixing flow and homogeneity characteristics which minimizes explosive vapor entrapment. The vapor alarm system was set to activate at 20% of the Lower Explosive Limit (LEL). Also all dual wheel mullers were modified with reverse (clockwise) rotation capability.

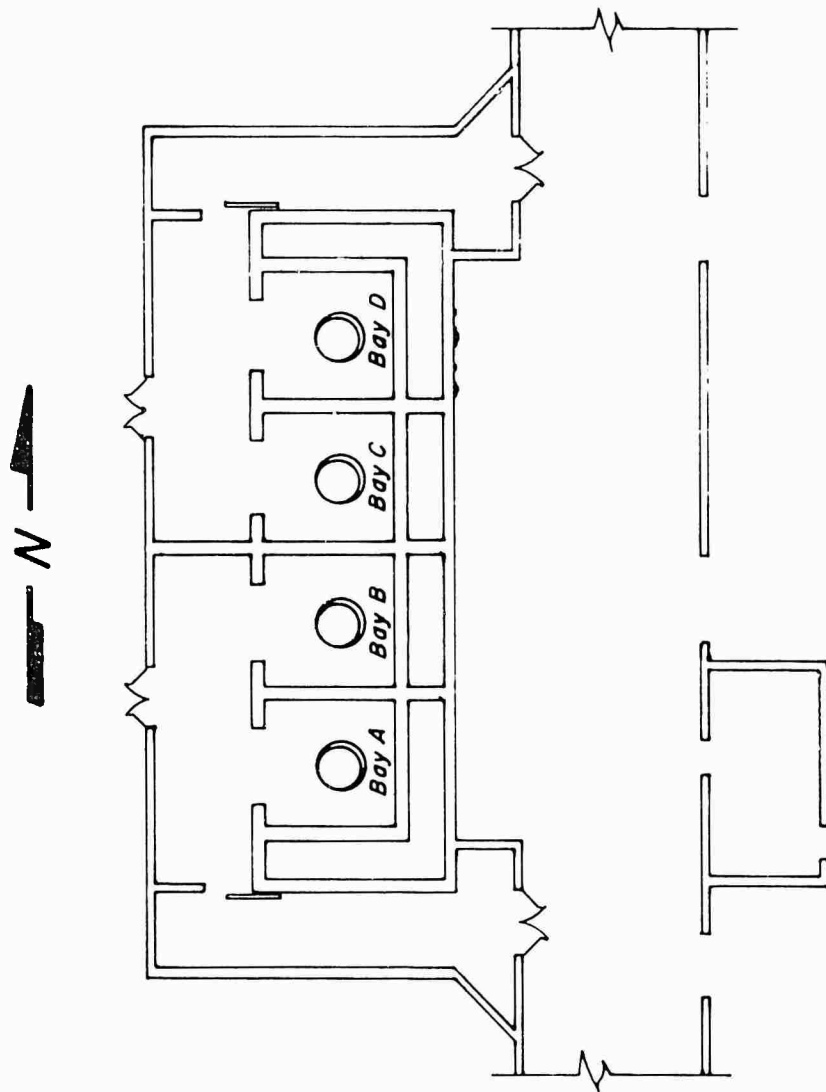
The improvements resulting from our Lessons Learned are being institutionalized at Longhorn AAP. All dual wheel muller mixers have been modified and we are now addressing a detailed design review of single wheel mullers. The procurement specifications for upgrade replacement of mullers have incorporated these refinements plus providing for a side opening dump door to aid in cleaning and maintenance, and thicker bowl construction to minimize flex and hold TIR.

It is the desire of Morton Thiokol that the Lessons Learned presented be of value and where applicable incorporated into the readers safety program. An explosives incident jeopardizes the safety and health of our most important resource - our employees - and tarnishes the credibility of our industry. We must continually strive for safety excellence. At Longhorn AAP our goal is "Zero Accidents " and is reflected in our Safety Creed:

- ° Pyrotechnics are Unforgiving
- ° Man can be Unthinking
- ° Complacency is the Road to Failure

While the tenants of that creed are absolutes the last is the most germane to the case study. The human fallacy of complacency coupled with the mystique of pyrotechnics and the philosophy of "Don't Fix It If It Is Not Broke" was the road to this system failure. Hopefully the Lessons Learned and the initiatives taken will assist our industry in being proactive rather than reactive in the future.

