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ORION

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FRONT AND BACK COVERS We salute **VP-10**—a pioneer squadron whose lineage can be traced back 44 years, through a number of designations, to VS-1S. It first became VP-10S on 1 July 1930, scouting in that year with T4M's and, later, with PM-1 flying boats.

During its early years Patron Ten first served at Hampton Roads, Va. and the Canal Zone (where its designation changed to VP-10F) then, in December 1933, transferred to Pearl Harbor. VP-10F, newly equipped with six P2Y-1's, set aviation records en route to Honolulu. The 2150-mile, day-long crossing was the first successful seaplane flight to Hawaii and was the longest non-stop, mass-formation flight in history.

Between 1937 and 1941 VP-10F's designation suffered some abuse—the "F" was dropped in 1937, in 1939 squadron designation changed to VP-25 and, in 1941, to VP-23.

On 7 December 1941 the squadron suffered more than a change in designation. Eight of its aircraft were strafed that day, but four others joined the search for the Japanese armada. The squadron served valiantly throughout WW II, seeing action during the battle of Midway, the early days at Guadalcanal, at Eniwetok, Saipan, Guam, and Iwo Jima.

Temporarily de-commissioned after VJ day, Patrol Squadron Ten was reborn in 1951, equipped with nine P2V aircraft, and, after deployments to Newfoundland and Iceland transferred to its present home at Brunswick, Maine in 1952. Since then VP-10 has ranged the world from the North Pole to Chile and from Burbank to Pakistan.

Commendations and awards too numerous to mention testify to Patron Ten's performance in USN, NATO, and South American assignments. It participated in the Lebanese and Cuban crises, helped the Portuguese find a pirated ship, spotted the oil slick from the Thresher, and played Santa Claus to a Sicilian orphanage to name a few recent exploits.

In the year since transition to P-3 Orions, VP-10 has patrolled the Atlantic from its home base and from Keflavik, Iceland. The cover picture shows a Keflavik-based aircraft flying over pack ice near Greenland.

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CORROSION AND THE P-3 ORION

by E. L. Grindle
Design Specialist

CORROSION can and must be controlled. You need go no further than the photograph on this page for a reason. The purpose of this article is to prevent corrosion from gaining such a foothold on P-3 aircraft by enumerating and discussing the specific corrosion control requirements of the P-3 Orion. Related information on this subject is contained in a general discussion of aircraft corrosion in Issue 49 of the *Lockheed Field Service Digest.* Official publications and directives which govern the activities

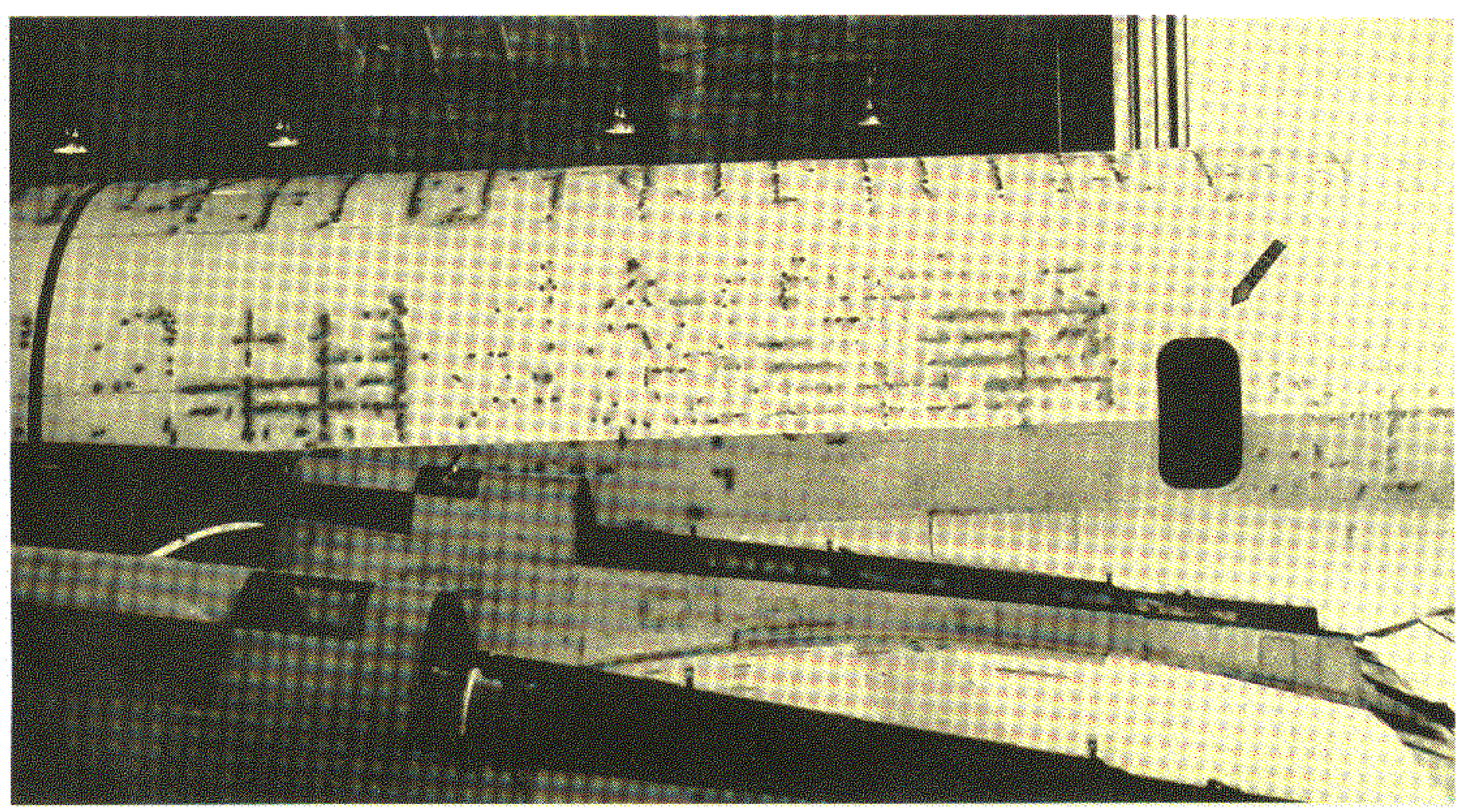


Figure 1
Fuselage After Vacu-Blast Treatment of Areas with Filiform Corrosion

of personnel directly engaged in Naval aircraft corrosion control are listed in Table 1.

Any corrosion control program must encompass certain fundamental elements: Prevention, Detection, Corrosion removal, Repair of structural damage, Cleaning and inhibiting surfaces, and Restoration of protective coatings. Each of these must be given consideration when acting on a particular corrosion problem, whether an airplane is undergoing a progressive overhaul at an overhaul and repair facility or is operating under maximum utilization conditions at some remote area.

PREVENTION By far, the most effective measures in any corrosion control program are those taken to prevent corrosive attack or protect metals from corrosive agents. Preventive measures start during the preliminary design stage with the selection of materials, their fabrication, and their processing and protection during construction. Each material, part, assembly, procedure and process is evaluated to determine what protective measures can be taken to avoid corrosive attack. Each part or assembly which is subject to corrosive attack is given one or more treatments or processes to render it as immune as possible to corrosion. Figure 2 shows the materials of the P-3 Orion's basic structure.

TABLE 1

1. P-3A Aircraft—Corrosion Control, Cleaning, Painting, and Decontamination —NAVWEPS 01-75PAA-2-2.1
2. P-3A Aircraft—Structural Repair Instructions—NAVWEPS 01-75PAA-3-1 & 2
3. T56-A-10 Aircraft Engine—Service Instructions—NAVWEPS 02B-5DC-2
4. T56-A-10 Aircraft Engine—Overhaul Instructions—NAVWEPS 02B-5DC-3
5. T56-A-14 Aircraft Engine—Service Instructions—NAVWEPS 02B-5DD-6-2
6. T56-A-14 Aircraft Engine—Overhaul Manual—NAVWEPS 02B-5DD-6-3
7. Model 54H60-77 Variable Pitch Aircraft Propeller—Operation and Maintenance Instructions—NAVWEPS 03-20CBBK-1
8. Model 54H60-77 Variable Pitch Aircraft Propeller—Overhaul Instructions— NAVWEPS 03-20CBBK-2
9. Preservation of Naval Aircraft for Shipment and Storage—NAVWEPS 15-01-500
10. Aircraft Maintenance Cleaning—NAVWEPS 01-1A-506
11. Corrosion Control for Aircraft—NAVWEPS 01-1A-509
12. Chemical Materials for Naval Weapons Systems Maintenance and Overhaul Operations—NAVWEPS 07-1-503
13. Periodic Maintenance Requirements Manual—NAVWEPS 01-75PAA-6

After an airplane is constructed and delivered, the only measure that can be exercised to prevent corrosive attack is to maintain the integrity of protective coatings that separate the susceptible materials from the corrosive environment. This is done through frequent inspection, washing, cleaning, and refinishing of these coatings.

DETECTION Discovery of corrosion at the earliest possible moment and immediate corrective action are the most important phases of corrosion control on existing aircraft. Frequent visual, ultrasonic, dye penetrant and, to some degree, disassembly inspections are the means by which this goal is accomplished.

The basic inspection requirements for the P-3 airplane are covered by the Periodic Maintenance Requirements Manual, NAVWEPS 01-75PAA-6. This manual prescribes *minimum* service - wide requirements to assure timely discovery of corrosion. Cognizant commanders may increase the scope or frequency of these requirements to properly support varying operational needs or environmental conditions.

In general, the best means of corrosion detection is by direct visual inspection. This inspection method is best suited for detection of incipient corrosion on exposed surfaces, but the splices and joints typical in aircraft structure limit its effectiveness. Furthermore, there is hardly a square inch on the P-3 Orion that is not covered by one or more protective coatings that introduce barriers to visual inspection. Corrosive deposits under these coatings are difficult to see until their volume builds up. Any ruptures or penetrations of a protective coating may be an indication of corrosion and should be investigated immediately.

Inspection of hidden structural surfaces and determining the extent of corrosion or cracks require the use of supplementary detection procedures. Dye penetrant (preferably the fluorescent type), magnetic, and ultrasonic inspections are some of the aids that can be employed, depending on the nature of the material or structure to be examined.

At any rate, whenever corrosion is detected, the penetration and area boundaries must be established to determine the extent of damage and assure complete corrosion removal.

REMOVAL When the extent of corrosion activity has been determined, the affected material must be removed as soon as possible. If corrosion is not arrested at an early stage, it may spread until its removal is a major operation or the structural integrity of the part is impaired.

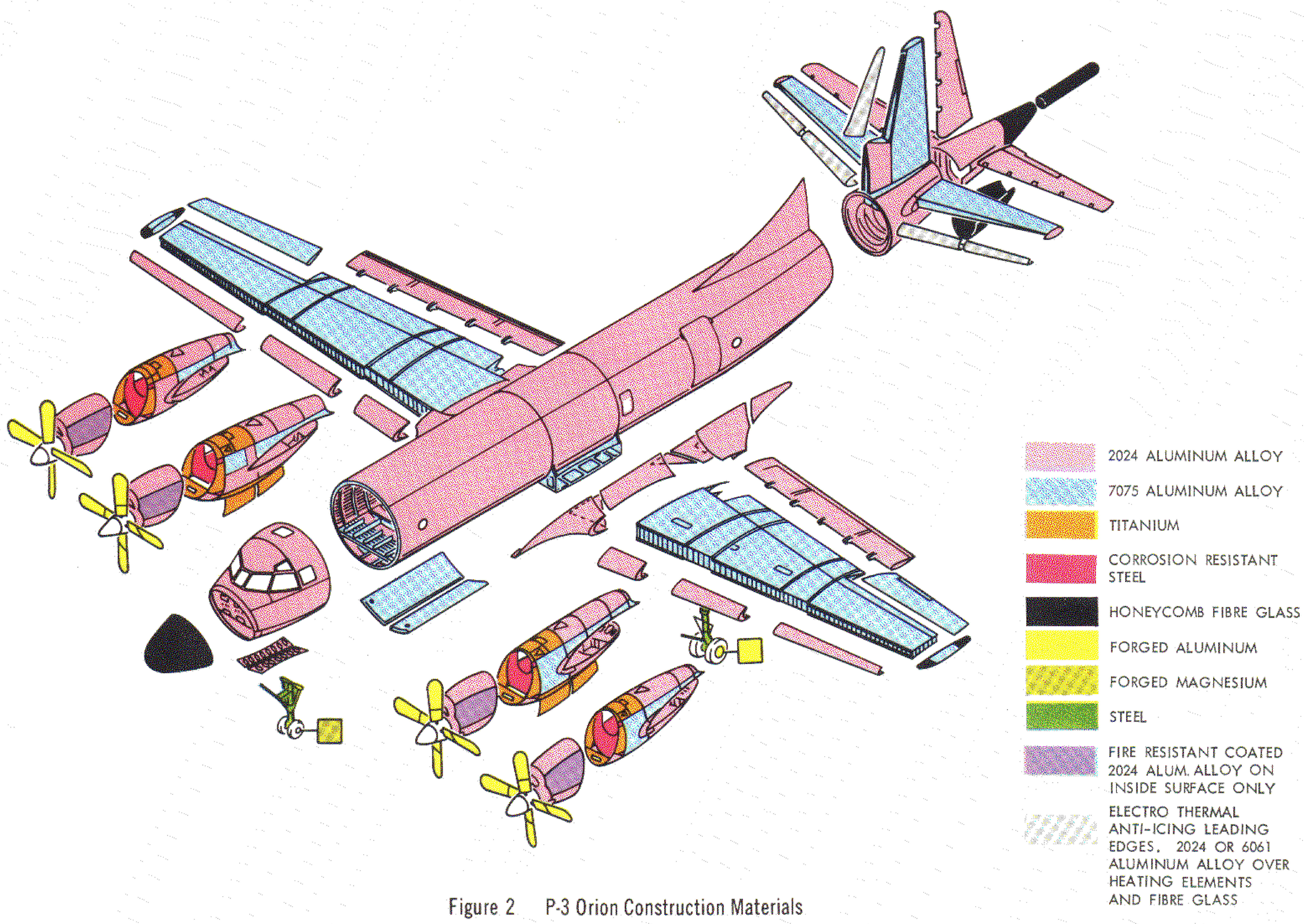


Figure 2 P-3 Orion Construction Materials

The procedure for removing corroded material must be adapted to the particular area, structure and extent of damage incurred. Removal may vary from chemical cleaning, through scraping and cutting, to replacement of major components. The materials, tools and equipment must be controlled to assure that they are compatible with the material that is to be cleaned.

Precautions must be exercised to protect unaffected structure and protective coatings. Masking and other barriers should be employed to confine corrosion removal activity to the affected areas, and power tools and equipment should be provided with fixtures or supports that will prevent inadvertent damage to surrounding structure when these tools are in use.

REPAIR Occasionally the removal of corroded material will exceed the allowable structural limits of penetration, and repairs will have to be made to restore the structural integrity of the part or area involved. Whenever this occurs, the P-3 Structural Repair Manual NAVWEPS 01-75PAA-3-1 and/or -2 should be consulted. If corrosion damage has progressed to the degree that the integrity of the associated structure is in question, the time has come to call in the specialist. Lockheed is available for consultation and assistance on such problems if the need arises.

In addition to restoring the structural integrity, precautions must be exercised to protect the repaired parts from subsequent corrosive attack. The installation of doublers should always be made with materials that are most compatible in galvanic activity relationship. For example, when aluminum alloy components are used, they should be anodized or treated with a chemical conversion coating (Spec. MIL-C-5541). The installation procedure should include use of sealants or other protective materials on the faying surfaces and fasteners. Where splice fillers are inserted between faying surfaces (which dictates clamping the fillers with fasteners), both the fillers and fasteners should be installed with wet sealant.

CLEANING AND INHIBITING Once complete mechanical or chemical removal of the affected material has been accomplished and the necessary repairs have been made, the reworked areas should be prepared to provide the most chemically clean surface possible for receiving protective coatings. It is often worse to apply protective coatings over a contaminated surface than to apply no protective coating at all. Many of the tools, abrasives, and other materials used for corrosion removal can leave impurities on the reworked surface that could cause corrosive attack to recur. These impurities also must be removed.

During cleaning and inhibiting processes, measures must be taken to protect the surrounding structure and finishes from damage by these agents. If cleaning agents can contact faying surface sealants or penetrate into voids or entrapment areas, precautions must be taken to prevent such penetration or to assure removal of these agents before restoring the protective coatings.

Cleaning and inhibiting procedure for aluminum alloys. Several discussions in this article deal with the corrosion problems of specific structures fabricated from aluminum alloys, and in many cases the cleaning and inhibiting procedure is exactly the same. Rather than repeat this procedure several times throughout the article, it has been placed in this section and is cited whenever applicable.

Use Specification MIL-D-16791 Type I Nonionic Detergent. This water-soluble material can be prepared by using a concentrate of 8 percent detergent, 20 percent isopropyl alcohol (MIL-F-5566) and the balance (72%) fresh water. One part of the concentrate should then be diluted further with nine parts of water, giving a final mixture of about 0.8% non-ionic detergent and 2% isopropyl alcohol.

Scrub, mop or wipe the solution into the oily soil and rinse the loosened soil from the surface with fresh water. If the water drains freely, the surface is clean; if the rinse water forms droplets when it drains, the surface is not clean and requires further treatment.

Wipe the surface dry and apply a solution of 50% Cleaning Compound (Specification MIL-C-5410 Type II) and 50% fresh water, using rags or sponge to saturate the area being treated. Scrub with nylon bristle brushes.

Allow the solution to react for 5 minutes, then rinse the surface thoroughly with fresh water. Immediately after rinsing and while the surface is still wet, apply chemical conversion coating Specification MIL-C-5541 in accordance with the manufacturer's recommendations. There are several suppliers who manufacture materials to this specification as proprietary items (two of the most common are Alodine and Iridite), consequently the application procedure and film color is dependent on the particular material drawn from stock. In the case of Alodine and Iridite, the thinner Alodine forms a very light green to yellow iridescent film as opposed to a brassy gold to brown film formed by the thicker Iridite.

Before the chemical conversion solution is dry (most applications require approximately 5 minutes reaction time), rinse the surfaces thoroughly with fresh water and then dry area thoroughly.

Paint coatings should be applied within 2 to 8 hours after the chemical conversion treatment. During this time-span, the treated surface is in its best possible condition to receive the primer and subsequent topcoats.

RESTORATION OF PROTECTIVE COATINGS After the corroded material has been removed and the exposed surfaces have been cleaned and treated with inhibitors, the coatings must be restored to protect these surfaces from further attack. Any processing such as plating, etching, priming and topcoating must be performed in accordance with those procedures set forth in the official documents that govern the restoration of protective coatings. Remember that one of the most important factors is to assure that the treated surfaces are chemically clean, otherwise the restored coatings will not adhere to them.

SUMMARY Every approach to corrosion control, whether general or specific, must include all six aforementioned steps. If, for any reason, temporary measures are taken wherein any of these steps are not performed, or some steps are accomplished only to a limited extent, all six steps must be repeated to the degree necessary to assure satisfactory permanent control.

Corrosion control unlike some other maintenance measures should not be postponed for heavy progressive overhaul services. Corrosive attack can progress rapidly and must be arrested as soon as it is discovered if major repairs or failures are to be avoided.

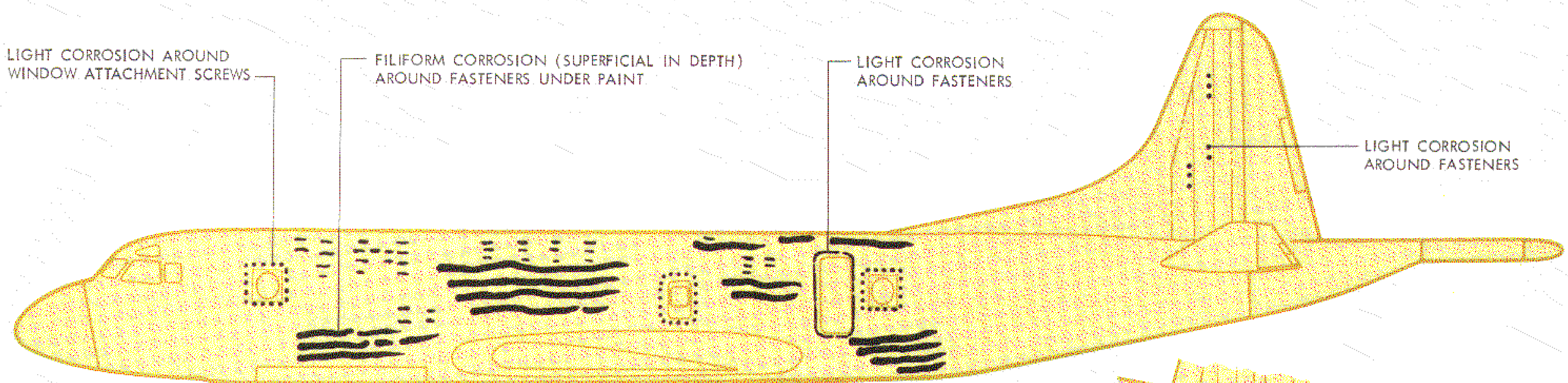
In the ensuing pages, we will deal with the specific corrosion history of the P-3 Orion, Lockheed's past and present action, and some long-range activities that have been prompted by the P-3 experience. As we outline specific problem areas, the discussions will be presented in this six-point corrosion control format.

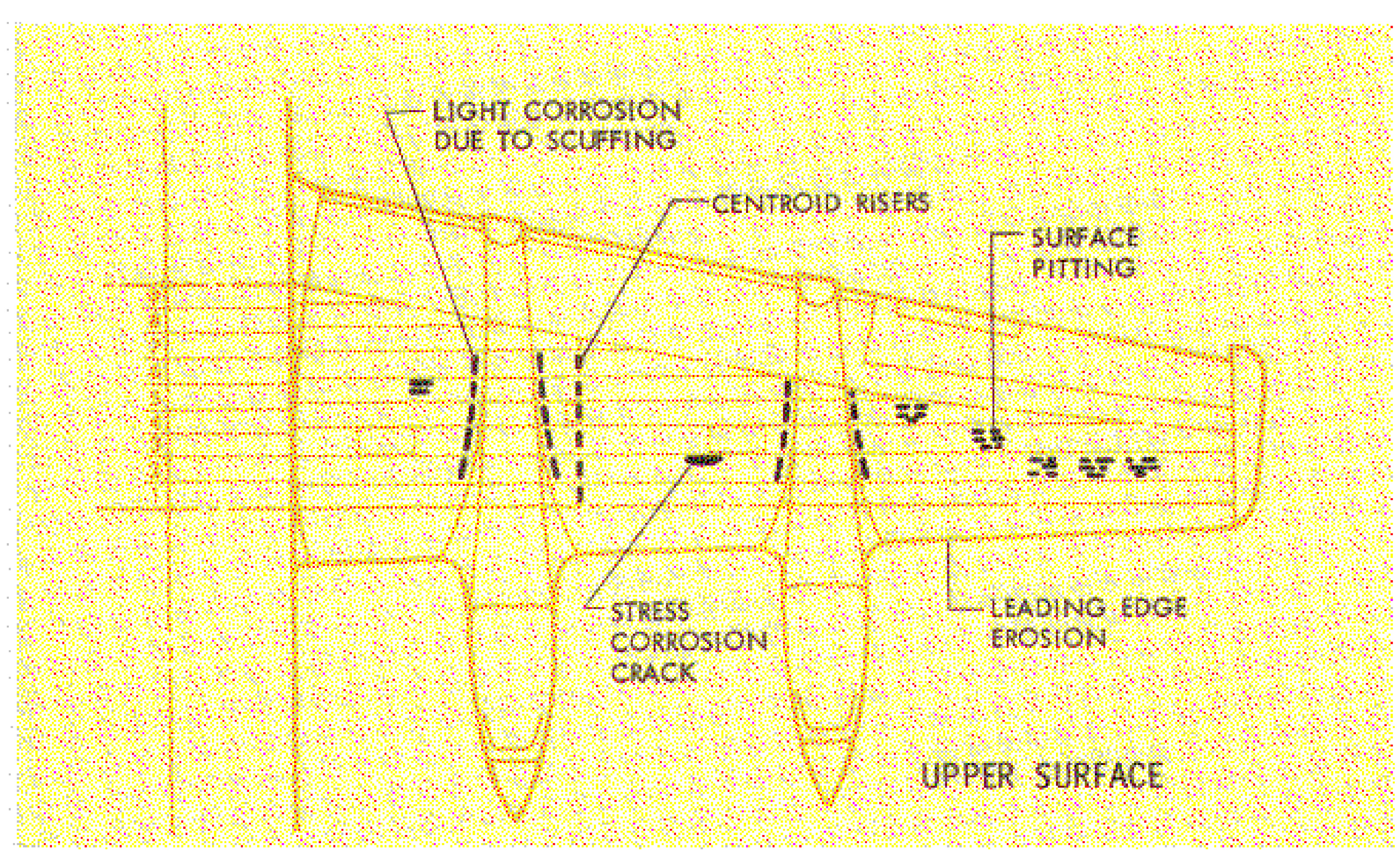
CORROSION PRONE AREAS

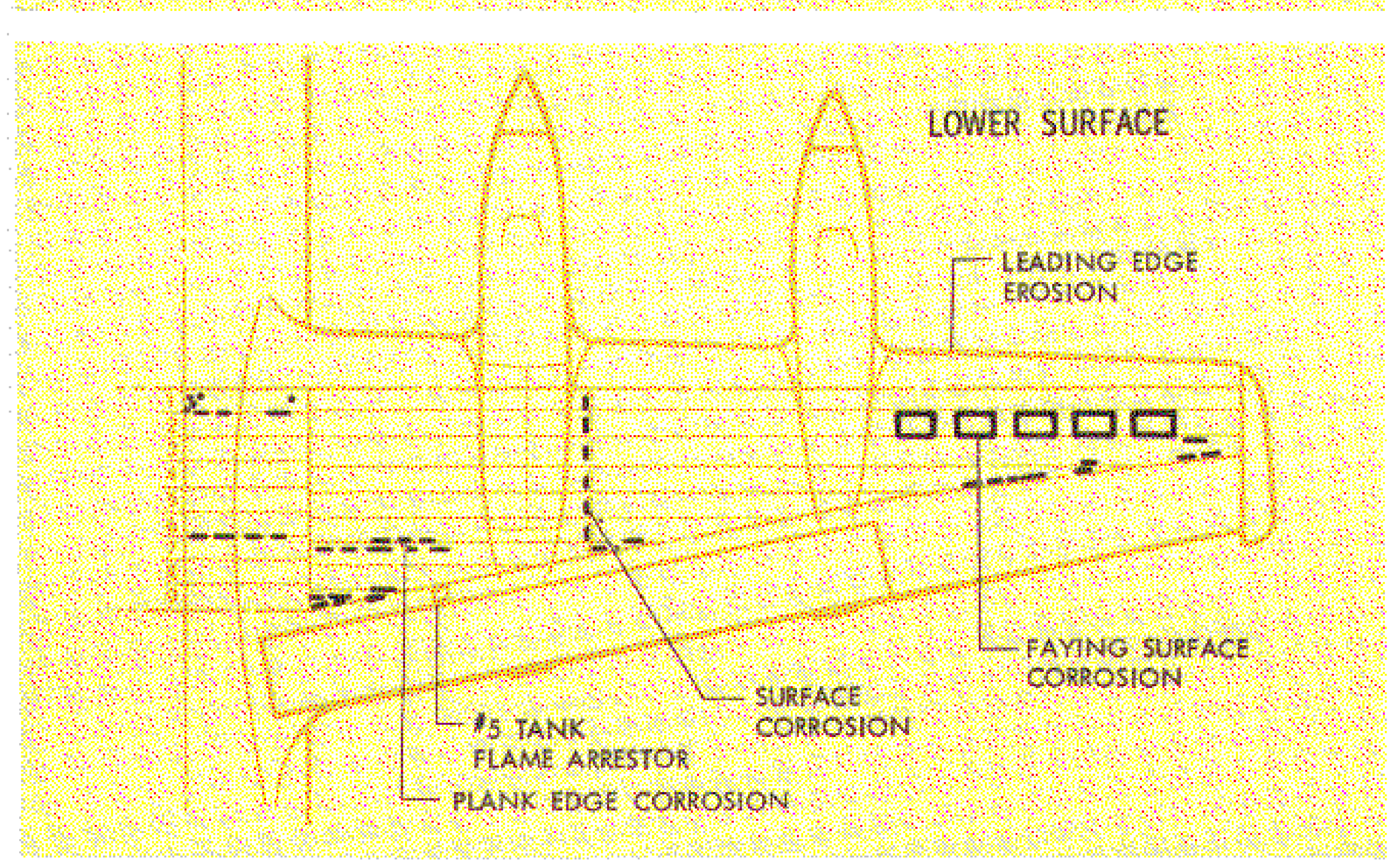
UPPER AND LOWER WING SURFACES (PLANK SKIN) The upper and lower surfaces of the wing box beam are constructed from extrusions of 7075-T6 aluminum alloy, machined to finish dimensions and tapered to match span and chordwise strength and contour requirements.