Figure 1



**BUILDING B-11**

Figure 2

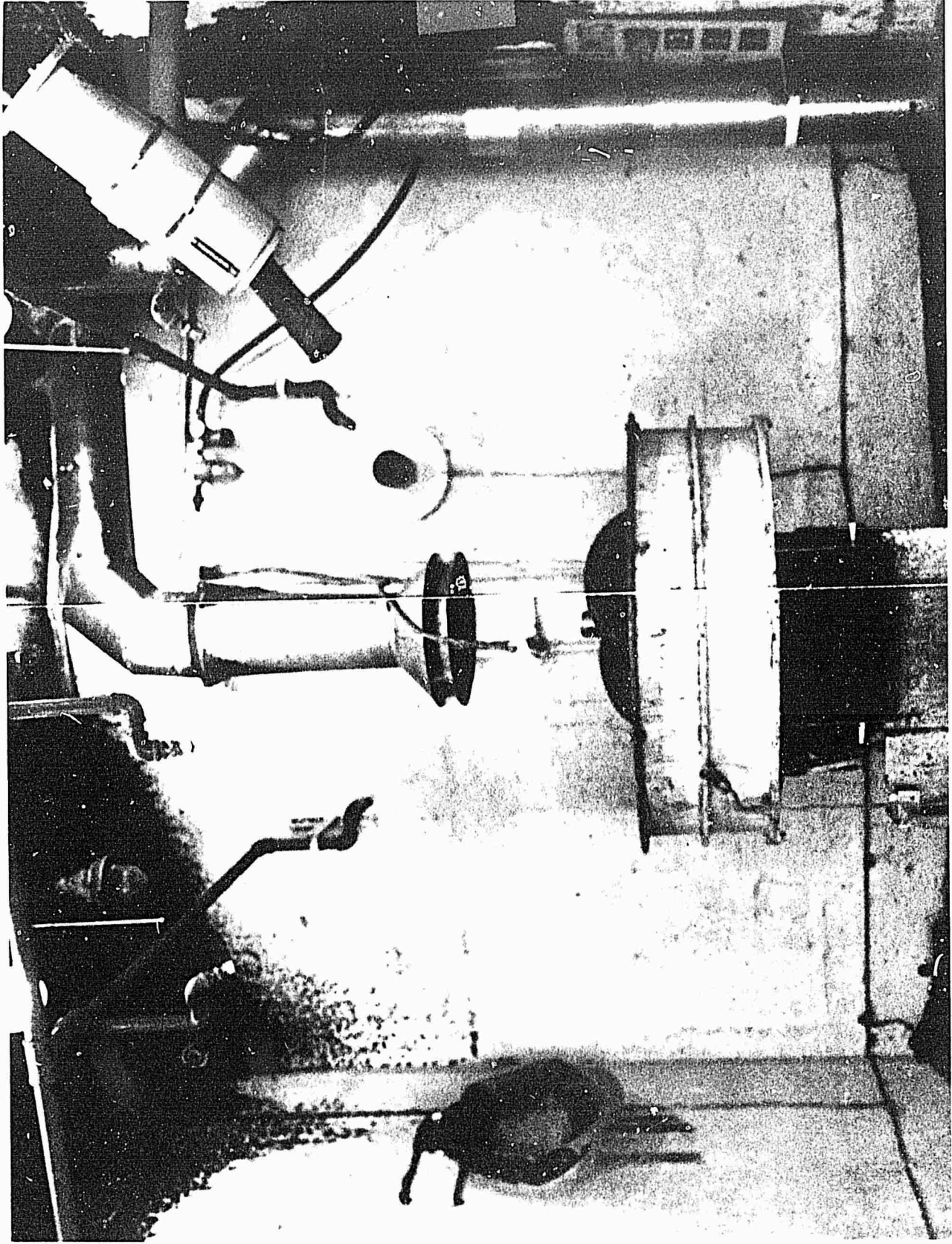






Figure 4

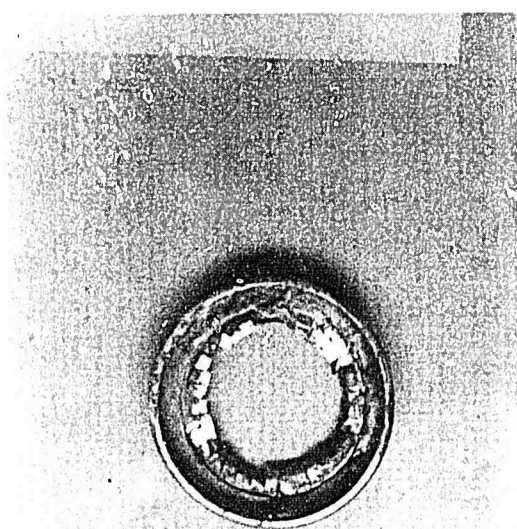
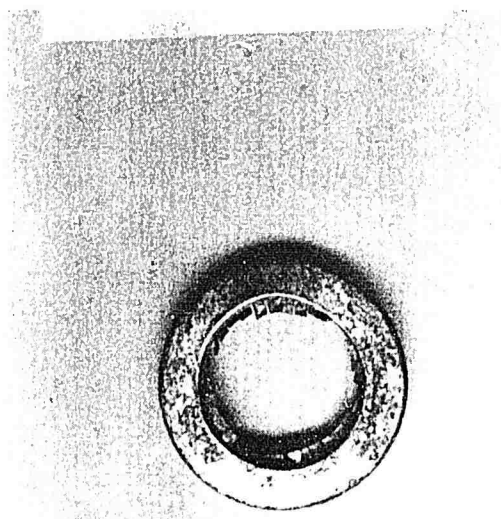
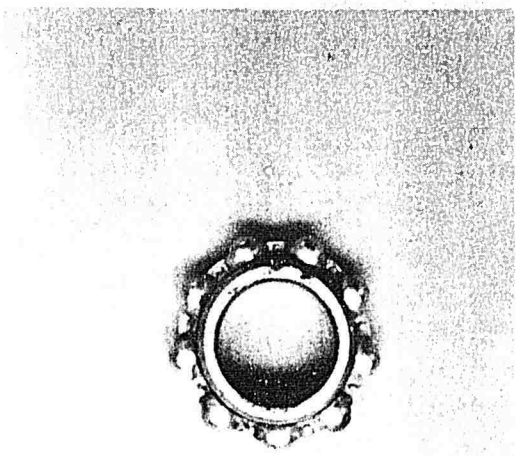


Figure 5

# GARLOCK KLOUSURE LIP SEAL

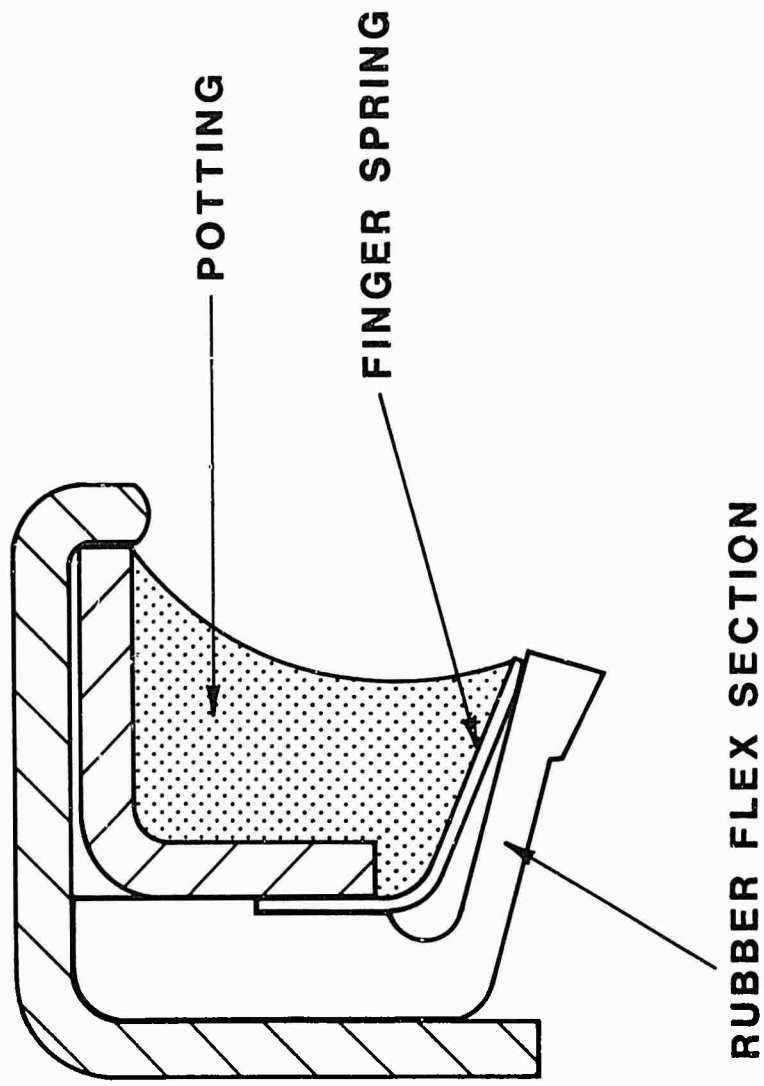