Protection Corrosion protection requirements originally consisted of Iridite chemical immersion treatment, wet tank sealant between faying surfaces on assembly, and dry installation of fasteners. After assembly, coatings of wash primer, lacquer primer, and two coats of pigmented acrylic-nitrocelluose lacquer were applied to the exterior plank surfaces. Changes in the protective finish system subsequently incorporated to improve corrosion resistance are:

1. Wet sealant installation of removable fasteners at Serial No. 5087 (BuNo 151374).
2. Paint system changed at Serial No. 5110 (BuNo 152140) to:
   a. Alodine chemical immersion treatment.
   b. Wash primer.
   c. Epoxy-polyamide primer.
   d. Epoxy-polyamide top coat.
3. Wet sealant installation of permanent fasteners at Serial No. 5126 (BuNo 152156).
4. Elimination of wash primer (2-b) and incorporation of "Scotch-Briting" to improve paint adhesion at Serial No. 5133 (BuNo 152163).
5. A polyurethane paint system is being evaluated on ten airplanes, Serial Nos. 5193 through 5199, 5201, 5203 and 5204 (Bu Nos. 152751 through 152760).







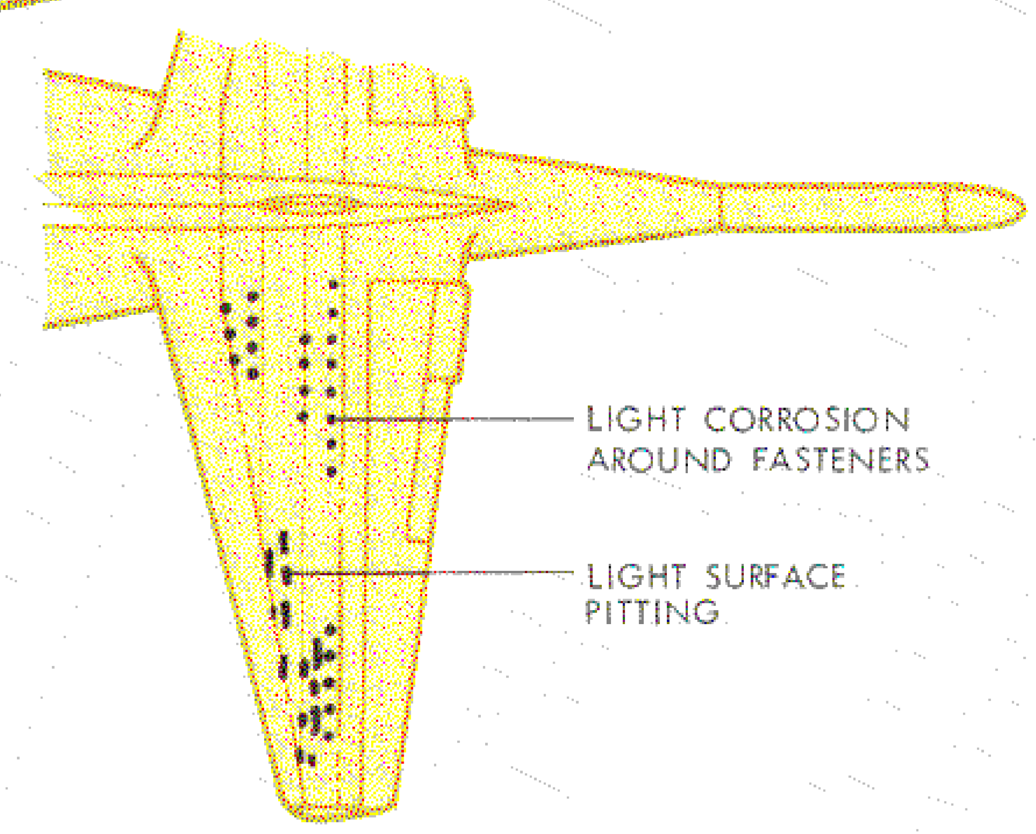


Figure 3
Summary of Corrosion Reports on the P-3 Orion

Detection Corrosion has been detected on some aircraft along the wing plank skin and fasteners at the locations shown in Fig. 3. This corrosion has been reported as surface pitting on intermediate skin surfaces (those skin areas not adjacent to fasteners), galvanic attack at fastener locations, paint blistering with surface corrosion underneath, corrosion under the centroid riser fillers, and faying surface corrosion around the outboard access doors in the bottom skin. There has also been one case of a corrosion crack at the inboard forward edge of the access door cut out at Wing Station 300 of the upper plank. With the exception of the single crack (which was obscured, but detected by a fuel leak), all of the reported wing plank skin corrosion has been detected by visual inspection techniques.

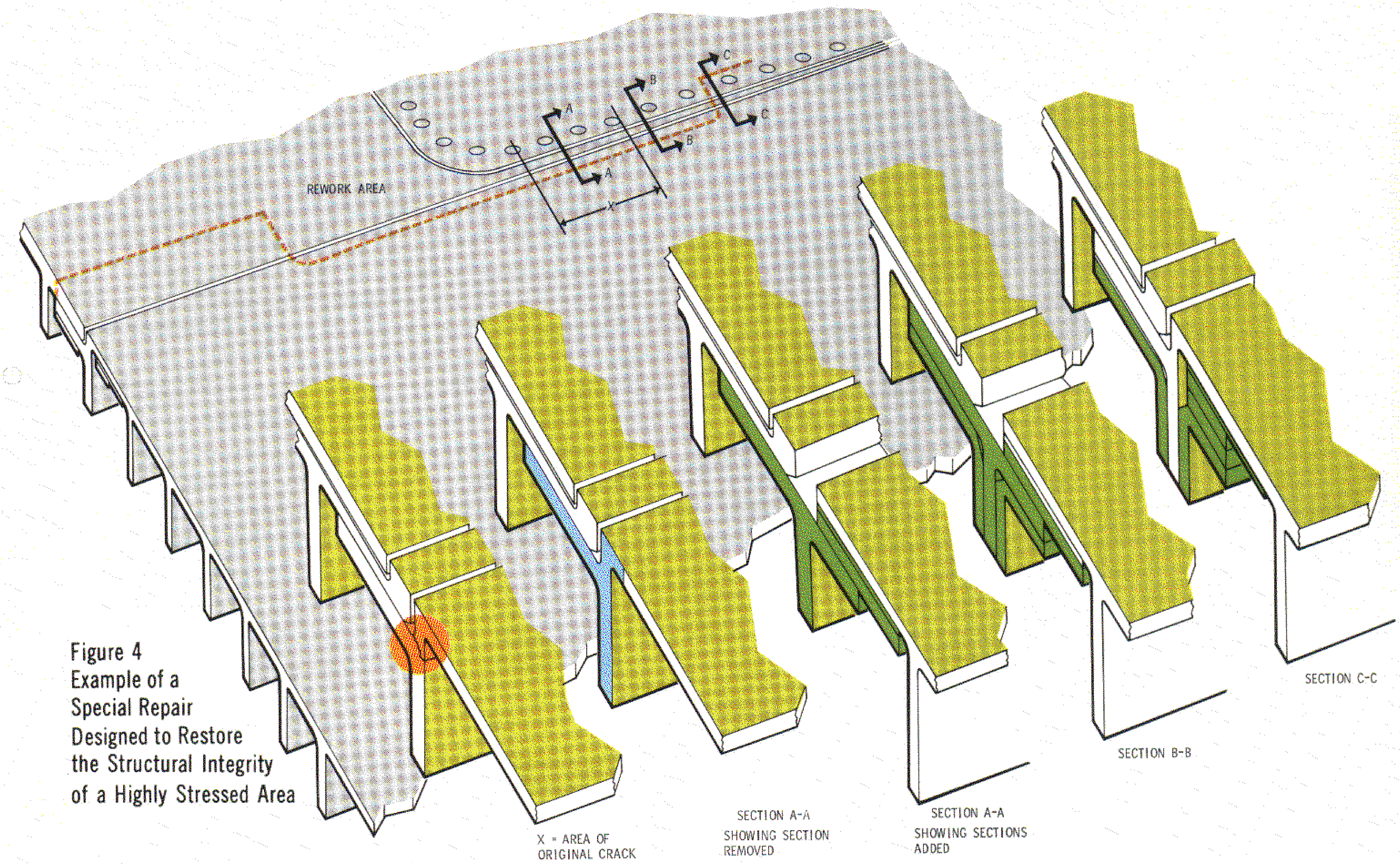


Figure 4
Example of a Special Repair Designed to Restore the Structural Integrity of a Highly Stressed Area

Removal, Cleaning and Restoration of Protective Finishes To date, the corrosion reported on the wing plank skin has been superficial in nature, with the exception of the one stress corrosion* crack. Removal of the corrosion deposits, cleaning of the surfaces, and restoration of protective finishes has been accomplished by standard procedures outlined in the official corrosion control publications.

Repair In the case of the crack, which was located in an area of relatively high stress, a special repair was designed by Lockheed to restore the structural integrity of the area (see Figure 4). Any repair of this nature must be designed by a qualified structures engineer, and he must give thorough consideration to P-3 stress distribution when making the design.

Although this was one crack on one airplane, it prompted a thorough investigation. The reason the crack occurred was because the sealant had not penetrated into the wing plank splice gap, permitting moisture and a concentration of contaminants to accumulate in this area. These gaps are now being sealed on all production aircraft, and aircraft in service are having these gaps sealed through incorporation of Airframe Change No. 79. Further measures are discussed in the next secton, entitled "WING PLANK SPLICES."

Referring once again to Figure 4, this case forcefully illustrates that once a primary structural member suffers crack damage, extensive repairs are necessary. Incipient corrosion must be detected to minimize the need for such repairs.

WING PLANK SPLICES The wing plank splices, although part of the box beam structure, are treated separately here because this is an area that has been particularly susceptible to corrosive attack. As stated earlier, the wing planks are machined from extrusions of 7075-T6 aluminum alloy. This splice area requires special treatment to prevent the incidence of corrosion.

Protection Before outlining the precautions that have been taken to provide protection in this area, we will explain some of the peculiarities that have been created in this material configura-

** Stress corrosion is the combined effect of static or steady-state stresses applied to a material over a period of time under corrosive conditions. Stress corrosion cracking is found in most metal systems: however, it is particularly characteristic of aluminum, copper, certain stainless steels, high strength alloy steels and magnesium alloys. It usually occurs along lines of cold working and may be transgranular or intergranular in nature.*

Stress corrosion cannot occur except in the presence of a corrosive environment. Exclusion of this environment by proper processing and sealing of the material will prevent stress corrosion.

tion. Fig. 5 shows a cross section of a typical splice joint looking spanwise. This basic joint configuration exists in the center section and throughout the outer wing. Fig. 6 shows the basic plank composition from raw extrusion to machined finish, with a macrograph portrayal of the granular flow in the finished radii. It was in the outer radius of the underlying tang that the crack previously reported had developed.

The steady-state stresses imposed in this area create the possibility of stress corrosion cracks if this area is also exposed to corrosive attack. Sealant placed in the gap area prevents the entry of materials which might cause corrosive attack. By shotpeening the radii, the material can be rendered resistant to stress corrosion cracking up to 75% of its yield strength. Application of surface coatings (see Figure 7) to exclude the corrosive environment will provide the radii additional protection.

Listed below is a summary of numerous corrosion preventive measures associated with the wing plank splice area:

1. Wet sealant has been applied between tang faying surfaces from the beginning of P-3 production.
2. From the beginning of production the interior wing surfaces (fuel tank area) have been sealed with BUNA "N" compound, and the lower tank surfaces have been overcoated with polyurethane.
3. Wet sealant installation of removable fasteners at Serial No. 5087 (BuNo 151374).
4. Sealing wing plank gaps and access doors in the outer wing during production at Serial No. 5087 (BuNo 151374).
5. Sealing wing plank gaps on aircraft in service by retrofit through P-3 Airframe Change No. 79.

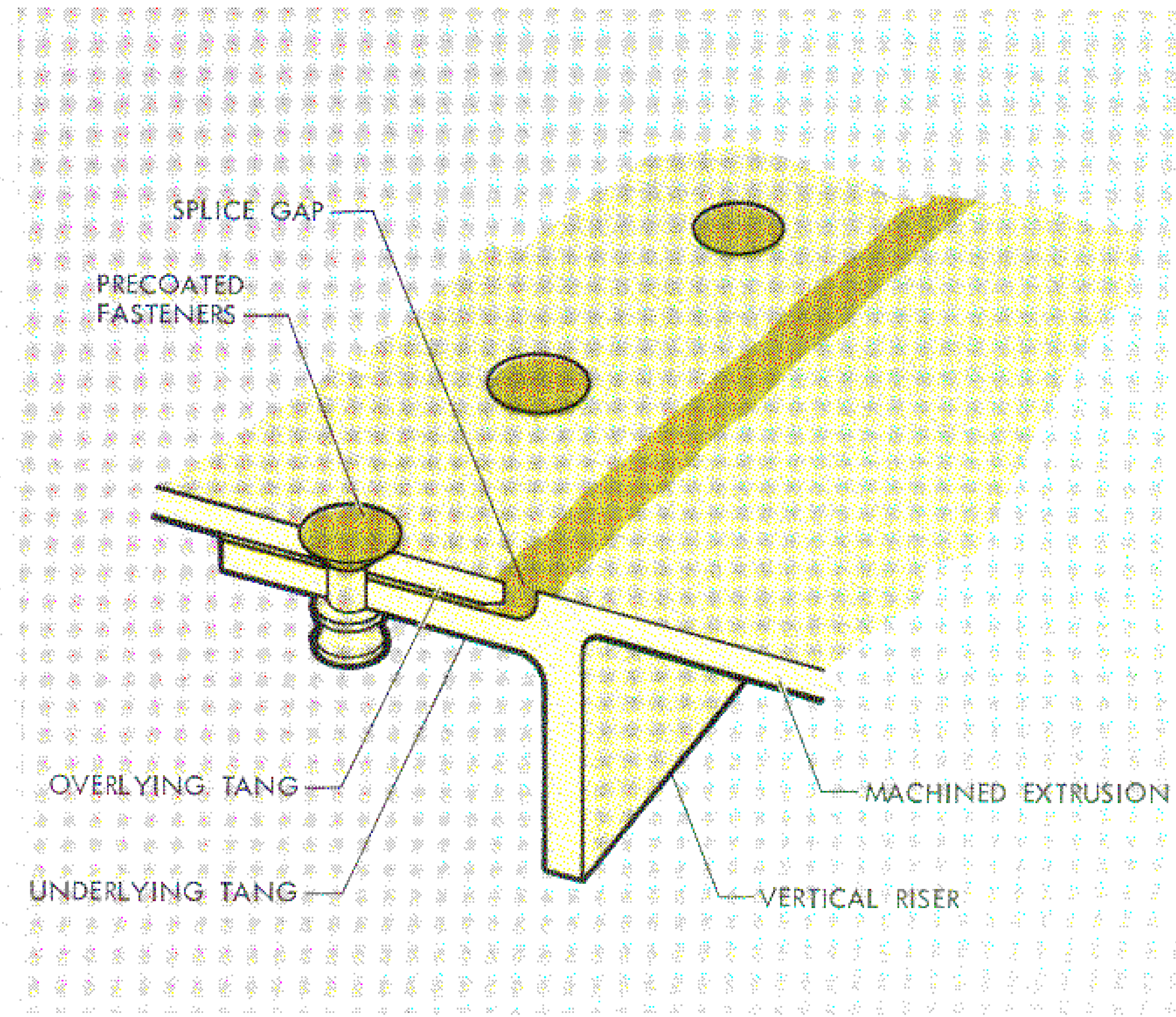


Figure 5 Cross Section of a Typical Lap Joint in the Wing Structure

6. Wet sealant installation of permanent fasteners during production at Serial No. 5126 (BuNo 152156).
7. Center section plank gaps will be sealed during production at Serial No. 5208 (BuNo 152890).
8. Shotpeening machined radii during production to begin with Serial No. 5226 (BuNo 153429).
9. Application of polyurethane coating over shotpeened underlying tang faying surface during production to begin with Serial No. 5226 (BuNo 153429).
10. Center section permanent fasteners will be installed with wet sealant at Serial No. 5226 (BuNo 153429).
11. Wing plank gap seams will be opened to .060 in. minimum during production at Serial No. 5239 (BuNo 153442) to facilitate application and maintenance of gap sealant.

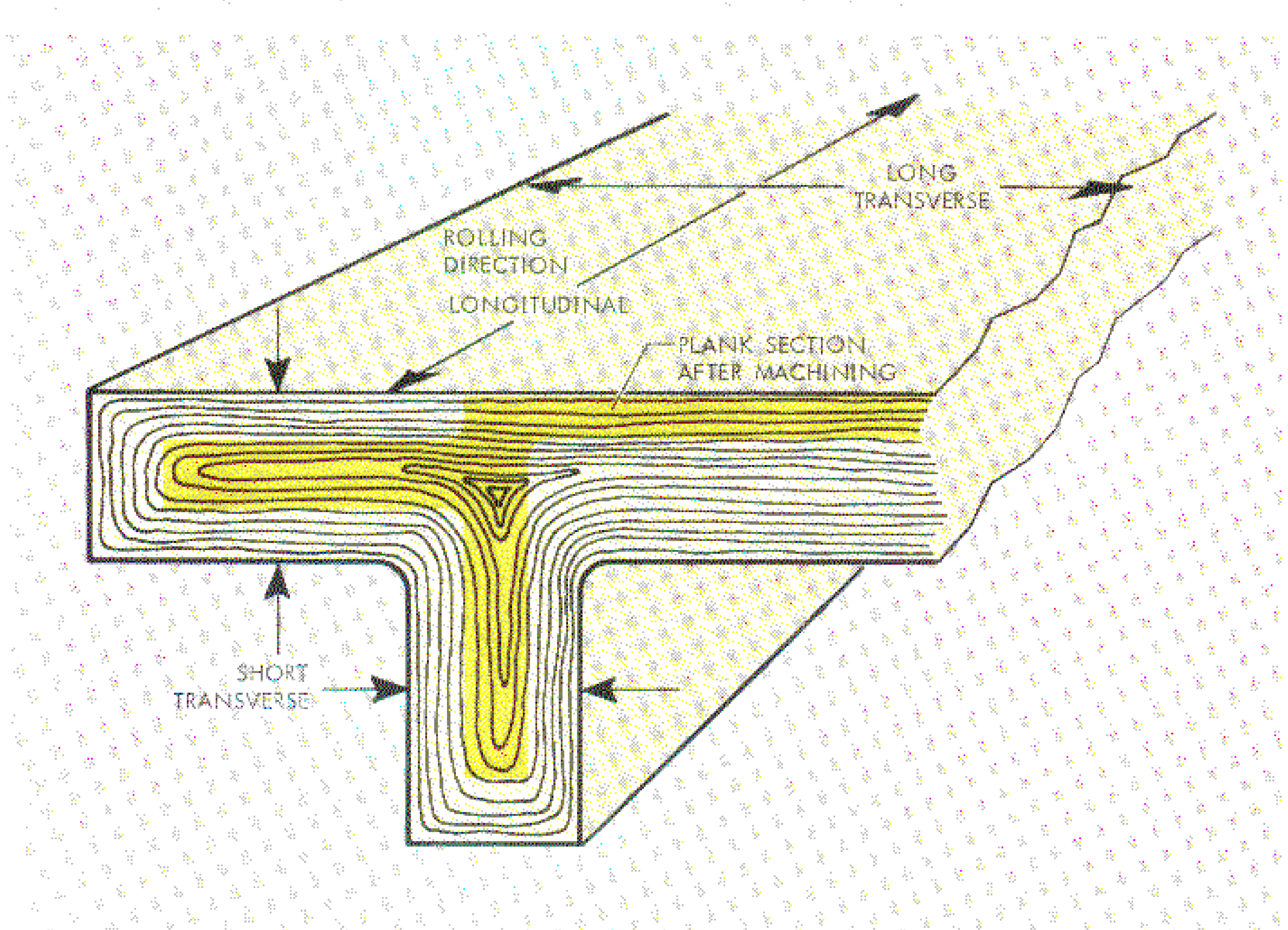


Figure 6

Section of the Basic Plank Showing the Typical Flow Pattern of the Extruded Metal. Superimposed over this section is a section of a finished wing plank.

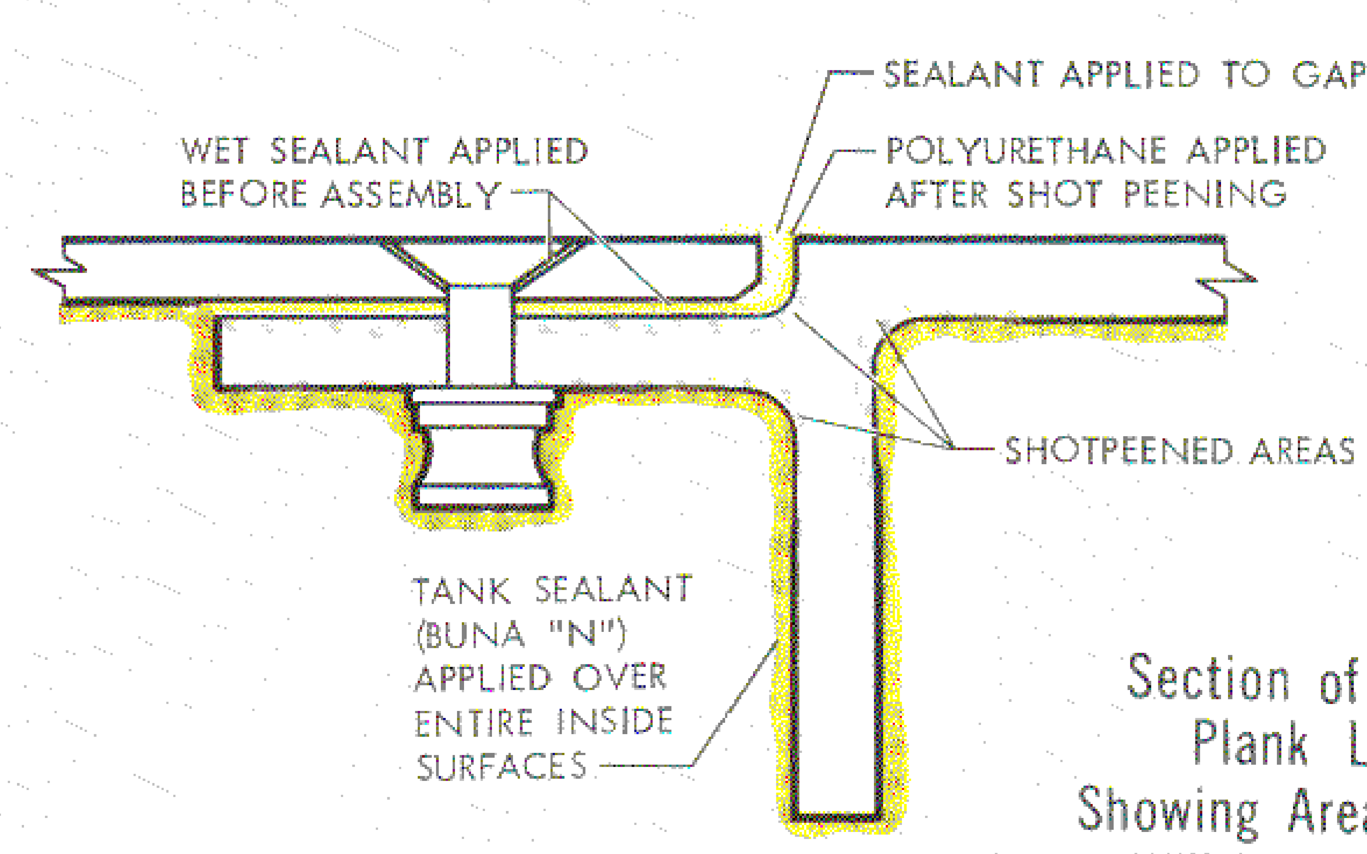


Figure 7 Section of a Wing Plank Lap Joint Showing Areas Where Radii Will be Shotpeened During Production.

Lockheed is continuing investigation into additional corrosion resistance measures for this particular area as well as general corrosion control improvement. These measures include basic alloy selection, aging, heat treatment, anodizing, metallizing, shotpeening, protective coatings, sealing and exterior finishes.

Detection The wing plank splices require frequent detailed inspection to detect incipient corrosive attack. Corrosion normally will be evidenced by light powdery deposits between the sealant and the gap edges. It usually will be accompanied by loss of sealant adhesion or bulging of the sealant.

Routine visual inspections should include probing of the gap sealant with the fingernail or a plastic or hard rubber probe. While probing, attempt to pick at or lift the sealant to determine if there has been a loss of adhesion or if a crevice exists. Any evidence of corrosion deposits or loss of sealant adhesion dictates further action to determine the extent of damage.

More advanced corrosive attack may result in exfoliation of the upper tang which will be evidenced by bulging or swelling of the gap edge material (Figure 8). Laying a straight-edge spanwise over a suspect area will assist in determining if any bulging exists. Whenever any such condition is detected, immediate remedial action must be taken.

If any of the above conditions are found, the first step should be to determine the extent of attack or damage. More serious damage may exist in the hidden structure than is indicated on the surfaces. Because visual inspection of this area is difficult, now is the time to call for specialized help in the application of ultrasonic*, X-ray, dye penetrant or other sophisticated detection methods. If there is any question about the extent of damage, these methods should be employed before corrosion removal or structural disassembly is attempted.

Removal Protect the surrounding area from tools, chemicals, or debris from the activity concentrated in the suspect area. Next, remove the sealant from the splice gap for a distance extending just beyond the boundaries of the affected area. Manually remove sealant by using micarta, plastic, hardwood or soft aluminum scrapers. If corrosion exists under the sealant, the sealant should be relatively easy to remove. More difficulty should be experienced when sealant removal progresses beyond the boundaries of the corroded area. Sealant removal should extend only to the point where it definitely is beyond the corroded area.

After the sealant is removed, the corroded metal should be cleaned up to the degree necessary to assure complete removal of the affected metal. This will mean removing a thin layer of the unaffected base metal. Periodic visual examination of the work area should be made using at least a 10X magnification aid and sufficient lighting of the gap to clearly show the cleanup progress.

Cleaning and Restoration of Protective Finishes when the mechanical cleanup is completed, the work area should be cleaned and chemically treated in accordance with the procedure described on page 6 of this article.

Repair If the corrosion removal operation exceeds allowable structural limits, repairs must be made before the application of protective coatings. Refer to the introductory section on repairs for precautionary measures and to the Structural Repair Manual NAVWEPS 01-75PAA-3-1 or -2 for allowable limits.

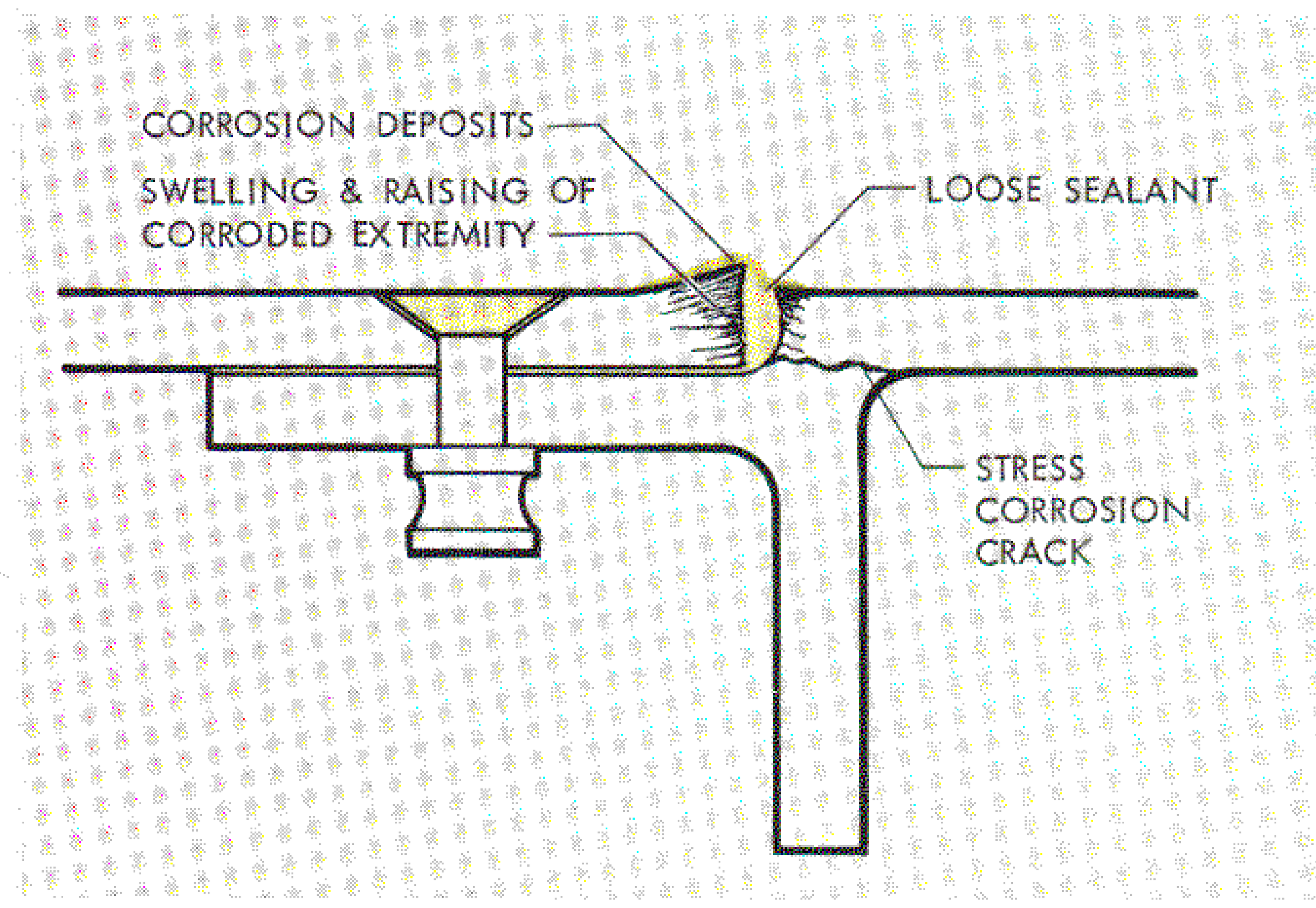


Figure 8 Exfoliation Causes Swelling of the Gap Edge Material

AILERONS The P-3 ailerons are constructed of 7075-T6 aluminum alloy ribs, skin, and stiffeners riveted and spotwelded into a permanent assembly. Service reports were received regarding faying surface corrosion in the riveted and spotwelded areas. This prompted an investigation which resulted in additional controls being exercised during aileron assembly operations. Subsequently, all spotwelded aileron assemblies were given a chromic acid immersion treatment followed by a coating of zinc chromate primer. Performance of assemblies so treated has been satisfactory.

Protection The aileron assembly is treated with chromic acid solution by a fill and drain process

**Lockheed has experienced reasonably good results using the Sperry Reflectoscope/UM 700 with a Krautkramer MWB-70 transducer for ultrasonic detection of cracks and advanced corrosion.*

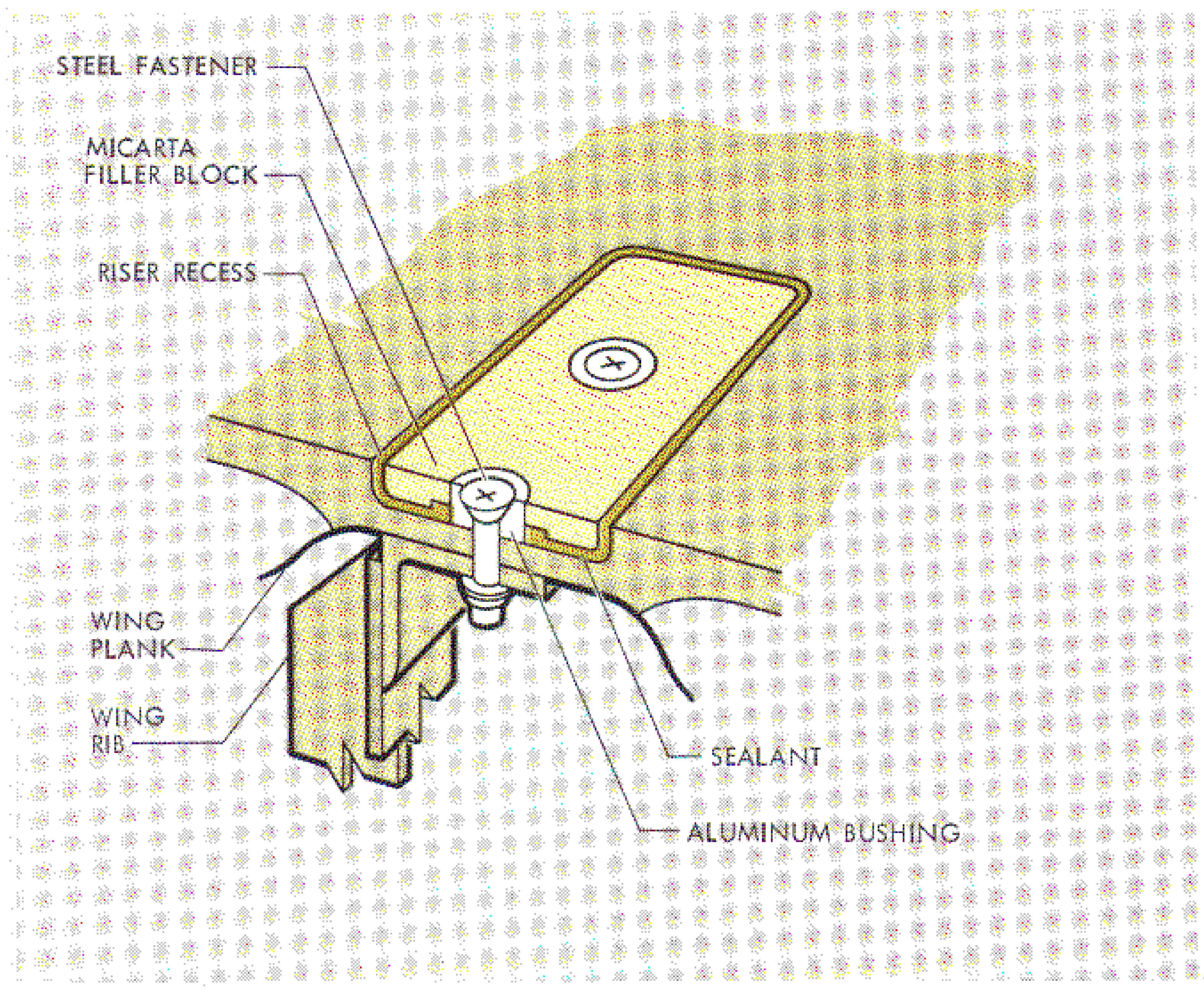


Figure 9 Older Style Centroid Riser Recess Micarta Filler Block

after spotwelding. This is followed by a fill and drain process with diluted zinc chromate primer. The exterior surfaces are finished with the standard exterior paint coatings.

Detection Conduct frequent visual inspections of the external surfaces and those surfaces which can be viewed through access holes, particularly in the outer area of the aileron inboard section.

Removal If corrosion deposits are detected at the edges of the riveted faying surfaces, the skin can be opened by removing rivets and prying the skin apart. (Be careful not to apply tension to the spot welds.) Remove corrosion with an aluminum wire brush, aluminum wool or aluminum oxide abrasive cloth.

Repair In general, if extensive damage is evident, the aileron should be replaced. Minor repairs may be accomplished in accordance with the Structural Repair Manual, NAVWEPS 01-75PAA-3-1 and -2.

Cleaning and Inhibiting Refer to the procedure described on page 6.

Restoration of Protective Coatings Apply zinc chromate primer over the exposed area and install rivets to close up the assembly. Apply the external paint coating in accordance with the Maintenance Instruction Manual, NAVWEPS 01-75PAA-2-2.1, Section VIII.

WING CENTROID RISER RECESSES The wing centroid riser recesses were originally filled with a micarta filler block which had a relief cutout on the bottom side to prevent contact of the filler block with the wing plank in the riser recess. Aluminum bushings were installed in the filler block, protruding through the filler to provide a standoff to assure that there would be no contact of the filler with the plank recess surface. The filler block was installed with wet sealant as shown in Figure 9, to provide an insulation barrier and to prevent the accumulation of moisture in the recess. Galvanic corrosion was detected where the plank surface contacted the aluminum bushing.

Protection The micarta filler block was redesigned to eliminate the recess in the block and the aluminum bushings. An O-ring was installed around the fastener to act as a standoff to prevent contact of the filler block with the plank surface (Figure 10). Otherwise the corrosion protection provisions remain the same. A program is presently underway to replace the phenolic filler blocks with blocks made of aluminum alloy because of the hygroscopic qualities of the phenolic material.

Detection, Removal and Restoration of Protective Finish Corrosion in this area was detected visually when the filler blocks were removed during PAR service. Corrosion removal cleanup and reinstallation of new filler blocks were accomplished without difficulty. As airplanes undergo PAR, the redesigned filler blocks with O-rings are installed.

INTEGRAL FUEL TANKS Except for the crack in one wing plank that was previously discussed, there have been no reports of corrosion in the integral fuel tanks. Commercial Electra experience with corrosion due to microbiological fuel contamination, however, prompted Lockheed to incorporate a coating of polyurethane on tank bottoms that extends six inches up the sides. This has proven to be an effective measure on the P-3, but research is continuing on this problem.

Although Issue 49 of the *Lockheed Field Service Digest* has covered this subject, we reiterate here

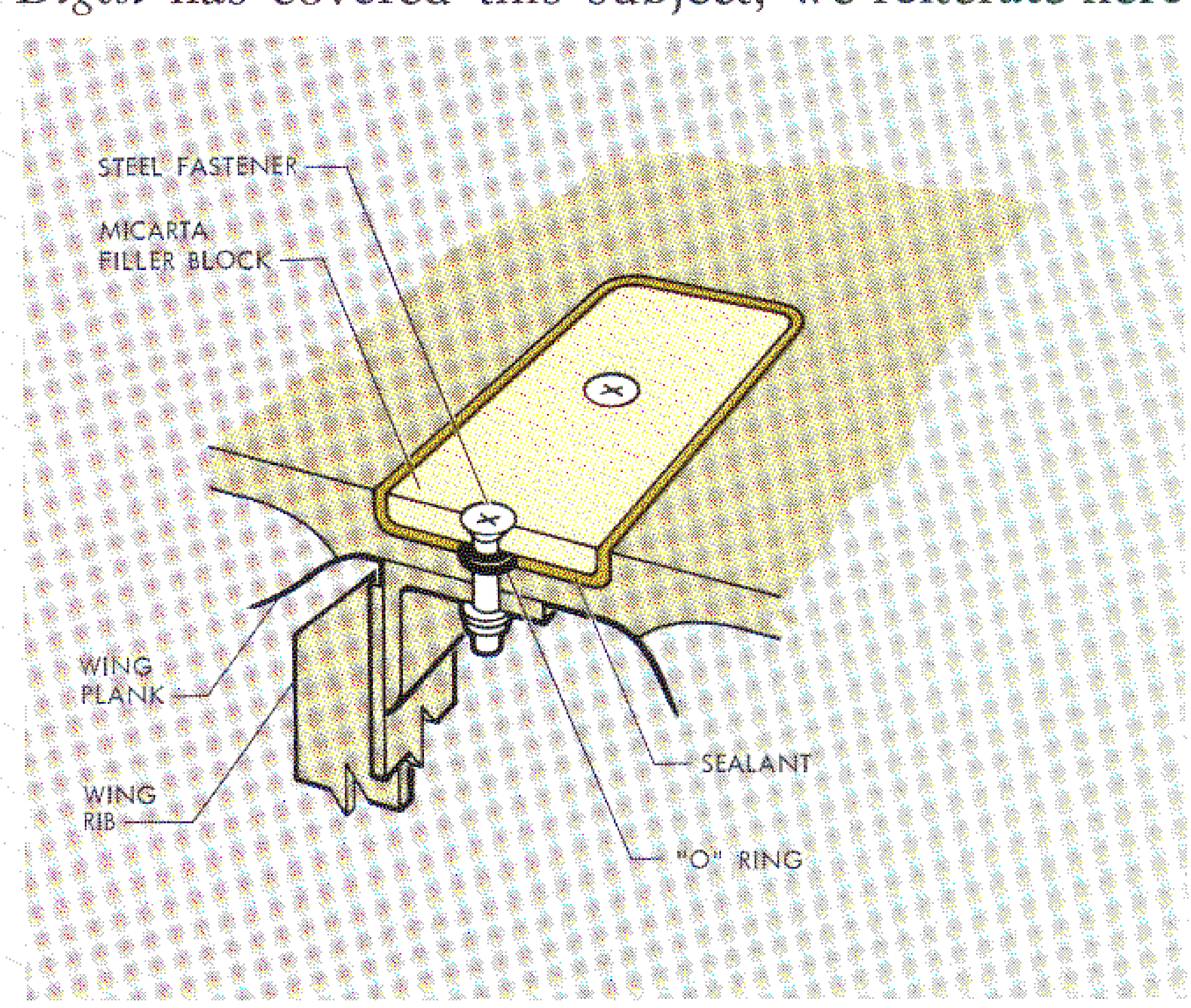


Figure 10 Newer Style Centroid Riser Recess Micarta Filler Block

the need for providing clean fuel and frequent sump draining to prevent the accumulation of "bug" havens which nurture microbiological fungi growth.

Due to the infrequent inspection of the fuel tank interior structure, corrosion may progress to an advanced state before it is detected. Any reports of fuel leaks should prompt a thorough inspection for corrosion as part of the leak repair procedure. Evidence of slime or plant fibers in daily fuel samples or on fuel filters should also prompt an inspection of the related fuel tank.

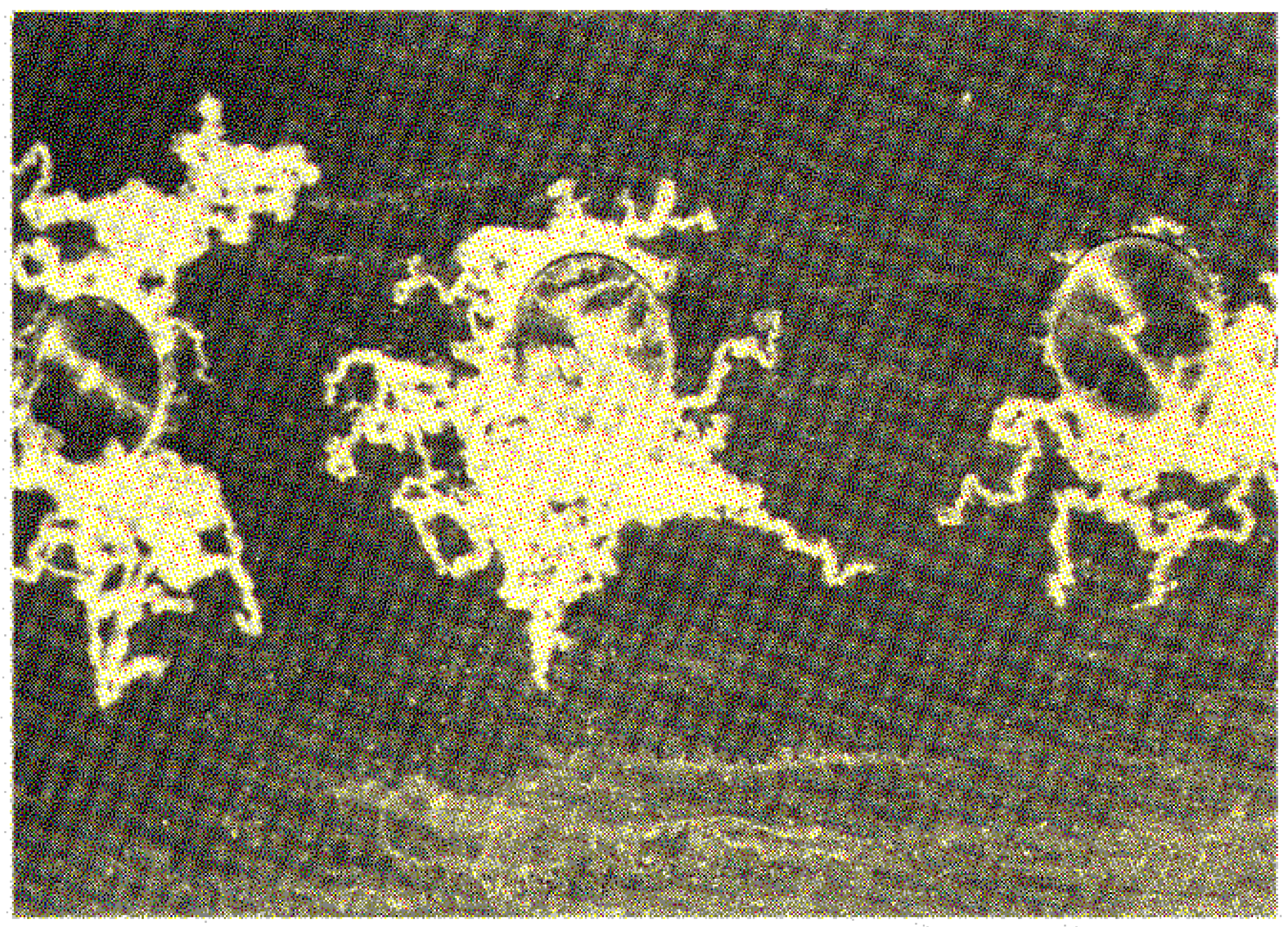


Figure 11 Example of Filiform Corrosion

FASTENERS Filiform* corrosion has been detected around steel and aluminum fasteners on the fuselage and empennage surfaces. It appears at random and usually shows evidence of microscopic working between the fastener and attaching surface. Manufacturing tolerances between the fastener head and the countersink may prevent accomplishment of a perfect seal during assembly and create small entrapment areas. These minute gaps are effectively masked from the environment by the protective paint coatings, but working of the fasteners may cause the paint to crack and permit entry of moisture and contaminants.

**Filiform corrosion is a unique form of galvanic corrosion that occurs around fasteners such as rivets, where minute movement of the fastened structure in the presence of moisture causes worm or filament-like corrosion strains to emanate from the fastener area. This condition is frequently noted where a surface is covered with a protective coating such as paint, where the adhesion is poor and where moisture can become entrapped under the coating. It occurs under conditions of high humidity (75 - 95%); however, the propagation stops when the humidity drops. Filiform corrosion has been particularly evident on the fuselage skin (2024 clad aluminum), but normally the penetration has been superficial.*

The corrosive attack is the result of galvanic action between materials of different electrochemical potential. The electrolyte is provided by moisture that has penetrated the protective coatings. Corrosive attack normally will cause further cracking or blistering of the protective paint coating. Where paint adhesion is poor, corrosion can spread extensively and develop into general surface pitting. An example of filiform corrosion is shown in Figure 11. Early detection and corrective action are essential to stop the attack before exfoliation and intergranular penetration results.

Protection Numerous measures have been taken to prevent filiform and other types of corrosion around fasteners, and positive results are being realized. Following is a list of steps that have been taken:

1. Wet sealant installation of removable fasteners in the wing and empennage during production beginning at Serial No. 5087 (BuNo 151374).
2. Wet sealant installation of permanent steel fasteners in the wing during production beginning at Serial No. 5126 (BuNo 152156).
3. Wet zinc chromate installation of aluminum fasteners and wet sealant installation of steel fasteners on permanent empennage structure, beginning at Serial No. 5139 (BuNo 152169).
4. Paint system changed from acrylic-nitrocellulose lacquer to epoxy-polyamide at Serial No. 5110 (BuNo 152140).
5. Use of primer-coated removable fasteners during production beginning at Serial No. 5155 (BuNo 152185).

In addition, if the protective coating has been removed from the top of the steel fasteners, it is recommended that these fasteners be coated with sealant or some other suitable surface protection.

Detection The best means of detecting corrosion around fasteners is by frequent visual inspection. Any signs of cracked paint, loss of adhesion or blisters may be an indication of corrosion and should be investigated. Remove cracked, blistered, or loose paint and examine the affected area with 10X magnification to define the extent of attack.

Removal, Cleaning and Inhibiting Complete removal of all corrosion products and damaged metal is vital because the residue can promote further corrosion after protective coatings have been reapplied. If there is any indication that corrosive attack has occurred under a fastener head, the fastener should be removed before the cleanup is attempted. Remove corrosion as outlined in the Maintenance Instruction Manual, NAVWEPS 01-75PAA-2-2.1, Section VI. If Vacu-Blast equipment is employed, use only glass bead blasting material, exercising extreme care to avoid contaminating the adjacent aluminum surfaces with steel particles. The use of this equipment is governed by NAVWEPS 01-1A-509, Corrosion Control for Aircraft.

If fasteners have been removed from a corroded area, mechanically remove the corrosion from each fastener hole and treat the hole with Alodine (see page 6 for the cleaning and inhibiting procedure) before installing the new fastener.

Restoration of Protective Coatings If fasteners have been removed for cleanup procedures, coat the replacement fasteners with zinc chromate primer or sealant, as applicable, and install them while they are still wet. In the wing plank splice area, apply sealant over fasteners as shown in Figure 12. Apply standard paint protection as outlined in the Maintenance Instruction Manual, NAVWEPS 01-75PAA-2-2.1, Section VIII.

FUEL VENTS AND FLAME ARRESTORS Corrosion has been reported on aluminum skin in the vicinity of the stainless steel flame arrestor fitting at the No. 5 tank vent line drain. This condition was attributed to galvanic activity between the fitting flange and the skin.

Protection Initially, the corrosion protection system in this area consisted of the standard exterior paint system. After trouble reports were received, a change was initiated to apply sealant between the faying surface of the fitting and aluminum skin. This change became effective in production on Serial No. 5088 (BuNo 151375).

Detection and Corrosion Removal Corrosion deposits found around the edge of the flame arrestor fitting flange usually can be detected by visual examination of the area. If corrosion is found, the fittings should be removed and all corrosion deposits removed from the surfaces of both the skin and the fitting.

Cleaning and Inhibiting Refer to page 6 for the cleaning and inhibiting procedure.

RAIN EROSION OF WING LEADING EDGES General erosion of the protective coating on wing leading edges has been attributed to impingement of heavy rain, hail, and light runway debris. Erosion of the painted protective coating exposes the wing leading edge surfaces to moisture and corrosive agents. Pitting corrosion results from impingement imbedding airborne foreign particles into the unprotected metal surface.