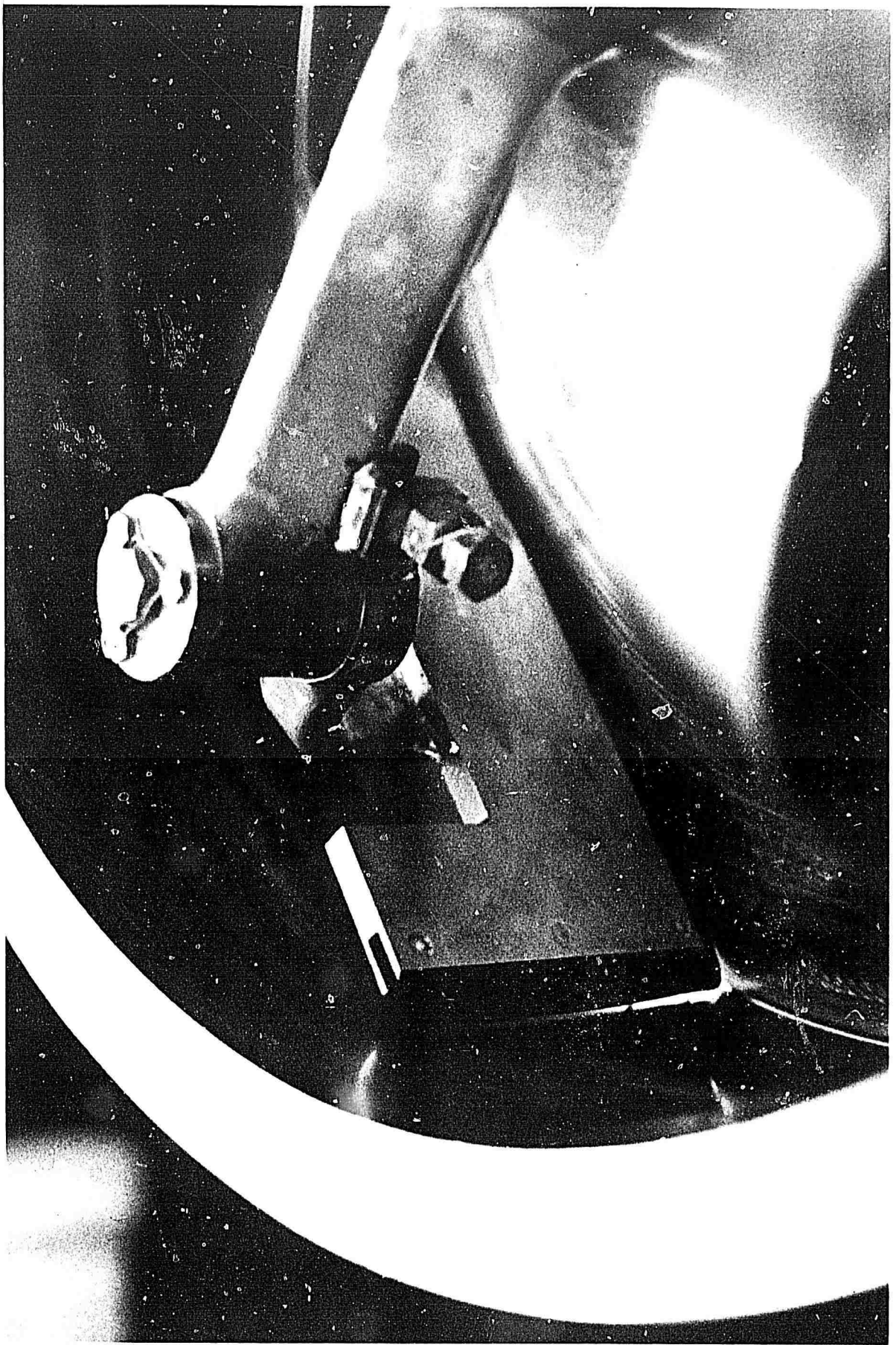


Figure 6



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