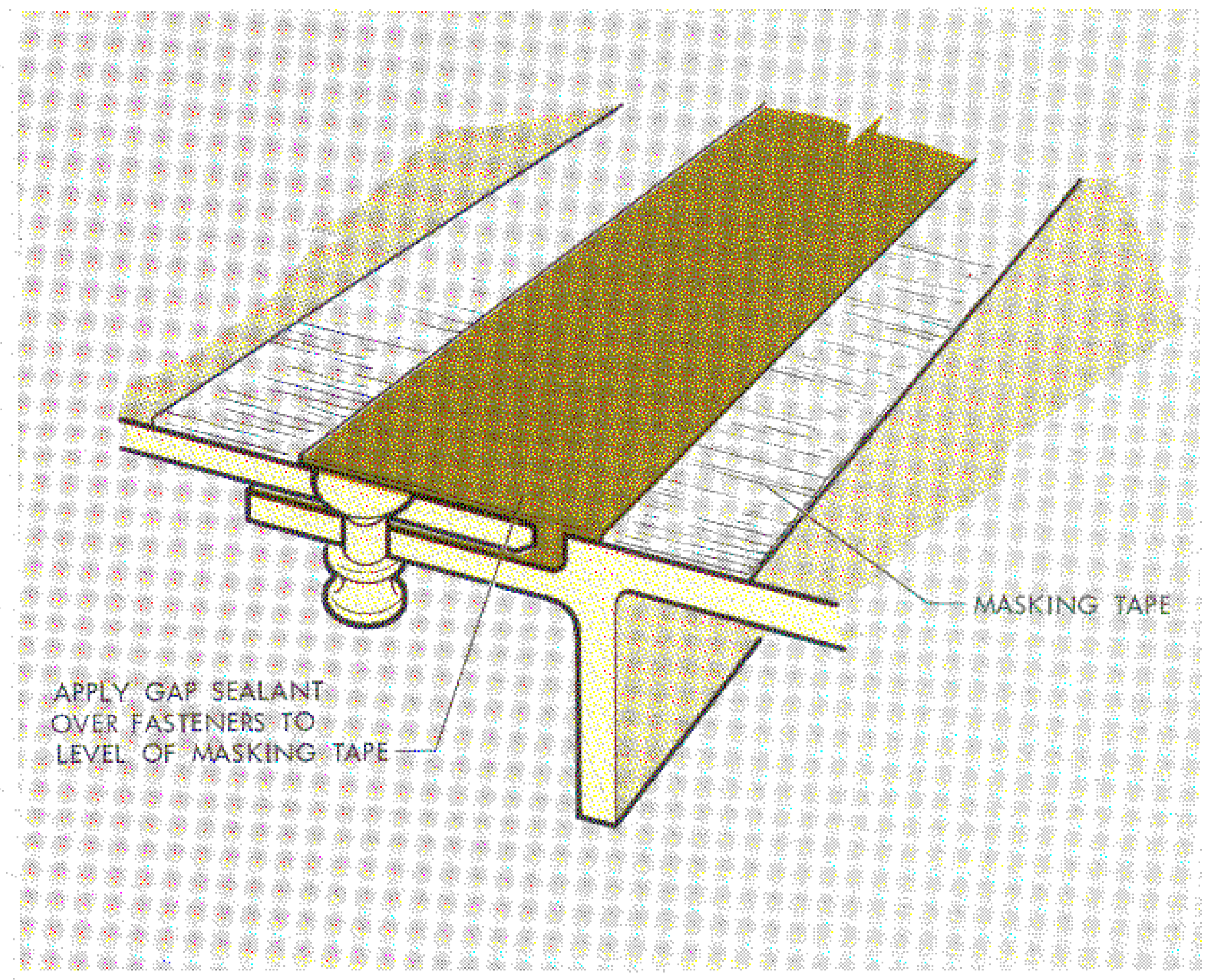


Figure 12 Method of Applying Sealant Over Steel Fasteners Installed in Wing Planks

Protection Originally the leading edges were protected with the standard acrylic-nitrocellulose lacquer, but due to its poor rain erosion resistance it was replaced in production at Serial No. 5110 (BuNo 152140) with epoxy-polyamide. The latter paint system has provided only a partial solution to the problem, therefore the search for improved erosion - resistant protective coatings continues. Presently there is a service evaluation of coatings of Laminar X500 Cermet over epoxy amine primer on the wing leading edges. This evaluation is being conducted on the same aircraft that are testing the polyurethane paint system (refer to page 7 for aircraft serial numbers).

Detection Erosion of leading edge paint is visually apparent, however any evidence of pitting should prompt close examination of the surface with a 10X glass for signs of corrosion. Frequently, pitting corrosion can extend deeply into a metal structure without appreciable evidence on the exposed surface.

Removal Remove corrosion deposits per the Maintenance Instruction Manual, NAVWEPS 01-75-PAA-2-2.1, Section VI, and examine the pits with a 10X magnifying glass to assure no deposits remain in the bottom of the pits.

Cleaning, Inhibiting and Restoration of Protective Finishes Refer to page 6 for the cleaning and inhibiting procedure. After the surfaces are thoroughly dry, apply protective coatings per NAVWEPS 01-75PAA-2-2.1, Section VIII.

WING LEADING EDGE-TO-SPAR JOINTS The leading edge of the P-3 airplane contains extruded sections that are fastened to the front spar caps. The lower extrusion is of two-piece piano hinge

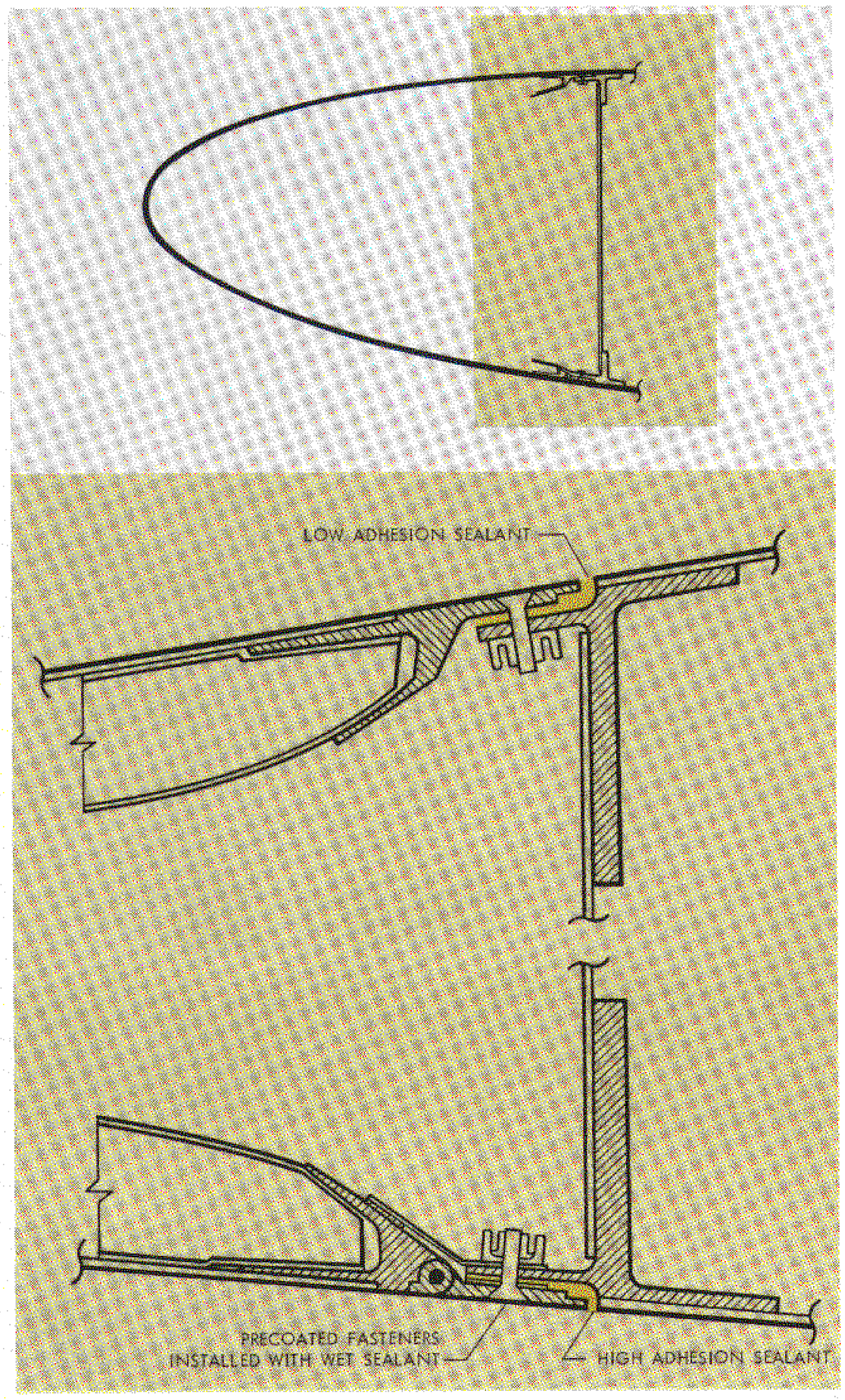


Figure 13 Location of Sealant on Wing Leading Edge-to-Spar Cap Faying Surfaces. High adhesion sealant is permanently installed.

construction. The leading edge skin forms the outer layer of a hot air duct system which provides anti-icing protection. Some reports of corrosion at the spar cap-to-leading edge faying surfaces and around the fasteners have been received on early aircraft. When removing or installing fasteners, proper screwdrivers must be used to avoid damage to the protective cadmium coatings on the fasteners.

Protection Originally, corrosion protection in this area consisted of chemical treatment of the spar cap and leading edge attachment extrusions and the subsequent application of the standard protective paint coatings. In response to reports of corrosion activity, changes were introduced effective on Serial No. 5084 (BuNo 151371) to seal the spar cap-to-leading edge faying surfaces and to install the fasteners with wet sealant. Delivered aircraft were brought to this configuration through the incorporation of AFC No. 79.

Detection Detection of corrosion in this area is accomplished by visual inspection. The faying surfaces should be checked for corrosive attack periodically and, particularly, at any time the leading edge is open during other maintenance activity.

Removal and Repair Removal of corrosion in the leading edge-to-spar joints and hinge areas should be accomplished in accordance with the general recommendations of NAVWEPS 01-75PAA-2-2.1. Refer to the Structural Repair Manual, NAVWEPS 01-75PAA-3-1, Fig. 2-13, for damage limits, missing hinge lobes and repair instructions.

Cleaning, Inhibiting, and Restoration of Protective Coatings Refer to page 6 for the cleaning and inhibiting procedure. After the surfaces are thoroughly dry, apply sealant Spec. MIL-S-8784, Class B-½ as indicated in Figure 13 on the leading edge-to-spar cap faying surfaces and close up the leading edge. Apply paint finish as applicable to the leading edge surfaces.

HORIZONTAL AND VERTICAL STABILIZERS The construction of the horizontal and vertical stabilizers differs somewhat from that of the wing, in that the extruded skin planks are joined by separate extruded "T" sections rather than being joined by integrally machined lap splices. Despite these basic structural differences, the corrosion control procedures are essentially the same as those outlined for the wing area, except for the empennage leading edges.

HORIZONTAL AND VERTICAL STABILIZER LEADING EDGES The construction of the empennage leading edges differs from the wing leading edge in that electrical thermal anti-icing is provided in lieu of compressor bleed hot air. General erosion of the empennage leading edges has occurred, with associated pitting corrosion progressing to extended surface attack of the skin. Figure 15 depicts the construction of the leading edges which consists of the outer aluminum alloy skin, various laminated layers of fabric, glass cloth, heating elements, adhesives and the supporting structure.

On early aircraft, fabrication techniques permitted voids in the laminate which contributed to corrosive attack of the skin. Special tooling was developed for this assembly to assure good lamination adhesion and minimize voids. Effective on production Serial No. 5141 (BuNo 152172) the leading edge skin was changed from .012 inch 2024 aluminum alloy to .016 inch 6061 aluminum alloy to further improve the corrosion resistance.

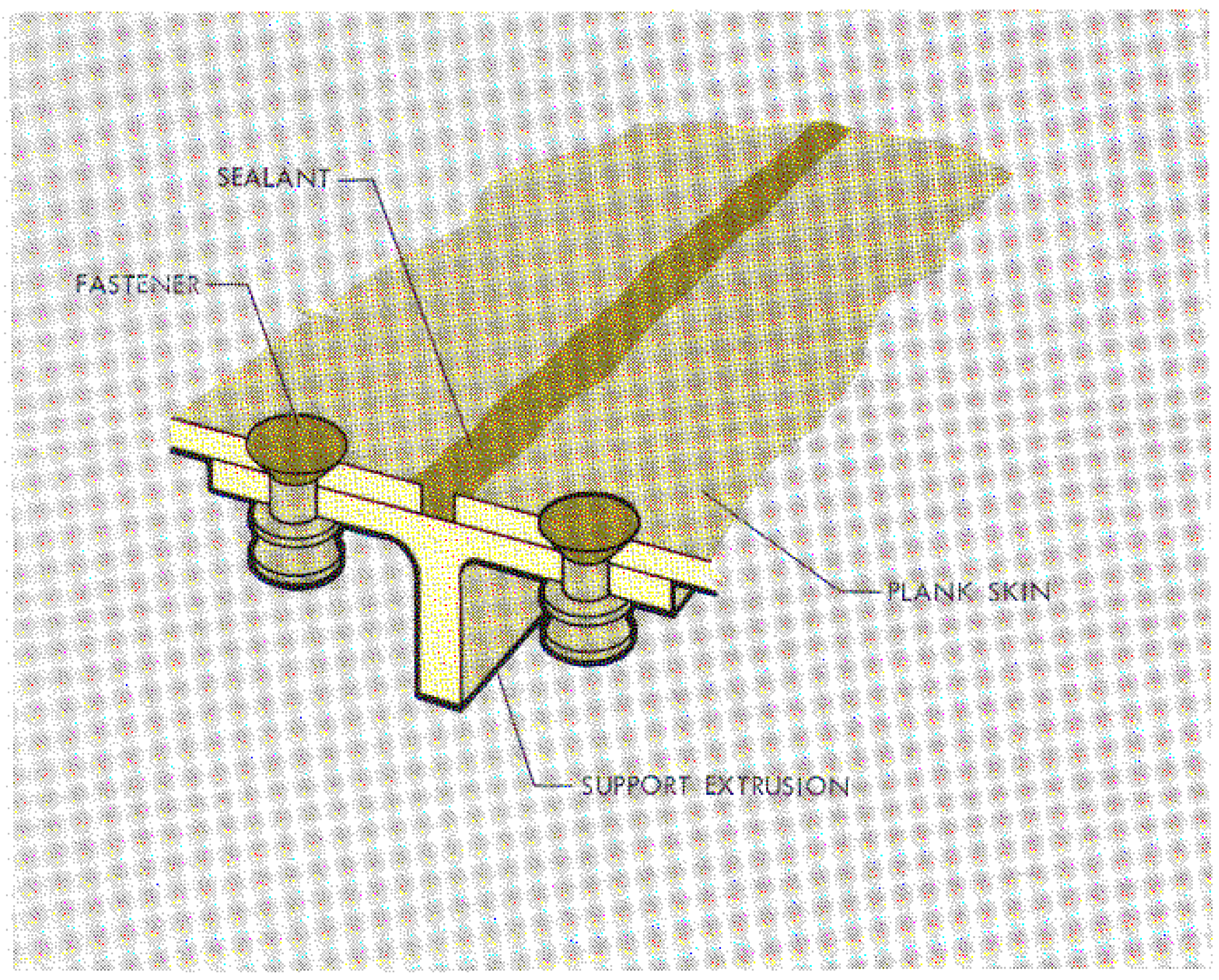


Figure 14 Stabilizer Planks Are Joined by "T" Sections

Protection In addition to the above fabrication improvements, the following changes were incorporated in production to improve the corrosion protection:

1. Wet sealant installation of removable fasteners during production at Serial No. 5087 (BuNo 151374).
2. Sealant applied in gaps and joints to completely seal the heated leading edges.
3. Incorporation of above changes on delivered aircraft through Airframe Change No. 79.
4. Change of paint system from acrylic-nitrocellulose to epoxy-polyamide at Serial No. 5110 (BuNo 152140).
5. The Laminar X500 Cermet coating (outlined in the wing leading edge discussion) will be service evaluated on the empennage leading edge of ten aircraft.

Detection Frequent visual inspection of the empennage leading edges for paint erosion, cracking or blisters should provide optimum corrosion control. Any of these indications warrant a detailed examination for pitting corrosion or moisture entrapment under the paint. If the metal skin is exposed, examine the area with a 10X magnifying glass for corrosive attack. Where concentrated erosion or blisters are noted, a tap check is recommended for detection of voids between the outer metal skin and inner laminate.

Removal and Repair Corrosion removal should be accomplished in the same general manner as outlined under the wing leading edge section. If voids have been detected under the skin, a small (No. 40) drill hole should be made as close to the center of the void as possible and epoxy EC-1751 (resin) and EC-1752 (accelerator) injected to fill the void. Care must be exercised to drill *only* through the outer aluminum skin and not penetrate the inner laminate. Refer to NAVWEPS 01-1A-509, Section II. If more extensive damage is detected, the leading edge should be removed and repaired, or replaced in accordance with the appropriate NAVWEPS 01-75PAA-2 Maintenance Manual.

Cleaning, Inhibiting, and Restoration of Protective Finish Refer to page 6 for the cleaning and inhibiting procedure. After the surfaces are thoroughly dry, apply protective coatings per NAVWEPS 01-75PAA-2-2.1, Section VIII.

NOSE GEAR WHEELS The nose gear wheels are of split-half, forged magnesium construction. The halves are fastened together with steel bolts. Originally the bolts were installed with a graphite lubricant which introduced an additional corrosive element into an already susceptible area. Since the steel bolts and magnesium castings are at almost opposite ends of the galvanic activity scale, they must be isolated from one another to prevent corrosive attack of the magnesium. The graphite provided an electrolytic path between the two materials, in addition to introducing a third element of different galvanic activity.

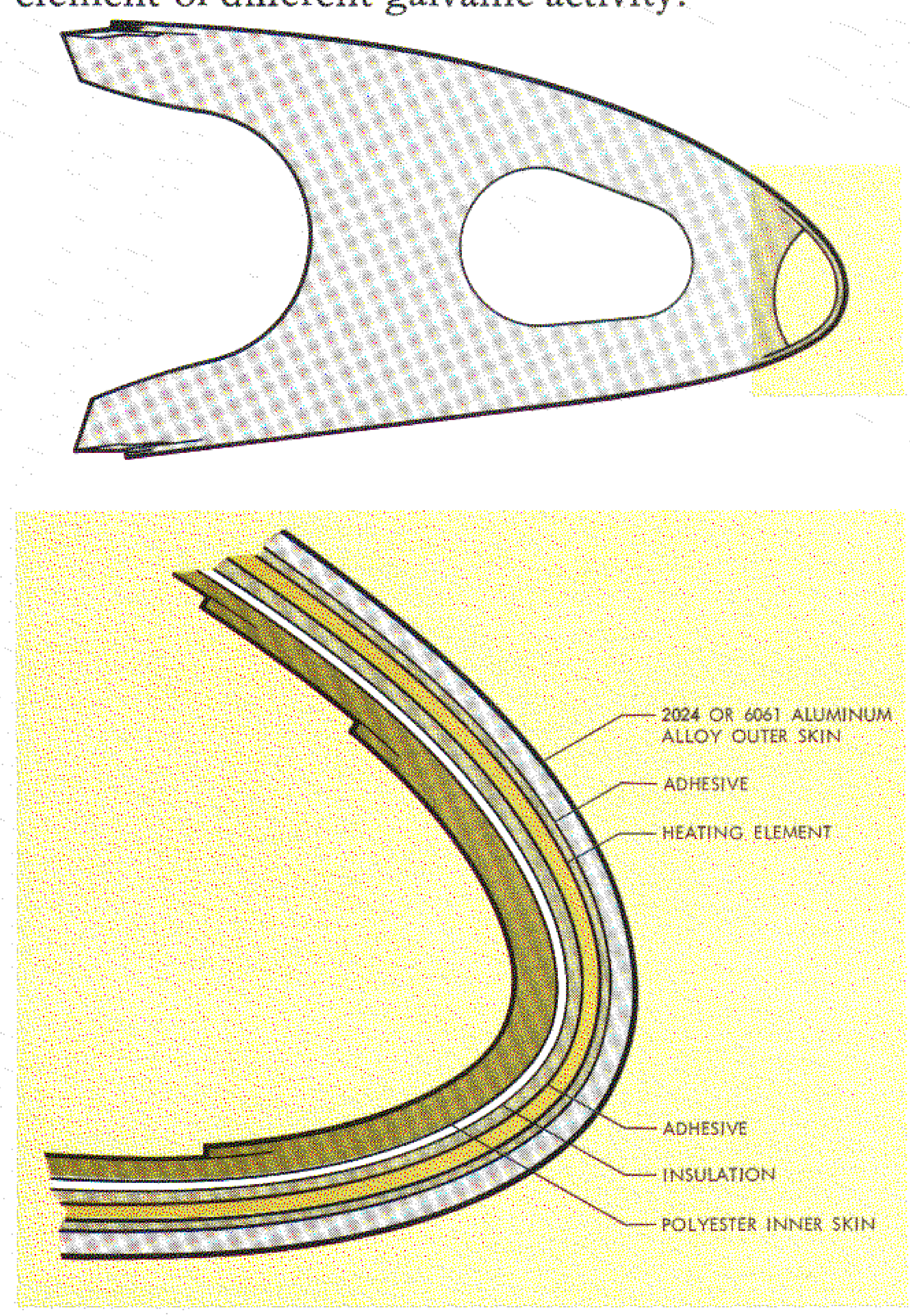


Figure 15 Detail of Empennage Leading Edge Construction

Figure 16a Structure in Galley Area Protected by Acid-resistant Lacquer

Figure 16b Galley Installation

Protection The magnesium wheel forgings are protected by a chrome pickle treatment followed by a dichromate treatment. During routine servicing such as tire changes, the integrity of these protective measures must be maintained.

On airplane Serial No. 5142 (BuNo 152172) and up, the nose wheel bolts are installed with MIL-G-25760 lubricant in lieu of the MIL-T-5544A graphite lubricant (also called "Lubtork") used previously. The wheel bolt lubricant is specified on an instruction placard on each wheel-half, but at present the instructions on the newer wheel-halves conflict with the instructions on the older wheel-halves. Refer to *Orion Service Digest*, Issue 13, pages 20 and 21 for additional discussion of this situation.

Detection On routine services or walk-around inspections, look for corrosive attack around the bolts. Magnesium corrosion has a salt and pepper-like appearance, and once started will progress rapidly, especially in the presence of salt water.

Removal and Repair Superficial magnesium corrosion can be removed mechanically with abrasive tools or scrapers. More extensive corrosion damage will require structural repair or replacement. For further corrosion control measures and overhaul and repair instructions, refer to NAVWEPS 03-25BA-19.

LAVATORY AND GALLEY AREAS The lavatory and galley areas have an obvious susceptibility to corrosive attack because of spillage, which dictates particular attention. The conventional aluminum structure utilized throughout the airplane is also used in the sub-structure under the galley and lavatory sections.

Protection The structures in the galley and lavatory areas (Figures 16 and 17) are protected with an acid-resistant white lacquer applied over zinc chromate primer.

Detection The only detection method deemed necessary in these areas is a routine visual inspection, but the floor structure must be opened up to whatever extent is necessary to permit a complete examination. Frequent inspection of these areas is recommended to determine if contaminants and entrapped fluids are present. Furthermore, in known cases of overflow or spillage, the sub-structure should be examined and cleaned as soon as possible in order to provide the greatest protection against corrosive attack.

Removal, Cleaning and Inhibiting Remove deposits with aluminum wool or aluminum oxide abrasive cloth until no evidence of corrosion remains. Refer to page 6 for the cleaning and inhibiting procedure.

Restoration of Protective Finish Apply zinc chromate primer and acid-resistant lacquer to the refurbished surfaces in accordance with NAVWEPS 01-75PAA-2-2.1, Section VIII.

BATTERY AND VENT AREA The battery is located on the right side of the nose wheel well on early aircraft, and at the aft right center of the nose

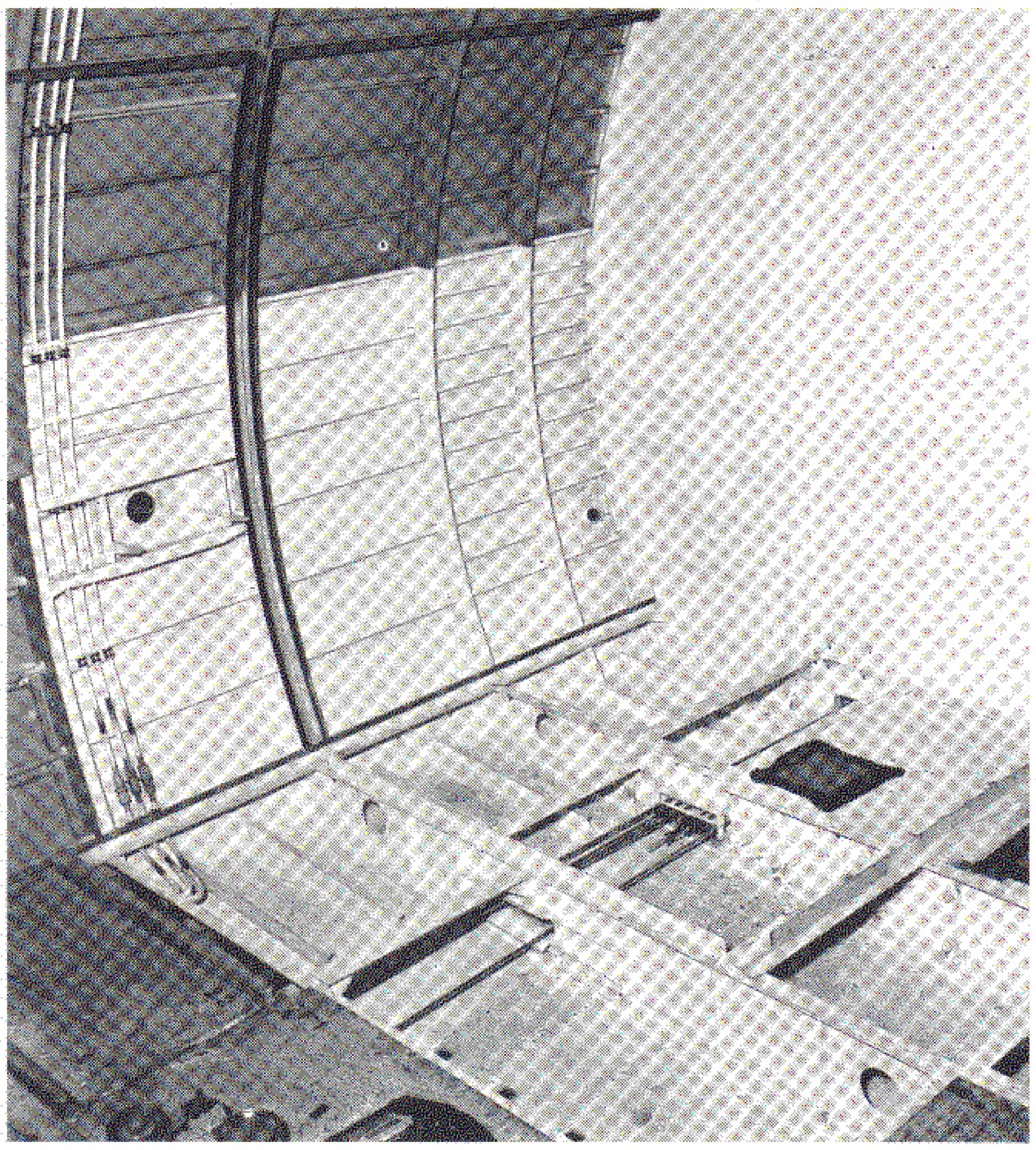


Figure 17a Structure in Lavatory Area Protected by Acid-Resistant Lacquer

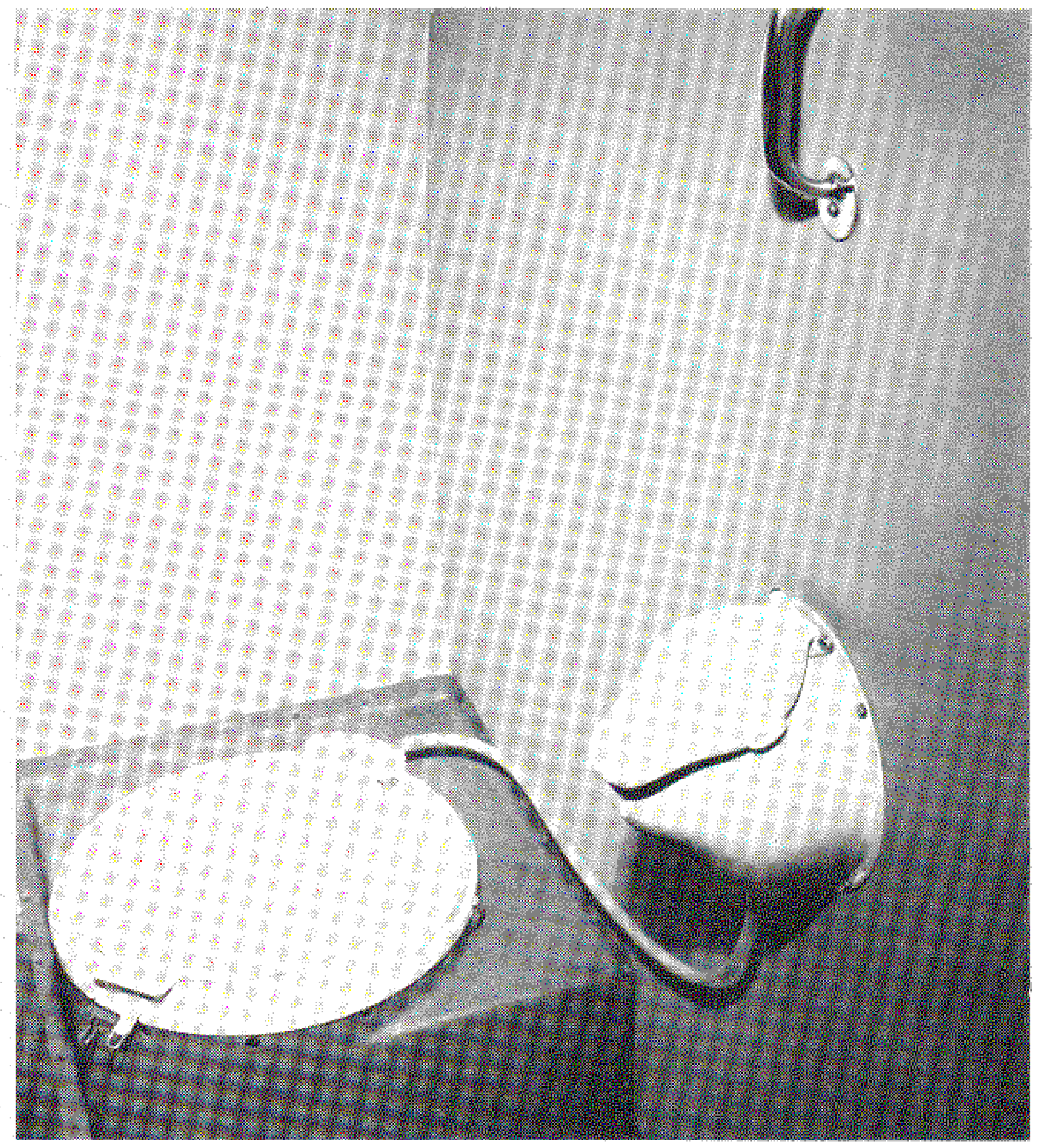


Figure 17b Lavatory Installation

wheel well on aircraft incorporating the integral starting system. The battery is housed in a container with inlet and outlet vent lines, that provide circulation through the battery cover. The exhaust outlet protrudes from the lower right side of the fuselage on the early aircraft and from the bottom center of the fuselage on the later aircraft. Certain adverse operating conditions may cause the battery fluid to boil, and the vented acid or fumes may be deposited on the bottom of the airplane and initiate corrosion. When this happens, the affected area must be cleaned as soon as possible.

Protection All metal structure in the battery area is protected with the standard epoxy polyamide paint system (which is acid-resistant), and the battery is housed in a sealed container. General battery maintenance precautions are covered in appropriate manuals.

Field reports of battery acid corrosion on the fuselage and in the integral starting system compartment have prompted an investigation by Lockheed to develop corrective measures. Installation of a battery vent jar has been proposed. Proper battery maintenance is an important corrosion protection measure. Battery condition and electrolyte level should be closely controlled. Overfilling must be avoided to prevent overflow.

Detection Battery acid attack will result in almost instant corrosion of metal surfaces. Corrosive attack results in white powdery deposits which can be seen readily with the naked eye.

Removal Any evidence of battery acid attack dictates immediate maintenance action. A solution of water and as much bicarbonate of soda as can be held in suspension should be generously applied to the affected surface, using a soft brush or saturated rags. Rinse the solution from the surface with soft water. Apply a second dose of the soda solution, and if any bubbling is detected continue the rinsing and soda application until all corrosive activity has been neutralized.

After the area has been treated for corrosive attack, clean and inhibit the surfaces and restore the protective finish as required.

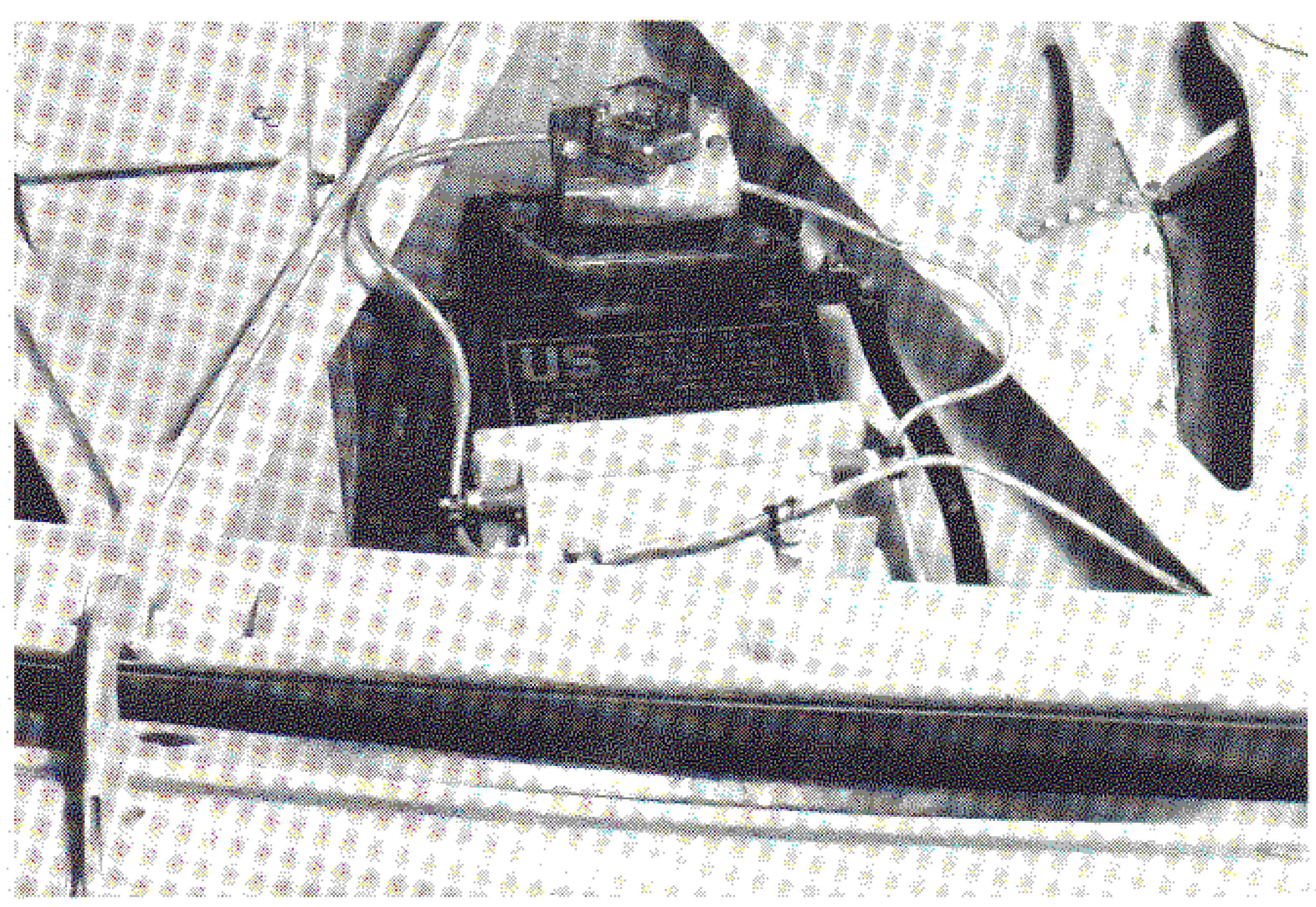
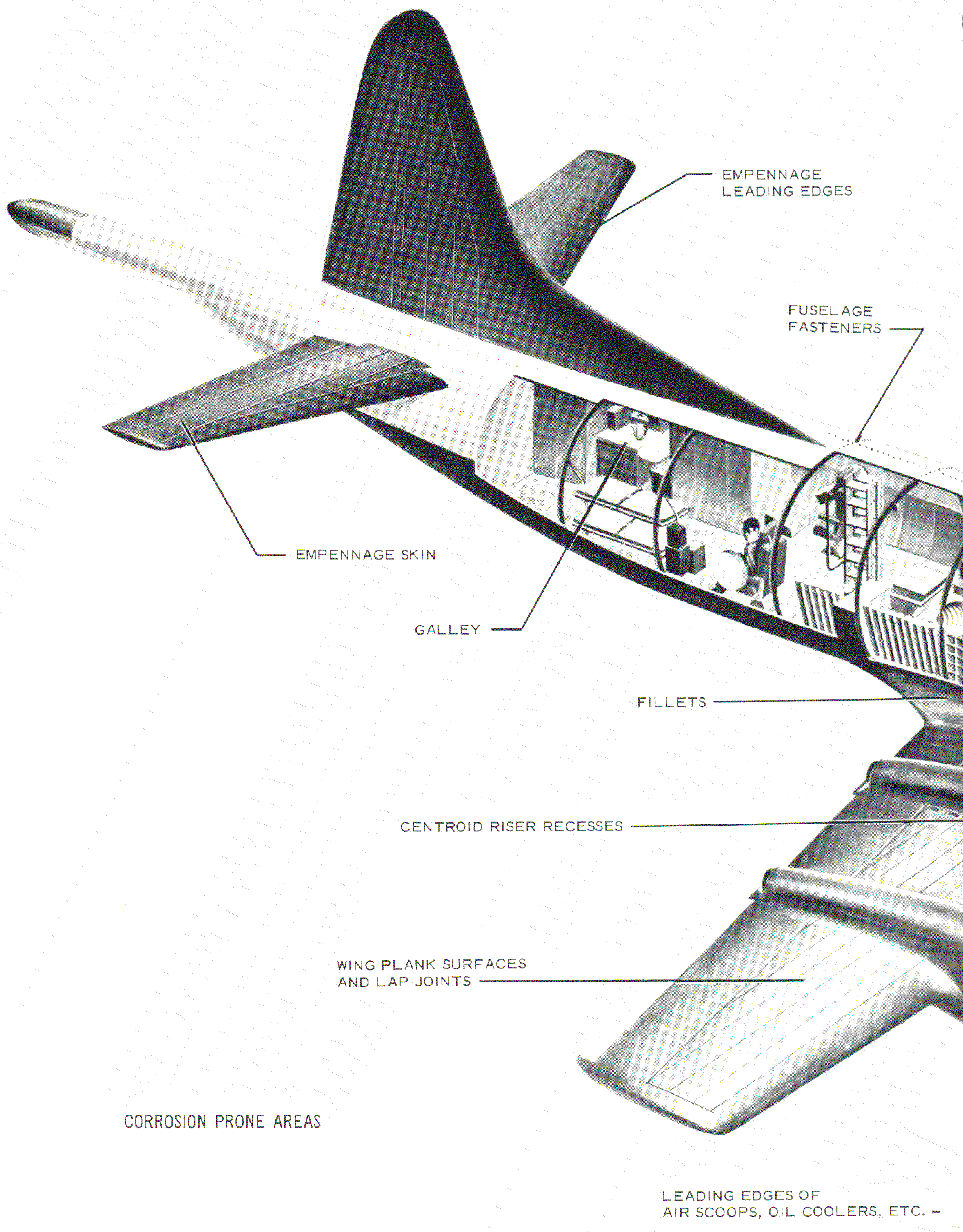
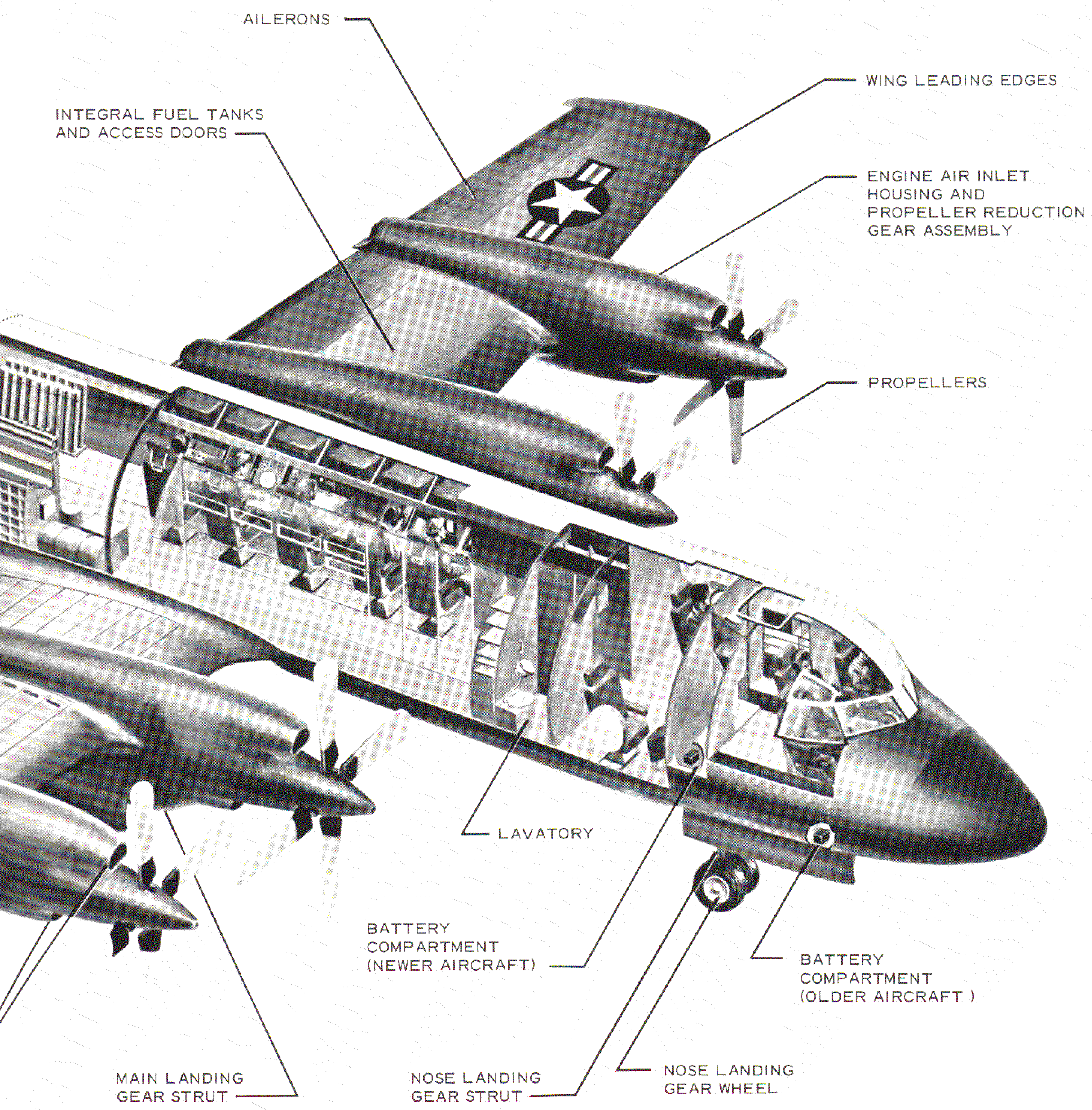


Figure 18 Battery Installation on Earlier P-3 Aircraft. On later P-3's the battery is installed at the rear of the nose wheel well.



CORROSION PRONE AREAS


AILERONS
WING LEADING EDGES
INTEGRAL FUEL TANKS AND ACCESS DOORS
ENGINE AIR INLET HOUSING AND PROPELLER REDUCTION GEAR ASSEMBLY
PROPELLERS
LAVATORY
BATTERY COMPARTMENT (NEWER AIRCRAFT)
BATTERY COMPARTMENT (OLDER AIRCRAFT)
MAIN LANDING GEAR STRUT
NOSE LANDING GEAR STRUT
NOSE LANDING GEAR WHEEL

AIRCRAFT CONTROL CABLES The P-3 aircraft control cables are fabricated from corrosion resistant steel or high-strength carbon steel treated with corrosion preventive compound. Corrosion resistant cables are used predominantly in areas most susceptible to corrosion (such as landing gear areas), and in the vicinity of the MAD boom (because of their nonmagnetic properties). The corrosion preventive compound on the carbon steel cables must be maintained. To assist maintenance personnel, the carbon steel cable systems are listed in Table 2.

Prevention Corrosion resistant steel cables do not have any supplementary protection measures, but should be inspected periodically for signs of corrosive attack. The carbon steel cables are protected with a coat of transparent corrosion preventive compound MIL-C-16173 Grade IV. Cables which are exposed during aircraft washing operations should be inspected frequently, and should be re-treated as required. Carbon steel cables located in the landing gear wells in particular require frequent re-treatment.

Detection The only known method of corrosion detection on control cables is through visual inspection. Corrosion will appear in the familiar form of iron oxide or rust, and can be seen through the transparent protective coating. If corrosion is found on the cable surfaces only, it can be removed; but if corrosion extends into the internal braiding, the cable must be replaced.

Corrosion Treatment Slight rust on the cable surface should be removed as follows:

a. Remove the rust preventive coating and light rust with a cloth saturated in dry cleaning solvent, Federal Specification P-D-680, or Thinner, Federal Specification TT-T-291. Limit this treatment to the area where rust is detected, treating overlapping unaffected areas only enough to assure complete rust removal.

b. Untwist the cables in the affected area just enough to assure that no rust is present in the internal braids. It may be necessary to relieve the cable tension to perform the inspection. *Any evidence of internal rust or broken strands may require replacement of cable.* Refer to NAVWEPS 01-1A-8, Aircraft Structural Hardware.

c. If no evidence of rust exists after cleaning the cables, re-treat the carbon steel cables with corrosion preventive compound. A coat of compound, Specification MIL-C-16173, Grade I, diluted with dry cleaning solvent, Federal Specification P-D-680, in a one-to-one ratio, should be used on carbon steel cables in exposed (and most other) areas. Apply this mixture with a clean, lint-free cloth.

TABLE 2

LIST OF CARBON STEEL CONTROL CABLES ON P-3 AIRCRAFT

RUDDER CONTROL

929187-1	Pedal Adjustment
906907-29	Flight Station - Left Rudder
810894-53	Flight Station - Right Rudder
LS6807-12-1370	FS 288 to 388 - Left & Right Rudder
LS6807-12-1861	FS 388 to 571 - Left & Right Rudder
LS6807-12-1850	FS 571 to 786 - Left & Right Rudder
LS6807-12-1851	FS 786 to 1015 - Left & Right Rudder
906907-17	Flight Station - Booster Shift
906907-19	Flight Station - Booster Shift

RUDDER TRIM TAB CONTROL

907573-3	FS 288 to 439 - Trim Left
907573-5	FS 288 to 344 - Trim Right
931535-103	FS 439 to 672 - Trim Left
931535-101	FS 344 to 571 - Trim Right
931535-107	FS 672 to 863 - Trim Left
LS6806-12-1721	FS 574 to 723 - Trim Right
931535-111	FS 723 to 958 - Trim Right

ELEVATOR CONTROL

810894-51	Flight Station Pilot - Elevator Down
810894-55	Flight Station Pilot - Elevator Up
810894-25	Flight Station Copilot - Elevator Up
810894-27	Flight Station Copilot - Elevator Down
831373-1	Forward Control Column Balance
LS6807-12-1381	FS 288 to 458 Copilot Elevator Up and Down
LS6807-12-1420	FS 288 to 458 Pilot - Elevator Up and Down
LS6807-12-1850	FS 458 to 620 Copilot - Elevator Up and Down
LS6807-12-1821	FS 458 to 620 Pilot - Elevator Up and Down
LS6807-12-1860	FS 620 to 825 Copilot - Elevator Up and Down
LS6807-12-1850	FS 620 to 825 Pilot - Elevator Up and Down
LS6807-12-1851	FS 825 to 1015 Copilot - Elevator Up and Down
LS6807-12-1851	FS 825 to 1015 Pilot - Elevator Up and Down
906907-21	Flight Station - Booster Shift
906907-23	Flight Station - Booster Shift

ELEVATOR TRIM TAB CONTROL

900861-3	FS 288 to 344 Trim Up
900861-5	FS 288 to 439 Trim Down
931535-101	FS 344 to 571 Trim Up
931535-103	FS 439 to 672 Trim Down
LS6806-12-1681	FS 571 to 723 Trim Up
931535-105	FS 672 to 863 Trim Down
931535-109	FS 723 to 958 Trim Up

AILERON CONTROL

812320-1	Control Column
810894-21	Flight Station Left
810894-23	Flight Station Right
LS6807-12-1371	FS 283 to 383 - BL 40 Right
LS6807-12-1801	FS 388 to 571 - BL 40 Right
911630-15	FS 571 to 694 Left
911630-13	FS 571 to 694 Right
826523-29	Booster Quadrant Left
826523-1	Booster Quadrant Right
906907-13	Booster Shift Flight Station
906907-15	Booster Shift Flight Station
911631-5	Booster Shift FS 288 to 405
911631-7	Booster Shift FS 288 to 405
906907-5	Booster Shift FS 405 to 695
906907-7	Booster Shift FS 405 to 695

AILERON TRIM TAB CONTROL

815806-3	Flight Station
900857-3	Flight Station
911630-5	FS 322 to 388 Left
911630-11	FS 439 to 615 Right
911630-7	FS 515 to Left Wing
911630-9	FS 515 to Right Wing
810894-3	FS 615 to Right Wing
810894-5	FS 615 to Left Wing
807500-7	Actuator
807500-21	Actuator

WING FLAPS

909944-1	Flight Station
911630-1	Flap Extended
911630-3	Flap Retracted

NOSE LANDING GEAR AND COCKPIT AREA

906831-1	Uplock Release
906832-1	Uplock Release
814595-1	Brake - Copilot Pedal
814595-3	Brake - Copilot Pedal
814595-5	Brake - Copilot Pedal

MAIN LANDING GEAR

906907-31	Uplock Release Flight Station
816926-47	Uplock Release Flight Station
906907-1	Uplock Release Left
906907-3	Uplock Release Right
903898-1	Emergency Brake Pilot
903897-1	Emergency Brake Copilot
903899-1	Emergency Brake
911631-23	Emergency Brake
911631-1	Emergency Brake Off
911631-3	Emergency Brake Applied
906907-9	Emergency Brake
906907-27	Power Brake Left
906907-25	Power Brake Right

AUTOPILOT DISCONNECT

816316-1	Flight Station
906907-11	Flight Station to FS 388
911631-13	FS 388 to 694
906907-33	FS 694 to 1015
816926-11	Aileron Booster
810895-71	Aileron Booster

BOMB BAY ARMAMENT

906034-1	Bomb Bay Doors Controls and Safety Lock
904691-1	Emergency Release
904691-7	Emergency Release
904691-9	Emergency Release
904691-11	Emergency Release
904691-13	Emergency Release
926856-1	Retainer Arm
903000-3	Reel

ENGINE CONTROLS

816927-27	Flight Station to FS 288 Power Advance -	Engine No. 1, 2, 3 & 4
816927-29	Flight Station to FS 288 Power Retard -	Engine No. 1, 2, 3 & 4
LS6806-12-1926	FS 288 to FS 458 Power Advance & Retard	Engine No. 1, 2, 3 & 4
906906-1	FS 458 to FS 571 Power Advance -	Engine No. 1
906906-9	FS 458 to FS 571 Power Retard -	Engine No. 1
906906-3	FS 458 to FS 571 Power Advance -	Engine No. 2
906906-11	FS 458 to FS 571 Power Retard -	Engine No. 2
906906-5	FS 458 to FS 571 Power Advance -	Engine No. 3
906906-13	FS 458 to FS 571 Power Retard -	Engine No. 3
906906-7	FS 458 to FS 571 Power Advance -	Engine No. 4
906906-15	FS 458 to FS 571 Power Retard -	Engine No. 4
LS6806-12-1801	Wing Front Beam Inboard -	Engine No. 1
LS6806-12-0151	Wing Front Beam Outboard -	Engine No. 1
810284-61	Power Advance	Engine No. 1
810284-63	Power Retard -	Engine No. 1
905746-1	Power -	Engine No. 1 & 4
LS6806-12-1161	Wing Front Beam Inboard-	Engine No. 2
810284-53	Power Advance -	Engine No. 2
810284-55	Power Retard -	Engine No. 2
819974-1	Power -	Engine No. 2 & 3
LS6806-12-1600	Wing Front Beam Inboard -	Engine No. 3
810284-57	Power Advance -	Engine No. 3
810284-59	Power Retard -	Engine No. 3
LS6806-12-2250	Wing Front Beam Inboard -	Engine No. 4
LS6806-12-1090	Wing Front Beam Outboard -	Engine No. 4
810284-65	Power Advance	Engine No. 4
810284-67	Power Retard -	Engine No. 4

ENGINE EMERGENCY SHUTDOWN CONTROLS

911629-13	Flight Station to Wing Front Beam -	Engine No. 1
911629-15	Flight Station to Wing Front Beam -	Engine No. 1
911629-11	Flight Station to Wing Front Beam -	Engine No. 2
911629-9	Flight Station to Wing Front Beam -	Engine No. 2
911629-7	Flight Station to Wing Front Beam -	Engine No. 3
911629-5	Flight Station to Wing Front Beam -	Engine No. 3
911629-3	Flight Station to Wing Front Beam -	Engine No. 4
911629-1	Flight Station to Wing Front Beam -	Engine No. 4
810284-51	Wing Front Beam Outboard -	Engine No. 1
905745-1	Wing Front Beam Outboard -	Engine No. 1
810284-43	Wing Front Beam Outboard -	Engine No. 2
819976-1	Wing Front Beam Outboard -	Engine No. 2
810284-47	Wing Front Beam Outboard -	Engine No. 3
820132-1	Wing Front Beam Outboard -	Engine No. 3
810284-41	Wing Front Beam Outboard -	Engine No. 4
905744-1	Wing Front Beam Outboard -	Engine No. 4

LANDING GEAR SHOCK STRUTS Many instances have been reported in which paint and cadmium plating have chipped, blistered, or peeled. The first few production airplane struts were cadmium plated by an electrodeposition process. In order to prevent any possibility of hydrogen embrittlement due to this process on steel parts heat-treated to 260,000-280,000 psi UTS, all subsequent landing gear struts have been cadmium plated by a vacuum deposit process in accordance with MIL-C-8837, Type I, Class I.

The vacuum deposit of cadmium plating precludes the occurence of hydrogen embrittlement due to the plating process, but the cadmium plating is still inherently porous. Process changes aimed at sealing the cadmium plating have been incorporated recently. Essentially, these measures consist of applying a dichromate seal (MIL-C-8837, Type II) and epoxy-polyamide primer to the surface immediately after it has been cadmium plated.

Prevention The basic corrosion prevention system on these subject components consists of controlled heat treat processes, vacuum deposited cadmium plating, chromate treatment, epoxy-polyamide primer, and epoxy-polyamide paint finish. The struts and other areas of the wheel wells must be cleaned frequently, and washed to prevent the accumulation of corrosive agents such as salt water and contaminated oil deposits.

Detection Routine visual inspection for signs of paint deterioration, rust, or cadmium plate penetration is the best line service detection method. When evidence of rusting is found, it is recommended that a fluorescent dye penetrant inspection of the affected area be performed to ascertain the limit of attack and assure that no cracks are present. If cracks are found, the strut must be replaced.

Corrosion Treatment Treatment of corroded landing gear strut housings has been divided into those measures that may be accomplished on the flight

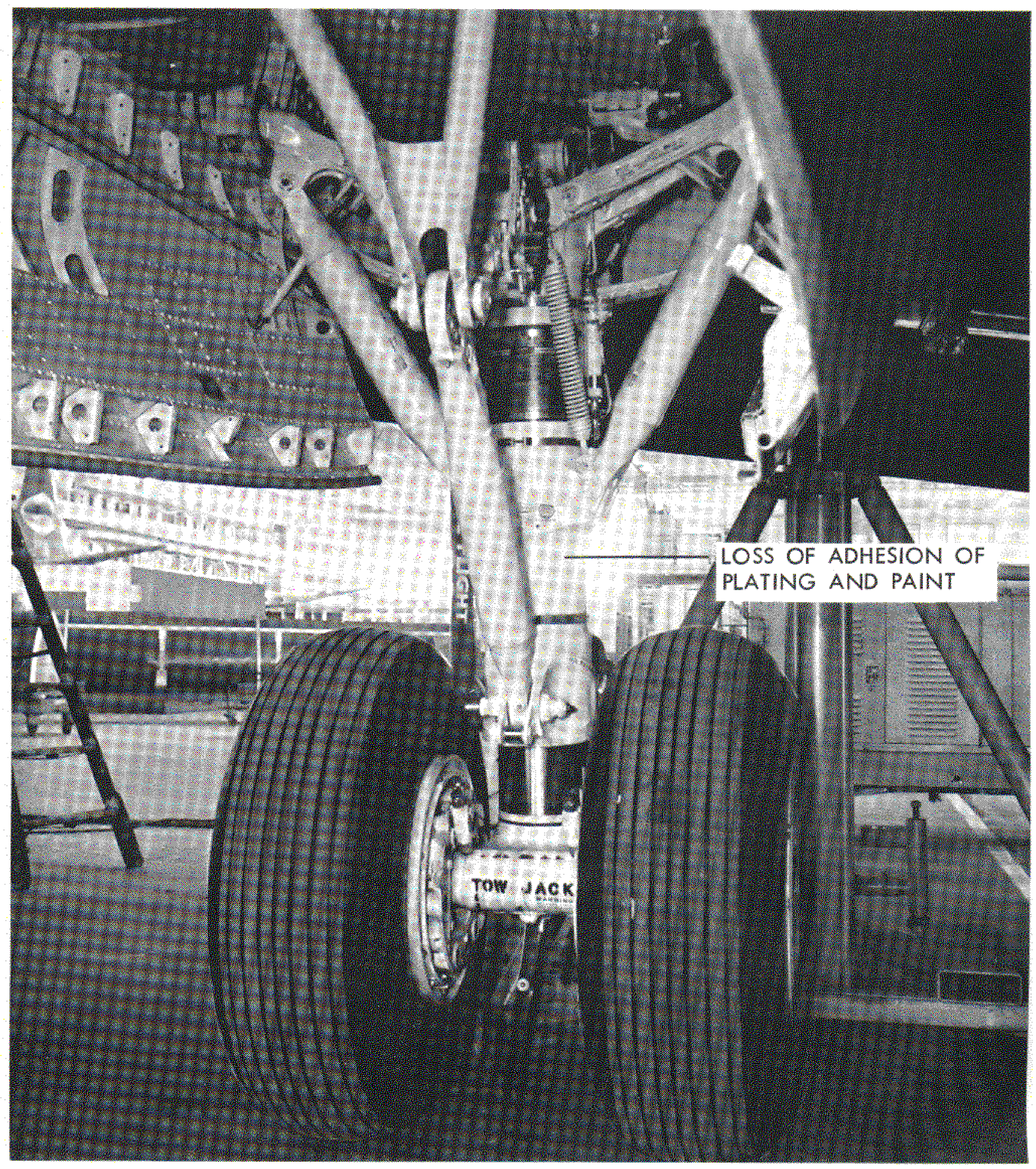


Figure 19
Main Landing
Gear Installation

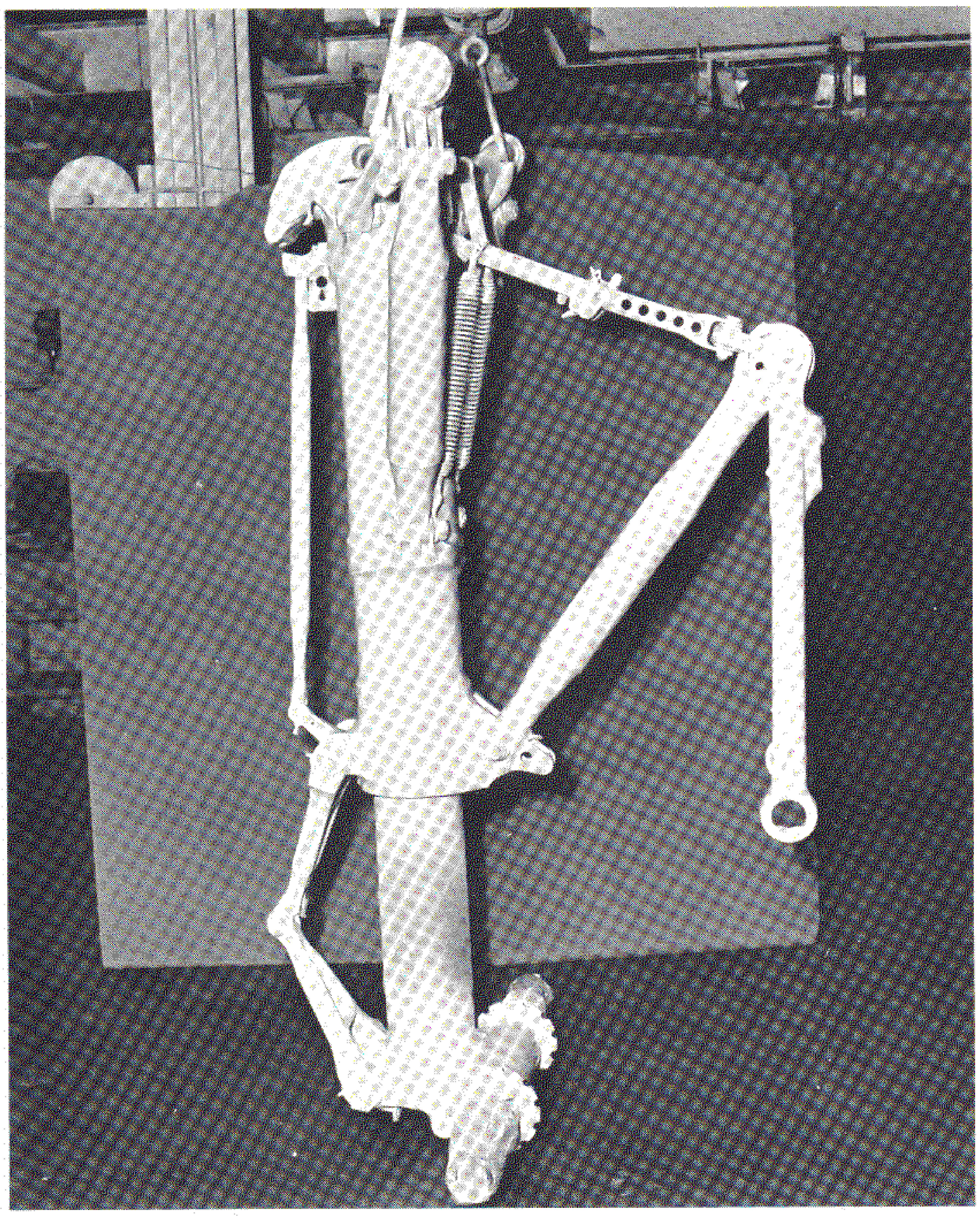


Figure 20
Mask Surfaces Adjacent
to Those Being Refurbished

line and those measures that may be accomplished during overhaul operations when the landing gear may be disassembled. Regardless of which measures are taken, *the use of cleaner-brighteners containing acids is prohibited.* For intermediate and organizational maintenance level applications of localized corroded areas:

a. Mask all bearings, bushings, joints, etc., to ensure that the paint stripper does not penetrate these areas.
b. Strip paint as required, using Turco T4669 Stripper. Delchem EZ Strip 19A, which is included in QPL* 25134, has been found effective in stripping epoxy. Delchem EZ Strip 19AY is a thicker version, and may be easier to control over limited areas.
c. Rinse the surface thoroughly with water and allow to dry.
d. Remove all loose cadmium or rust deposits, using No. 400 wet or dry sandpaper. *Exercise caution and sand only as required to thoroughly clean the affected area.*
e. Thoroughly clean the sanded area and unaffected adjacent painted area, using Toluene TT-T-548.
f. Apply one coat of epoxy-polyamide primer coating MIL-P-23377 (WEP) over the cleaned area, and two coats of epoxy-polyamide MIL-C-22750 (WEP), color 17875 of Federal Standard 595 (Insignia White), over the primer and extending approximately one inch over the cleaned unaffected adjacent painted area.

For depot level corrosion removal applications where the gear is disassembled:

a. Mask as necessary.
b. Strip paint, using Turco T4669 Stripper.
c. Rinse thoroughly with water and dry.
d. Strip cadmium by immersion in a 13%—15% by weight ammonium nitrate solution in water (at room temperature), or by light sand blasting. Immediately bake part for 7 hours at 375° ± 25° F.
e. Recoat the part with vacuum deposited cadmium in accordance with MIL-C-8837, Type II, Class I.
f. Finish in accordance with paragraph f, above.

**Qualified Parts List*

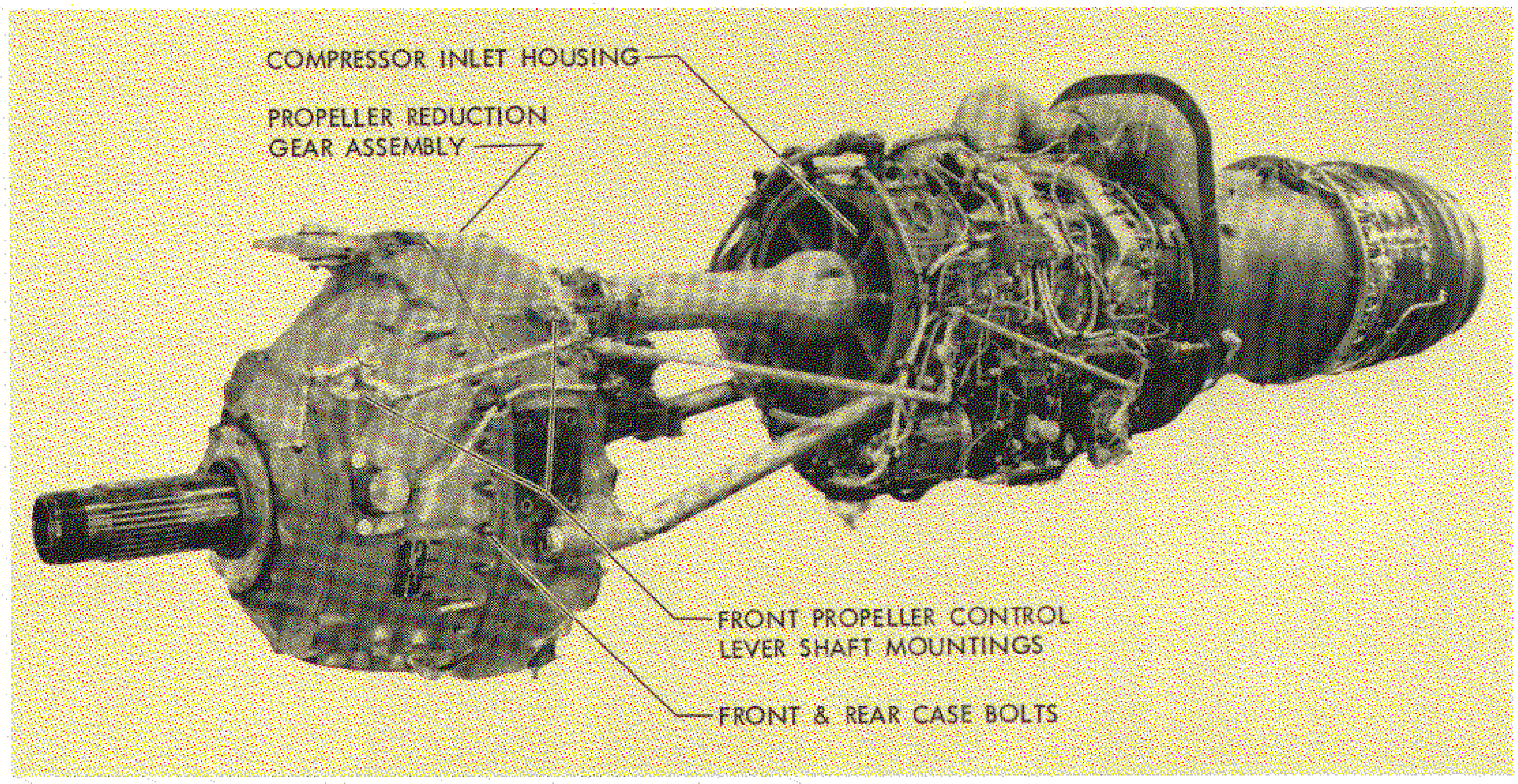


Figure 21
The Allison T56-A-14 Engine

ENGINE AIR INLET HOUSING The T56-A-10W engine air inlet housing is of cast magnesium construction, with a special erosion/corrosion protective coating. However, due to the severe atmospheric environment in which the airplane operates, this protective coating did not prevent corrosive attack of the magnesium. The problem was considered severe enough to warrant the replacement of the housing with one of cast aluminum alloy, which imposes a weight penalty of approximately 19 lbs. per engine. This change is effective on the T56-A-14 engine. The aluminum inlet housing can be retrofitted on the A-10 engine, and is at present being considered on a future spares procurement basis.

Although the change from magnesium to aluminum should reduce appreciably the rate of corrosive attack on air inlet housings, it will not eliminate the problem entirely, and corrosion control measures will have to be retained.

Prevention The T56-A-10W engine inlet housing (magnesium) is protected by a patented HAE coating with a Nubelon-S paint overlay. HAE is a ceramic-like coating of magnesium oxide formed by electrolysis. This process results in a hardened surface of magnesium oxide from 1.5 to 2 mils thick which must be sealed for utmost corrosion protection. Nubelon-S is a modified silicone paint that is used to seal the HAE surface. The T56-A-14 engine inlet housing (aluminum) is anodized, and also is coated with Nubelon-S paint.

Corrosion of the compressor air inlet housing must be prevented. To assist in keeping the area free of corrosive agents (salt spray in particular), the inlet should be flushed any time the airplane has been subjected to salt spray exposure.

The following flushing procedure is recommended, using a lance and nozzle similar to that shown in NAVWEPS 01-1A-506, Section III,

a. Use a fresh water source with ordinary line pressure, or portable tank and pressure source of 40 - 50 psi.
b. Extend lance down into the QEC air inlet duct and open spray valve for twenty (20) seconds while rotating the nozzle around the inlet housing to assure complete coverage.
c. The lance should be kept inserted well into the inlet duct while the water is being sprayed to avoid spraying water into the EDC air intake ducts.
d. It is considered mandatory by the Allison Division of General Motors to run the engine for 5 minutes at idle power after flushing in order to thoroughly dry out the inlet.

NOTE:

1. Do not attempt water flushing when the outside ambient temperature is below +40°F.
2. The airplane water/alcohol system (installed on P-3A aircraft only) can be used at temperatures below +40°F. to flush the inlet, but this does not do a thorough job because the aqueous solution does not reach the outer strut or housing areas.
3. The overall aircraft washing system, which is conducted with engines running, will also provide some flushing of the inlet housing with somewhat the same limitation as outlined in Note 2, above.

Detection Visual inspection of the inlet housing is recommended as the best means of corrosion detection in this area. The following procedure is suggested after exposure to salt spray:

a. Use a strong light and an inspection mirror and inspect upper struts and upper portions of housing through the air inlet duct.
b. Inspect lower struts and lower portions of housing by removing the air inlet inspection door P/N 803566-1. See Figure 22.
c. Note any evidence of corrosion, visible pitting and/or corrosion products, paying particular attention to the leading edges of struts and the upper surfaces of horizontal struts.
d. Upon completion of inspection, any engine found with evidence of corrosion should be reported for follow-up action on the appropriate discrepancy form.
e. Not later than the next calendar inspection, remove those engines in which evidence of corrosion has been found for a more detailed inspection and repair at the Intermediate maintenance level.

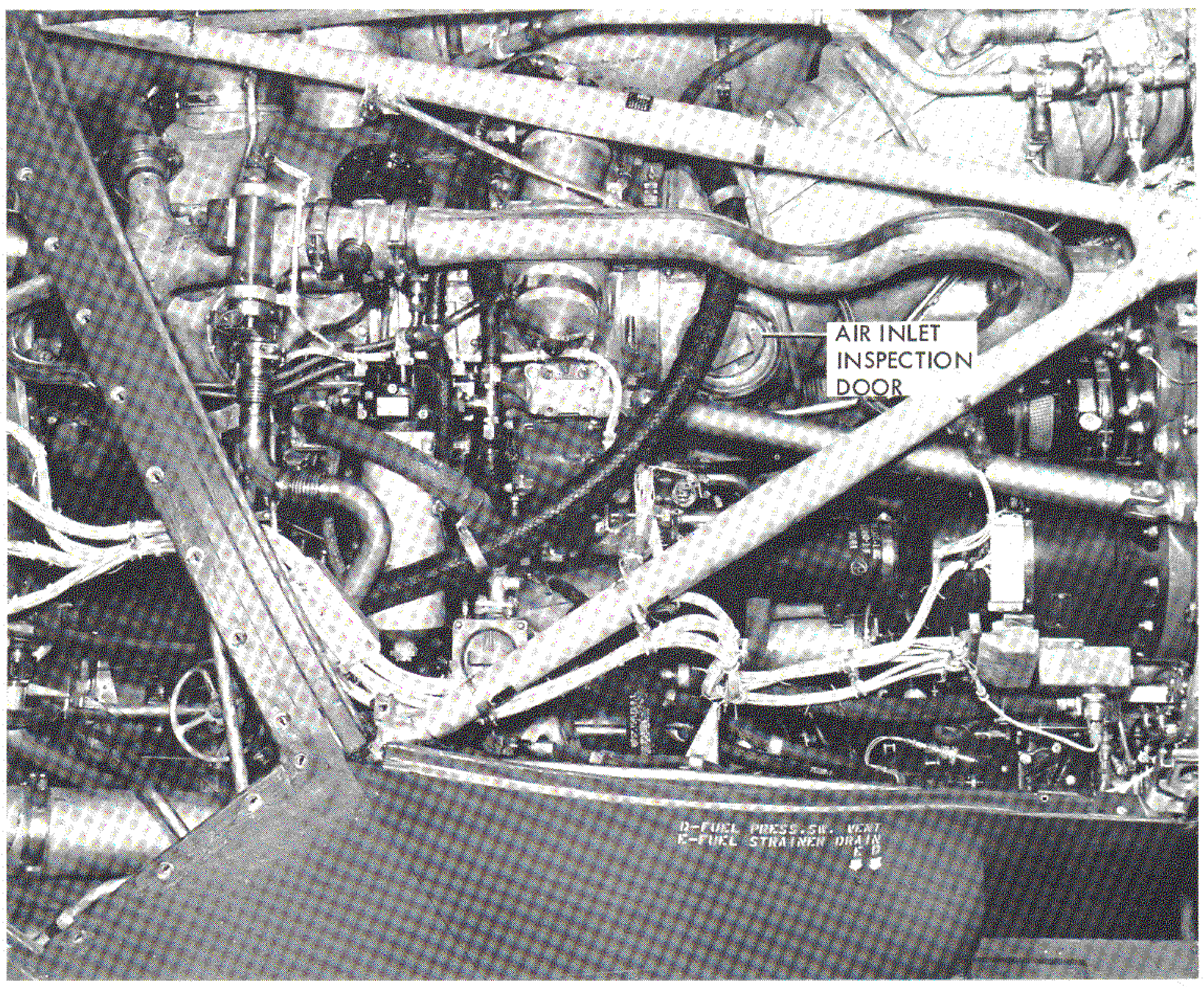
Removal The following procedure is recommended for removal of corrosion damage:

a. Remove the power section from the QEC and install it on a separate stand.
b. Inspect the housing thoroughly to determine the extent of corrosion damage. Ensure that the strut trailing edges and the rear flange area are inspected with a strong light and an inspection mirror. If corrosion is evident in this area, repair will require removal of the housing from the engine. Ensure that pitting or other damage does not exceed the rework limits of NAVWEPS 02B-5DC-3. If it cannot be definitely determined that damage is within the rework limits, the housing shall be rejected to overhaul.
c. Flush the entire housing thoroughly with fresh water and dry with compressed air.
d. To prevent foreign materials from entering compressor during rework, mask off and cover the compressor inlet at the inlet guide vanes.
e. Remove corrosion by wire brushing the affected areas, using a soft wire brush (aluminum brush FSN 7920-514-0234 is suitable). Use caution not to remove excessive amounts of material. After corrosion removal operations, the reworked area is considered acceptable, even though the surface may be rough or pitted.

CAUTION: Ensure that reworked areas do not exceed rework limits.

f. Wash the area thoroughly with fresh water and dry with clean, dry compressed air.

Figure 22
Location of the Engine Air Inlet Inspection Door



Inhibiting Immediately after all evidence of corrosion has been removed, the reworked area should be treated as follows:

a. Tilt the engine at a slightly nose-down attitude when the inlet housing is installed to assist in preventing the chrome-pickle solution from entering the compressor section.
b. The chrome pickle treatment shall be accomplished by using 12% chromic acid solution MIL Spec. FED O-C-303, FSN G6810-264-3939. Apply one coat of the solution to the wire brushed areas and allow to stand for fifteen minutes. Wash the areas with fresh water or clean them thoroughly by wiping with a wet rag, and allow the surfaces to dry.

Restoration of Protective Coating Immediately after the surfaces have dried, apply protective coatings as follows:

a. Apply a coat of Nubelon-S, No. 902, Gray, FSN 8010-200-3259 and special lacquer reducer No. 9012, FSN 8010-663-0395. Mix the paint and reducer in a ratio of two parts paint to one part reducer by volume. The paint coating shall be continuous, uniform and free from bubbles, pin holes, sags and other surface imperfections.
b. Air dry the surface for twenty minutes, and apply a second coat. Dry the second coat with a heat lamp.
c. When the Nubelon-S is thoroughly dry, apply three coats of BUNA "N", MIL-S-4383B, FSN KZ8030-664-4019. Apply these coatings one inch wide from leading edge rearward to the full height of each strut. Allow thirty minutes drying time after each application.

PROPELLER REDUCTION GEAR ASSEMBLY (FRONT AND REAR CASE BOLTS, AND FRONT PROPELLER CONTROL LEVER SHAFT MOUNTINGS) The propeller reduction gear assembly is constructed of cast magnesium alloy with steel thru-bolts. Steel and magnesium are incompatible from the standpoint of galvanic activity, particularly in the presence of an electrolyte such as salt water.

Prevention This particular area is protected with AMS 3110 zinc chromate primer and a corrosion resistant AMS 2510 gray enamel paint coat. A service evaluation of eight engines incorporating WC-100 gray Actithane coating (FSN 8010-831-5934) in lieu of the zinc chromate primer was conducted and revealed greatly improved resistance to corrosion. WC-100 has now been incorporated on production engines.

Detection Frequent visual inspection of the reduction gear assembly is recommended as the best means of detecting corrosion. Use a strong light and an inspection mirror to check the housing bolt and nut area and the front propeller control lever shaft mounting area.

Removal If there is corrosion around the front propeller control lever housing, remove the housing and clean up the corrosion by wire brushing the affected areas, using a soft aluminum brush (FSN 7920-514-0234). Use caution not to remove excessive material.

For corrosion around the case bolts, it will be necessary to remove the engine and the housing bolts in order to gain access to the affected areas. If corrosion is slight, corrective measures may (on proper authority) be deferred for action at a major facility.

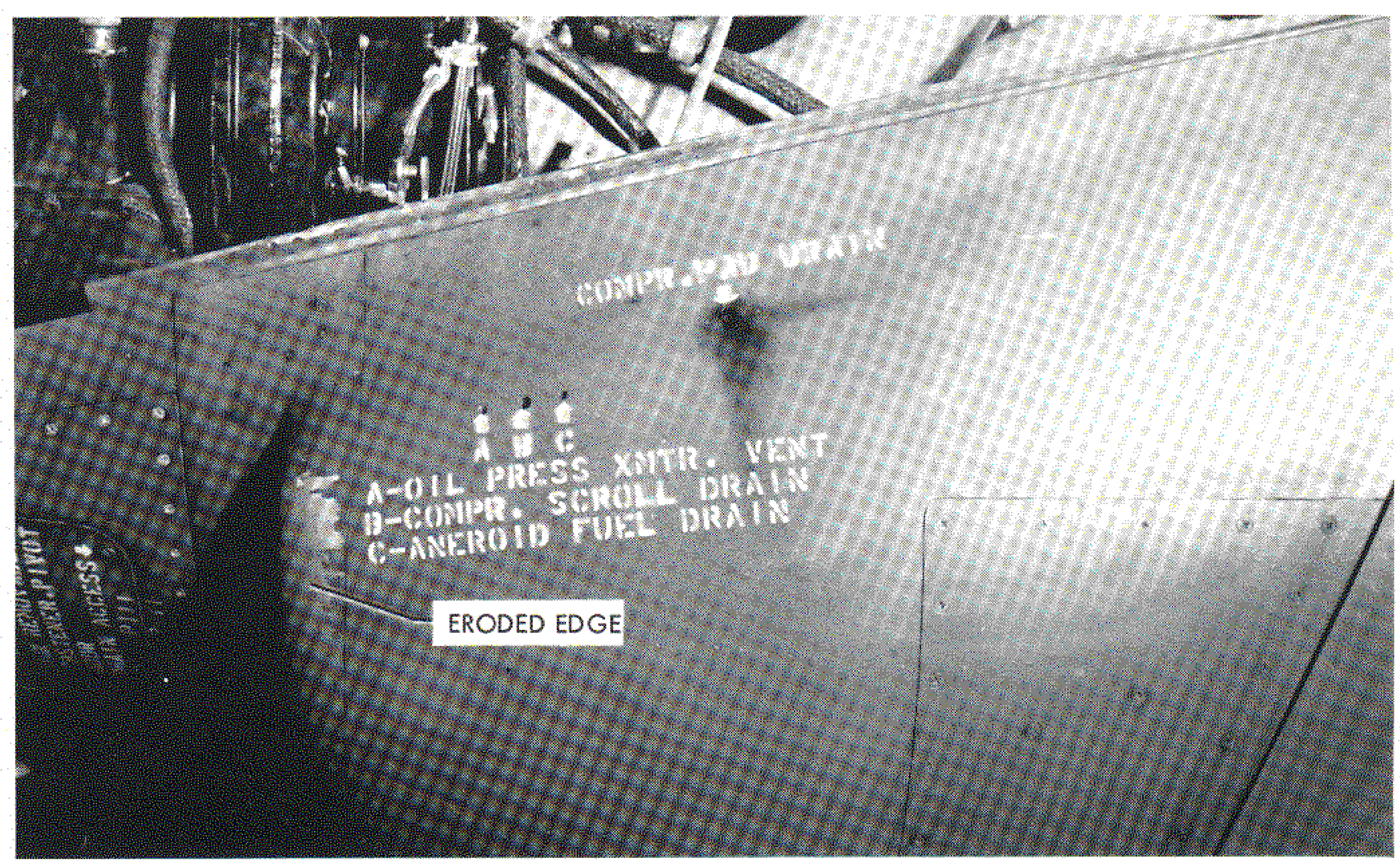


Figure 23
Erosion of Paint on the
Oil Cooler Air Scoop Leading Edge

Cleaning and Inhibiting Immediately after removal of corrosion products, wash the reworked area with fresh water and allow to dry. Inhibit the area by using chromic acid solution, MIL Spec. FED-0-C-303, FSN G6810-264-3939. Apply one coat of solution and allow to stand for fifteen minutes. Wash the area with fresh water and allow to dry.

Restoration of Protective Coating Treat the entire exposed surface with three coats of zinc chromate primer, allowing fifteen minutes between each coat for drying. After final assembly, clean the surface with Aliphatic Naptha (TT-N-95, Type II), paint the affected area with gray Actithane WC-100 (FSN 8010-831-5934), including bolt heads, nuts and washers in contact with the magnesium case. Refer to NAVWEPS 02B-5DC-2 and -3, Aircraft Engine Service Instructions and Overhaul Instructions, for detailed corrosion control procedures.

PROPELLERS In cases where the airplane is operated near salt water, wash the propeller blades thoroughly with clean (fresh) water, dry completely and then apply a thin film of clean engine oil. This shall be done on a daily basis.

For other corrosion control measures on the 54H60-77 propeller, refer to NAVWEPS 03-20-CBBK-1 & -2, Propeller Maintenance Instructions and Overhaul Instructions.

MISCELLANEOUS Areas not specifically covered in detail in this article which, nevertheless, need attention are:

Fillets

a. Maintain protective paint coatings.
b. Maintain chafing compound in faying surfaces.
c. Apply sealant when installing screws and washers.
d. Maintain vapor barrier seals.

Access Doors

a. Maintain faying surface and gap sealant.
b. ·Apply sealant when installing screws.
c. Maintain protective paint coatings over fasteners.

Entrance Doors

a. Maintain protective coatings on sills.

Nacelles and Wheel Wells

a. Maintain free of oil and dirt to preserve protective coatings.

Leading Edges of Oil Coolers, Air Scoops and Landing Gear Doors

a. Maintain protective coatings. These areas are subject to erosion and will require freqent touch-up.

LUBRICATION In addition to their primary use as lubricants, oils and greases also serve the equally important function of protecting bearing materials from corrosive attack.

Such protection is even more essential when a design involves the use of different materials in contact with each other and there is exposure to galvanic attack. Such configurations as jackscrews, cable drums, tracks and rollers, etc., are usually constructed of materials which have no protective coatings other than some form of lubricant. It is vital to these parts, both from a wear standpoint and as protection against corrosion, that the lubricant film be maintained at all times.

WASHING AIRCRAFT One of the fundamentals of corrosion control is cleanliness, for the dirt and salt deposits on aircraft surfaces are a prime cause of corrosive attack. Thus, one of the most elementary but effective means of corrosion control is to wash aircraft frequently and thoroughly. The wash water should be fresh, clean, pure, etc., but the available fresh water sources cannot always provide water of optimum purity. Even if the purity of the water does leave something to be desired, it is generally accepted that *any* fresh water cleaning program is better than none at all, for surface deposits are almost invariably more detrimental than are the undesirable impurities in the water. Lockheed recommends the optimum usage of aircraft washing facilities at the squadron's disposal.

LOCATION	PRECAUTIONS	REMOVAL OF PROTECTIVE COATINGS		CORROSION REMOVAL			CLEANING	
		ACRYLIC NITRO-CELL	EPOXY POLYAMIDE	ALCLAD & THIN SHEET	MAGNESIUM & HEAVY AL. AL.	STEEL	ALUMINUM	STEEL
REFER TO APPROPRIATE SECTION FOR DETAILS	1. USE SAFETY EQUIPMENT AS REQUIRED 2. MASK AREA ADJACENT TO REPAIR 3. AVOID SPILL OR DAMAGE FROM TOOLS	PAINT STRIPPER SPEC MIL-R-8633	PAINT STRIPPER TURCO T4669	ALUMINUM WOOL, FINE ABRASIVE PAPER OR	CARBIDE SCRAPERS OR	FINE ABRASIVE PAPER OR	REFER TO PAGE 6 FOR DETAILS	WIPE DOWN WITH ALIPH-ATIC NAPTH SPEC. TT-N-9 TYPE II
				VACU-BLAST WITH MIL-A-22936 GR. A GLASS BEADS				
UPPER & LOWER WING SKIN	X	X	X		X		X	
WING PLANK SPLICES	X	X	X		X		X	
AILERONS	X	X	X	X			X	
WING CENTROID RISER RECESSES	X	X	X		X		X	
INTEGRAL FUEL TANKS	X	PLASTIC, PHENOLIC SCRAPER			X		X	
FASTENERS	X	X	X	X			X	
FUEL VENTS	X	X	X	X			X	
WING LEADING EDGES	X	X	X	X			X	
L.E. TO SPAR JOINTS	X	X	X		X		X	
STABILIZERS	X	X	X		X		X	
EMPENNAGE LEADING EDGES	X	X	X	X			X	
NOSE LANDING GEAR WHEELS	X				X			
LAVATORY & GALLEY AREAS	X	X		X			X	
BATTERY & VENT AREA	X		X	X	BICARBONATE OF SODA		X	
CONTROL CABLES	X					SOLVENT FED SPEC P-D-680		
LANDING GEAR SHOCK STRUTS	X		X			X		X
ENGINE AIR INLET HOUSING	X				X			
REDUCTION GEAR ASSY	X				X		CLEAN MAG. HOUSING WITH ALIPH. NAPTHA TT-N-95 TYPE	
FILLETS	X	X	X	X			X	
ACCESS DOORS	X	X	X		X		X	
ENTRANCE DOORS	X	X	X	X			X	

Figure 24 Summary of Corrosion Control Measures

SUMMARY OF CORROSION CONTROL MEASURES Figure 24 summarizes the corrosion control measures to be followed after the discovery of corrosion. It is constructed in the sequence of the detailed coverage in this article. For details, refer to the appropriate section in this article and the related publications referenced in Table 1.

REPORTING One final aspect of a sound corrosion control program is to document the corrosion experience on fleet aircraft. It is necessary to have complete histories on corrosion problems to properly determine the cause and select the proper solution.

An extensive corrosion control effort is being conducted at Lockheed, covering the development of basic material selection, treatments and processes. The feedback of experience on all cor-

CHEMICAL CONVERSION		SEALING				PAINTING (SEE NOTE)		
ALUMINUM	MAGNESIUM	GAPS, JOINTS & SEAMS		FASTENERS		ACRYLIC NITRO-CELL.	EPOXY POLYAMIDE	ACID RESIST. LACQUER
				ALUMINUM	STEEL			
PER SPEC. MIL-C-5541 ALODINE OR EQUIVALENT	CHROMIUM TRIOXIDE MIL SPEC. FED-0-C-303	HIGH ADHESION COMPOUND MIL-S-8802 CLASS B-2	LOW ADHESION COMPOUND MIL-S-8784 CLASS B-1/2	WET ZINC CHROMATE SPEC. MIL-P-8585	COMPOUND SPEC. MIL-S-7502	1. WASH PRIMER MIL-L-8514 2. PRIMER MIL-P-7962 3. TOPCOAT (2) MIL-L-19537	1. PRIMER MIL-P-23377 2. TOPCOAT (2) MIL-C-22750	1. PRIMER MIL-P-8585 2. TOPCOAT (2) MIL-L-7178
X		X	X	X	X	X	X	
X		X	X	X	X	X	X	
X						X	X	
X			X		X	X	X	
X		POLYURETHANE MIL-C-27725 OR BUNA-N MIL-S-4383		X	X			
X				X	X	X	X	
			X	X	X	X	X	
X			X	X	X	X	X	
X			X	X	X	X	X	
X		X		X	X	X	X	
X			X		X	X	X	
	X			LUBRICANT MIL-G-25760				
X								X
X							X	
CORROSION PREVENTIVE COMPOUND MIL-C-16173								
							X	
						1. NUBELON "S" NO. 902 GRAY 2. TOUCHUP WITH BUNA-N MIL-S-4383B		
	X			WC-100 GRAY ACTETHANE FSN-8010-831-5934		1. PRIMER AMS 3110 2. ENAMEL AMS 2510 GRAY		
X	X	X			X	X	X	
X			X		X	X	X	
X						X	X	

NOTE:
INSTRUCTIONS FOR APPLICATION OF THE EXPERIMENTAL POLYURETHANE PAINT SYSTEM ARE INCLUDED WITH SPECIAL PAINT KITS FOR THE AFFECTED AIRCRAFT. THESE KITS MAY BE OBTAINED FROM YOUR LOCAL LOCKHEED SERVICE REPRESENTATIVE.

rosion control measures is important to the evaluation and perfection of each.

Planform diagrams, indicating exact location, type and extent of corrosive attack are invaluable in performing the task of providing sound factory assistance to operations personnel. Environmental exposure, time in flight hours, elapsed time and notice of any unusual activity should be reported. Details on corrosion removal, repairs and refinishing are, likewise, invaluable in the proper evaluation of the overall problem.

The Lockheed Field Service Representative provides a direct line of communication between the fleet activities and the factory. Field experience input to the factory on a continuous basis is the most reliable record of performance that is available to us, and we encourage the flow of operations experience through this medium.

AUTOMATED AIRCRAFT RINSE RACK

This article was prepared from material provided by our Service Representatives at Patuxent River NAS, Brunswick NAS, and Moffett NAS with the assistance and co-operation of the U.S. Navy.

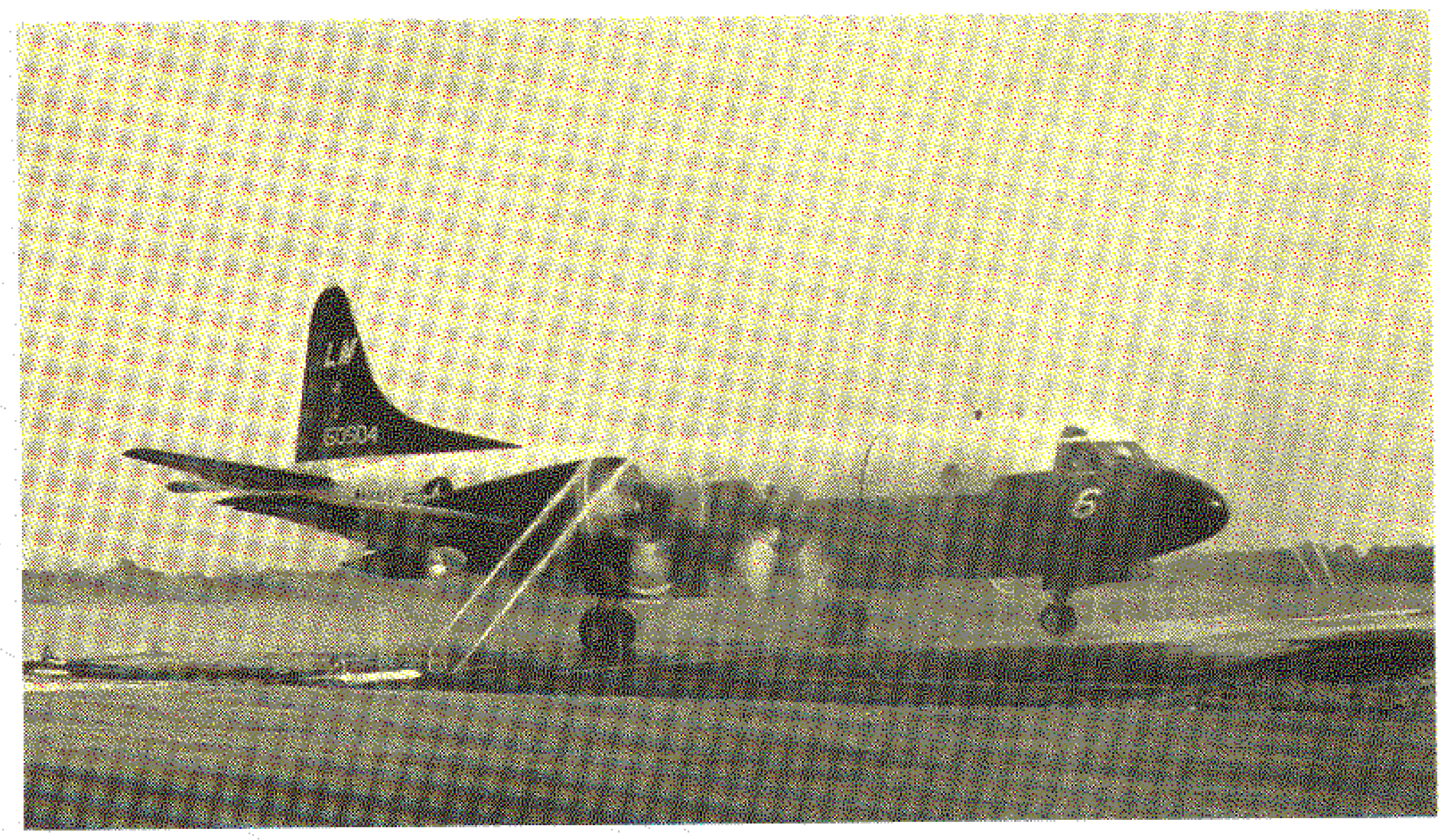


Figure 1
Prototype Rinse Rack
at Patuxent River NAS

Official Photograph, U.S. Navy

FOR MANY YEARS Naval aviation has been faced with corrosion problems caused by the involuntary reclamation of salt from marine atmospheres by aircraft flying low over the water during routine patrols. Under these conditions heavy salt deposits accumulate on the leading edge surfaces, although some salt is deposited on the entire exterior of the aircraft. Jet engine intakes and the power plants themselves are particularly susceptible because of the immense volume of salt-laden air that is consumed during flight operations in a marine environment.

General surface corrosion on P-3 aircraft and corrosion of the magnesium inlet housings of the P-3's T56-A-10 engines prompted Lt. R. Morris III, an Aircraft Maintenance Officer at Patuxent River Naval Air Station, to devise an inexpensive method of rapidly removing salt deposits. From experience, Lt. Morris knew that carrier-based pilots routinely flew their aircraft through convenient rainstorms to rinse away the unwanted salt, so he designed his own ground-based artificial fresh-water rainstorm (rinse rack) that could be actuated at will. AMD Airframes Division at Patuxent River NAS built a prototype rinse rack from salvage material for Lt. Morris after the P-3 engine manufacturer determined that the chemical content of the station's water and the temperature extremes would not damage the engines, and the tests were begun.

The prototype rinse rack shown in operation in Figure 1 was made up of a 20-foot, 2.5 inch diameter manifold with a center tap inlet and three 55-foot, 1-inch diameter "fingers" containing a total of twenty-seven ¼-inch formed outlets. Two ½-inch diameter, 3-foot high nozzles were installed at a later date to rinse the top surface of the aircraft.

The primary test phase used only regular water system pressure to operate the rack. This limited the height of the spray at all outlets to a marginal area that required taxi and/or stop and soak for one minute in order to rinse all areas, especially the engine inlet guide vanes. As an interim measure to increase the water flow, the NAS Fire Department furnished a pumper truck "on call." Later a pump (500 GPM at 150 psi) was obtained and used as the booster unit.

With the booster unit in the system, an adequate rinse of one side of the aircraft was obtained by a slow taxi of the aircraft through the rinse rack. This was demonstrated by the use of water-soluble food dye painted on various aircraft surfaces as the indicator.

ALL THAT GLITTERS IS NOT GOOD VP-44 furnished three aircraft for a thirty-day period to test the rinse rack concept. During this time the designated aircraft taxied through the rinse rack one time after each flight, rinsing *only* the right-hand side of the aircraft. The weather co-operated by staying very dry during the test period, thus the test evaluation was not complicated by spurious rainstorms of natural origin.

After thirty days, comparative inspection of the rinsed and unrinsed sides of the aircraft proved conclusively that the rinse rack was doing the job of controlling salt deposit accumulation. Examination also showed that all salt deposits had been eliminated from the engines on the sides that were rinsed. However, when the engine inlets on the *unrinsed* sides were inspected with a flashlight, their appearance was described as "Like looking into tubes lined with diamonds." Needless to say, Lt. Morris' rinse rack was considered a success, and BuWeps made funds available to NAS Patuxent River to develop a permanent automatic rinse rack system. Meanwhile, use of the prototype imitation rain storm was opened to all P-3 squadrons at Pax River.

RAIN ON DEMAND The one obvious disadvantage of the prototype rinse rack was that only half an airplane could be rinsed during one pass through the rack, necessitating a return pass in the opposite direction. Installation of Patuxent River's full-sized permanent rinse rack (which is wide enough to rinse an entire aircraft) eliminated this inconvenience.

The permanent rack, installed in a taxi-way detour, acquired an extra digit, having a total of four "fingers" imbedded in the taxi-way. The nozzles of these fingers can form a wall of water some sixteen feet high. The four standing nozzles, two on each side, are directed high to rinse the upper surfaces of the wings, the horizontal stabilizer, and the vertical stabilizer.

Finally, the rinse rack is automatic. The rinse rack is turned on by a treadle-type switch actuated by the aircraft nose wheel, and is controlled by a timer set at 50 seconds that maintains operation of the pump for a given time period. In the majority of cases, this time span is considered adequate to allow complete passage and rinsing of the aircraft. Figure 2 shows Patuxent River's automated rinse rack in operation, and the schematic in Figure 3 shows the basic idea that Patuxent River NAS Public Works has submitted to BuWeps for consideration as a standard plan for aircraft rinse rack facilities.

Official Photographs, U.S. Navy

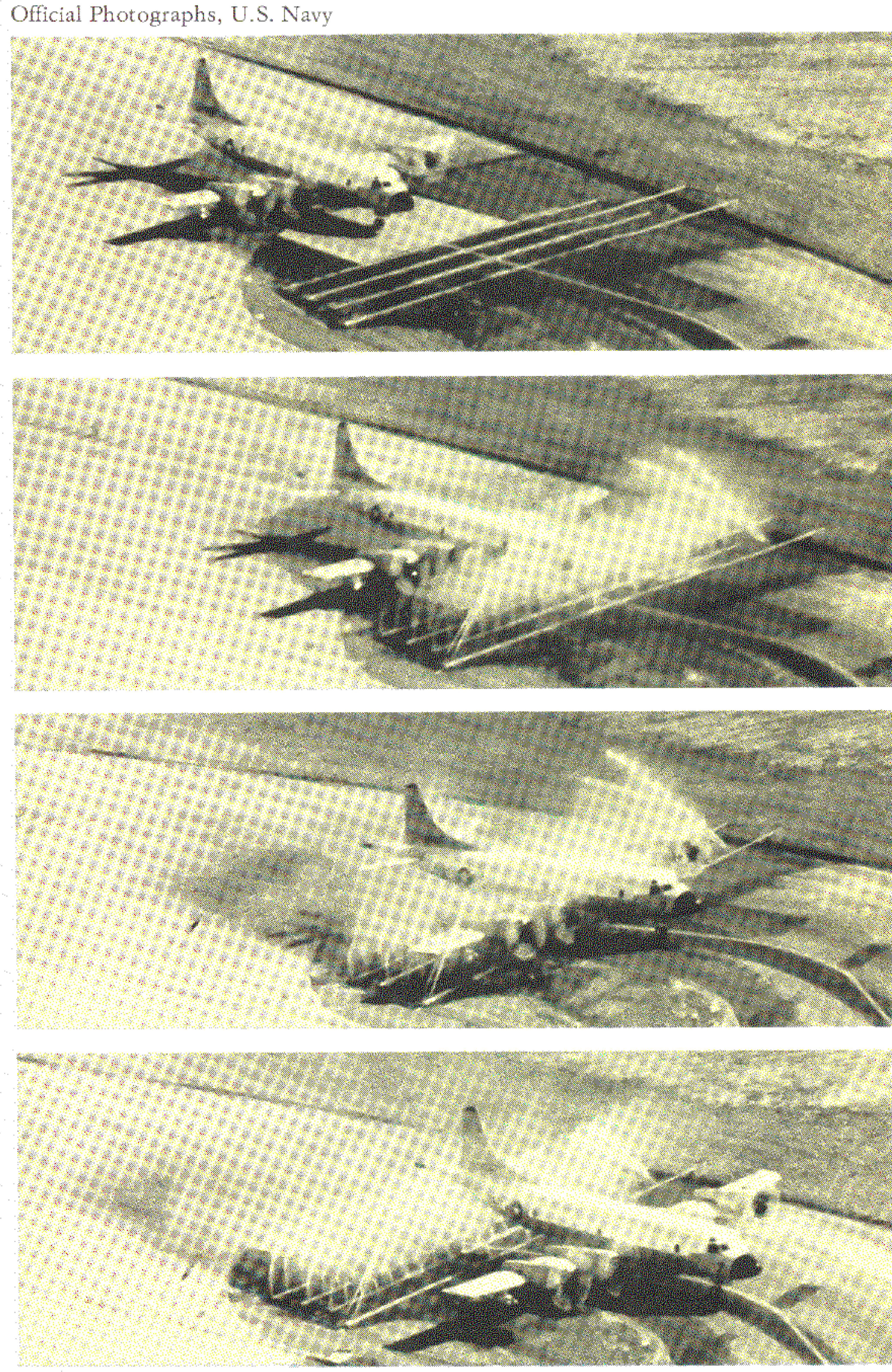


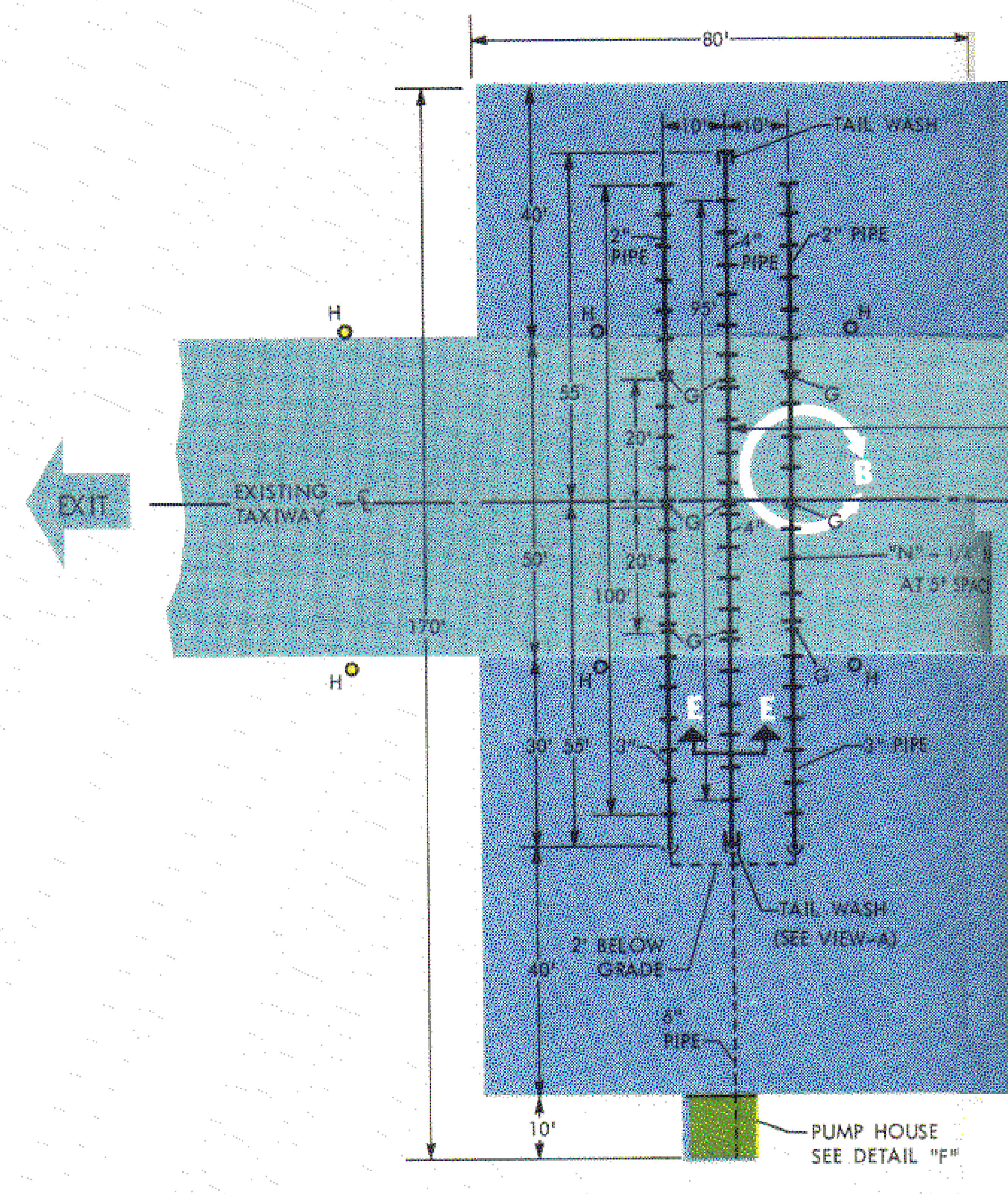
Figure 2 Aerial Views of the Automatic Rinse Rack in Operation

CRITIQUE The effectiveness of the rinse rack concept has been substantiated by the lack of engine removals due to corroded inlet guide vanes. Since use of the rinse rack became standard procedure on all P-3's based at Patuxent River, three engines have been removed at this station for what was thought to be excessive corrosion. All three engines were cleaned, found to be within the tolerances set forth, the inlet vanes treated and coated with Buna "N," and the engines returned to service. Personnel at this base estimate that use of the fresh water rinse rack is saving them over 14,000 man-hours per year on the guide vane clean-up and treatment job alone.

It is impossible to draw a precise comparison of the incidence of corrosion on unrinsed P-3's versus rinsed P-3's at Patuxent River, because after the initial tests established that the rinse rack is a beneficial tool for corrosion control, all P-3 aircraft based there have been using it. However, in one case two P-3 aircraft from Patuxent River were stationed at Bermuda for three months and were deprived of their daily ablutions. Upon their return these aircraft were found to have notably more corrosion than the Patuxent River-based aircraft. Any conclusions drawn from this instance must be tempered by the fact that even the conventional aircraft washing facilities at Bermuda are necessarily limited, and that the only water available is of the reclaimed variety.

The only important limiting factors on the rinse rack concept are water purity and the ambient temperature. The water must be fresh and low in chemical impurities, especially calcium—basically this means the water should be "soft." Temperature restrictions which presently limit use of the rinse rack to temperatures above 34°F are intended to keep ice from forming on the aircraft and the taxi-way. The rinse rack is thermostatically controlled to prevent automatic operation below this temperature. An exception to the 34° rule can be made by manually resetting the thermostat if the aircraft is to be hangared immediately after rinsing so that it will "drip dry" without water freezing in some critical crevice or channel. There is, of course, a low temperature limit which will be determined by other prevailing circumstances, for example, ice formation on the taxi-way which may pose a hazard to aircraft following the first one of the day.

It was determined that for the sake of standardization it is best to require use of the rinse rack at the completion of every flight. To try to tie the required use of the rack to "low



SITE PLAN

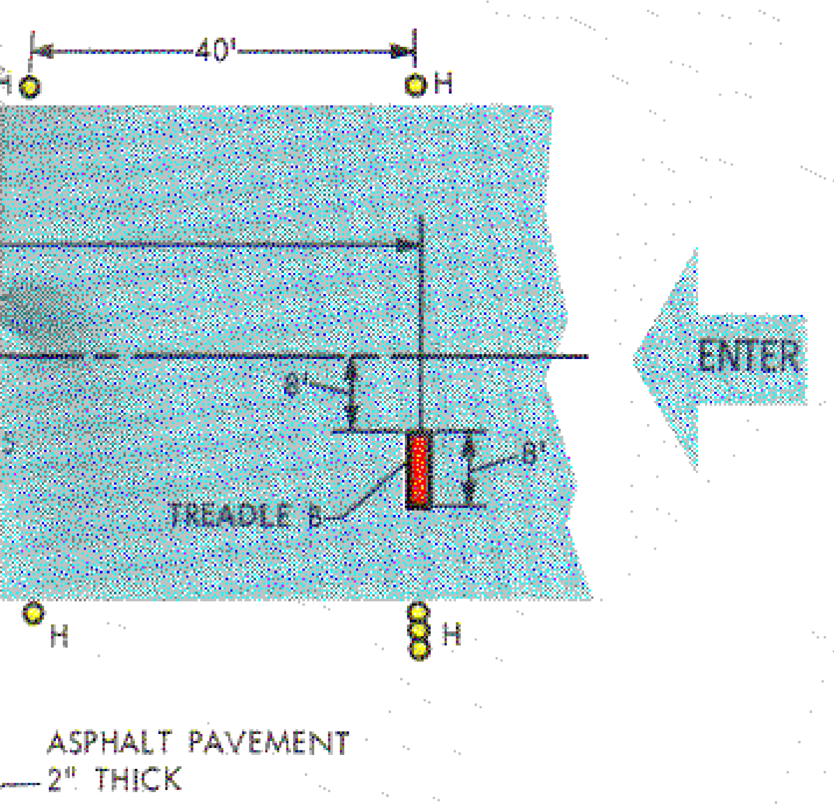
SITE REQUIREMENTS

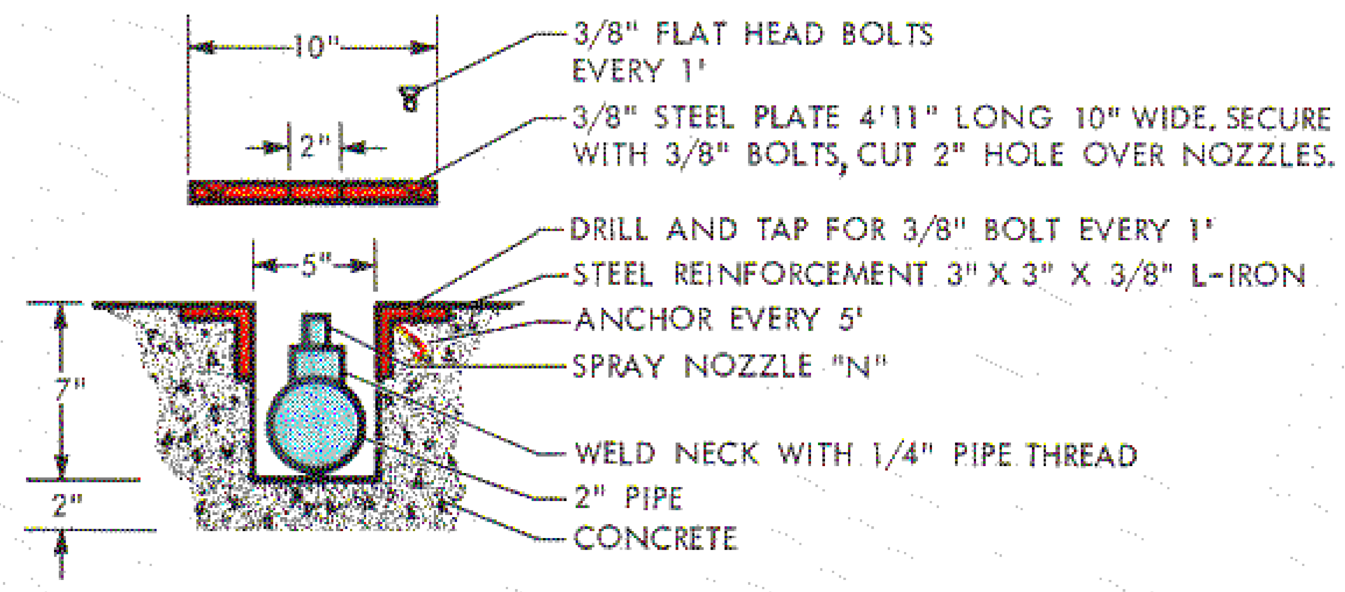
WATER	1000 GPM FOR 2 MINUTES.
ELECTRIC	150 KVA 3 PHASE. 440 VOLT PREFERABLE, 220 VOLT ACCEPTABLE.
DRAINAGE	10" STORM DRAIN OR PAVED DRAINAGE DITCH.
GRADING	SLIGHTLY DOWNHILL OR LEVEL. AVOID UPHILL GRADING.

CONSTRUCTION

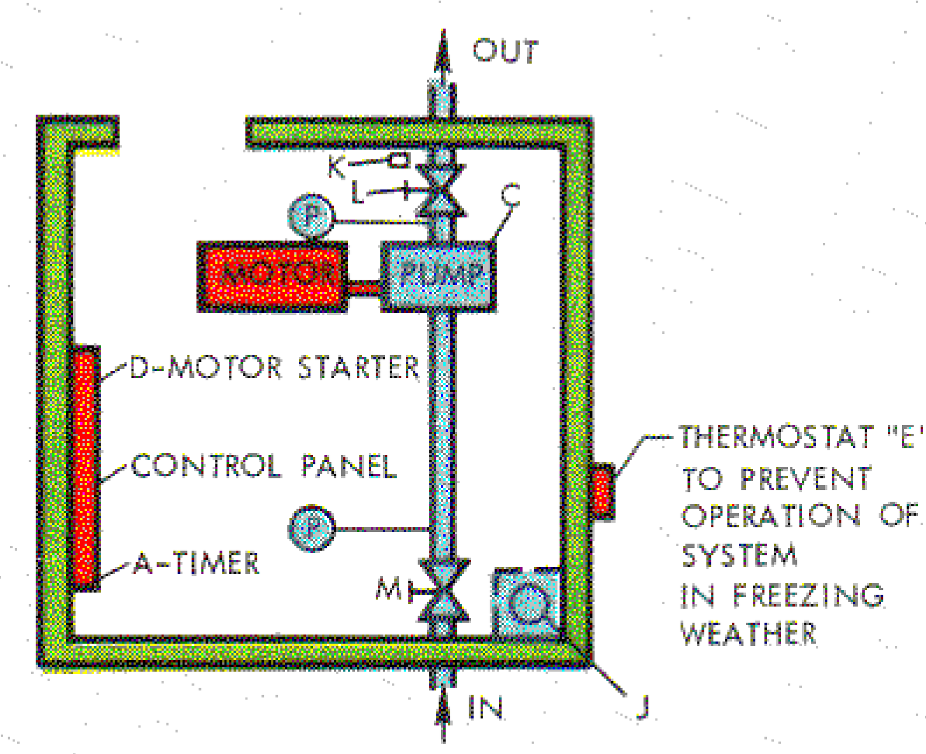
PAVEMENT	DRAINAGE AREA. 2" ASPHALT. 80' X 120' = 9,600 SF. PAVE DITCH TO NEAREST STORM DRAIN OR PAVED DITCH.
PUMP HOUSE	10' X 10' SHED ROOF OVER SUNKEN CONCRETE FLOOR & WALLS. LOCATE PUMP HOUSE AS CLOSE TO RINSE RACK AS POSSIBLE.
GENERAL	ALL EXPOSED PIPING MUST DRAIN IN FREEZING CLIMATES. ELEVATION OF PUMP SHOULD BE BELOW ALL EXPOSED PIPING TO MINIMIZE AMOUNT OF WATER WASTED IN DRAINING PIPE AFTER EACH WASH CYCLE. LOCATE TREADLE FURTHER FROM RINSE NOZZLES IF EXCEPTIONALLY LONG PIPES DRAIN, TO ALLOW PIPES TO REFILL BEFORE AIRCRAFT ARRIVES AT NOZZLES. LOCATE TREADLE OFF CENTER FOR MAIN GEAR ACTUATION.
PAINTING	PAINT CENTER LINE ON NEW TAXIWAY.

Figure 3 Schematic and Details of the Automatic Rinse Rack

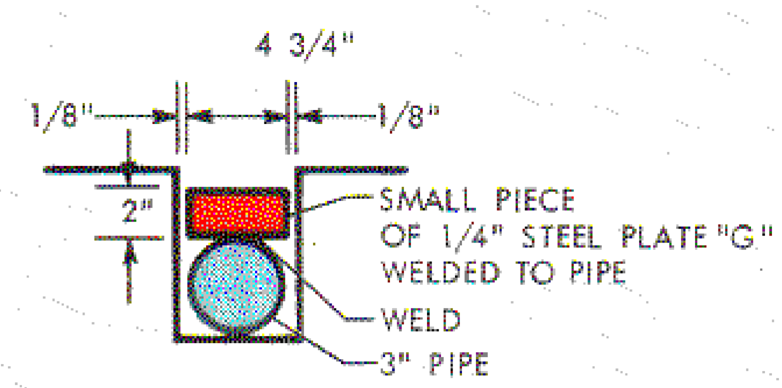




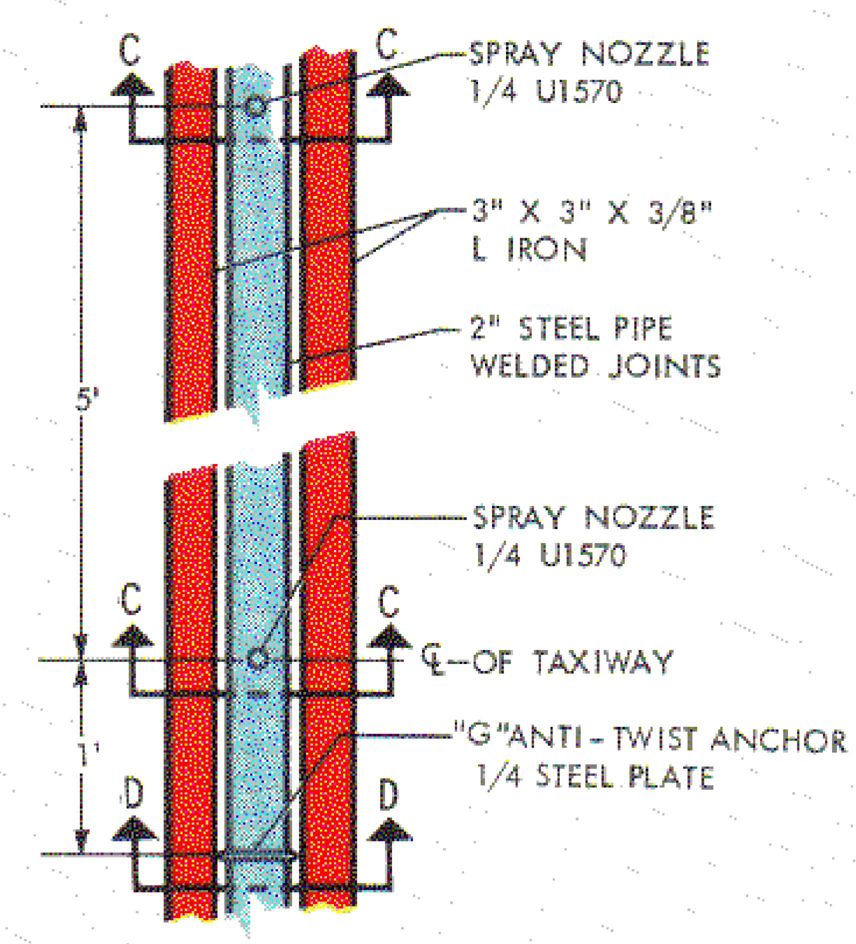
SECTION "C-C"



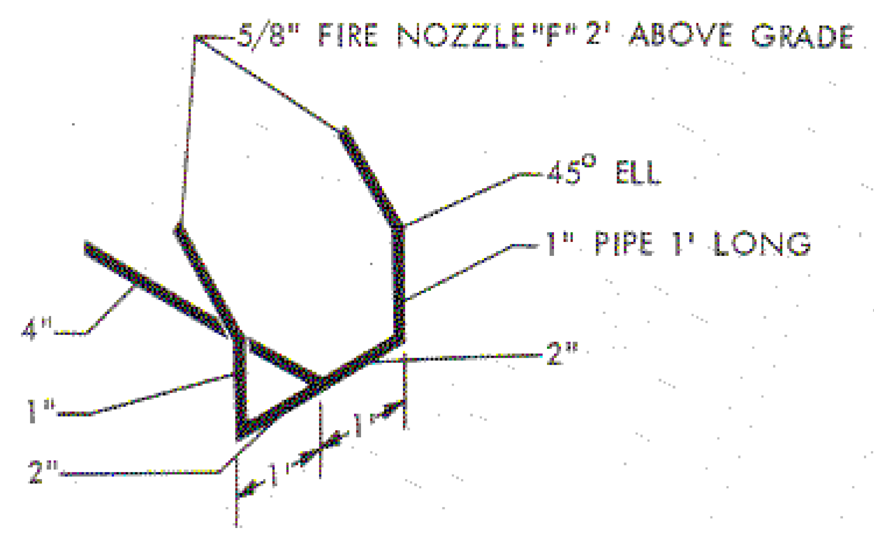
DETAIL "F"



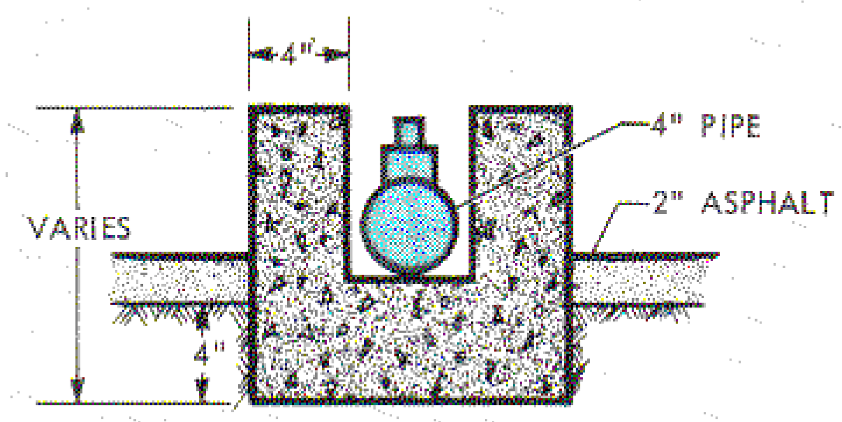
SECTION "D-D"



DETAIL "B"



VIEW A - TAIL WASH

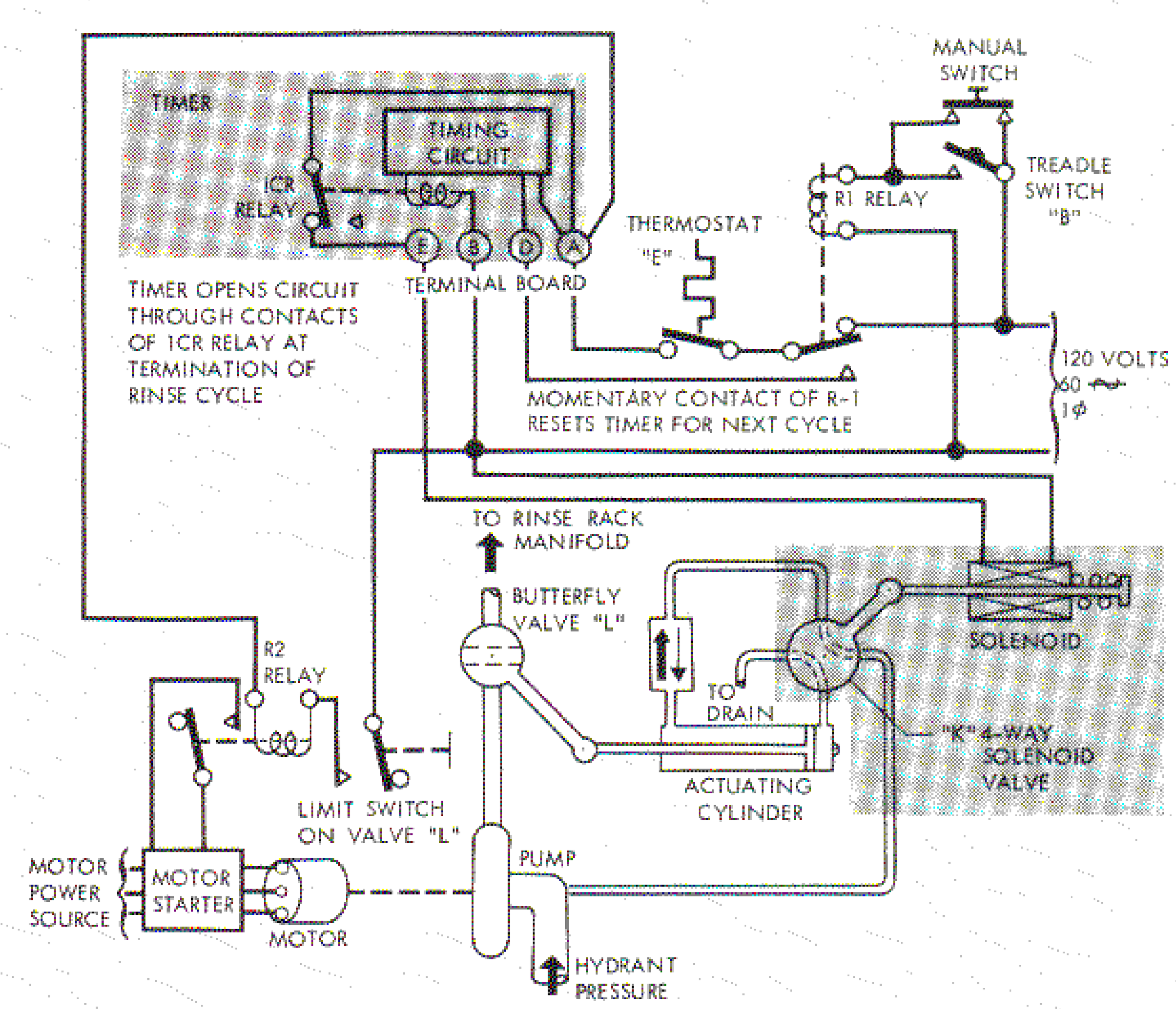


SECTION "E-E"

EQUIPMENT LIST

SYMBOL	NUMBER	DESCRIPTION	PROCURE FROM
A	1	TIMER G.E. 3S7504ET550B6 WITH G.E. 3S7504TM550F1 TIMING DIAL	GENERAL ELECTRIC CO.
B	1	TREADLE CONTROL	STANDARD COMMERCIAL PRODUCT
C	1	WATER PUMP 1000 GPM AT 230 FT. STATIC HEAD WITH 100 HP ELECTRIC MOTOR *	STANDARD COMMERCIAL PRODUCT
D	1	SIZE 4 NEMA 1 MAGNETIC STARTER.	STANDARD COMMERCIAL PRODUCT
E	1	COOLING TYPE THERMOSTAT – RANGE 30° – 50°	STANDARD COMMERCIAL PRODUCT
F	4	5/8" FIRE NOZZLES FOR TAIL WASH	STANDARD COMMERCIAL PRODUCT
G	9	ANTI TWIST ANCHOR 4 3/4" X 2" X 1/4" STEEL PLATE	STANDARD STOCK
H	AS REQUIRED	TAXIWAY LIGHTS AT 40' INTERVALS	STANDARD COMMERCIAL PRODUCT
J	1	SUMP PUMP	STANDARD COMMERCIAL PRODUCT
K	1	4 WAY SOLENOID VALVE NO. 83451 WITH SPEED CONTROL VALVE.	ASCO VALVE CO, FLORHAM PARK, N.J.
L	1	6" BUTTERFLY VALVE WITH 3 1/4" CYLINDER OPERATOR FOR WATER OPERATION.**	STANDARD COMMERCIAL PRODUCT
M	1	6" BUTTERFLY VALVE WITH MANUAL OPERATOR	STANDARD COMMERCIAL PRODUCT
N	62	SPRAY NOZZLES 1/4 U1570	SPRAYING SYSTEMS CO, BELLWOOD, ILL
P	2	PRESSURE GAGE.	STANDARD COMMERCIAL PRODUCT
S	1	LIMIT SWITCH (ON VALVE)	STANDARD COMMERCIAL PRODUCT
	*	PUMP HP WILL VARY. ENGINEER EACH INSTALLATION.	
	**	SIZE OF CYLINDER OPERATOR DEPENDS ON LINE PRESSURE.	

ELECTRICAL CONTROL DIAGRAM



level" flights, only brings up the debatable question of "How high is low level?" Some of the heaviest salt deposits on aircraft stationed at Patuxent River were accumulated while the aircraft were flying at levels of from 3,000 to 5,000 feet in, around, or near storm areas.

Now that the automatic rinse rack has been in use for over a year, the following special techniques have been developed:

1. Trip the "Start" treadle with the nose wheel, then wait until the water system is operating to full capacity.
2. Set the flaps to MANEUVER.
3. Set the inboard engines to NORMAL RPM. This provides a more positive forward thrust to maintain a constant forward motion of the aircraft through the rinse rack.
4. Turn on the windshield wipers to ensure good visibility.
5. Monitor the engine instruments for any sudden or unusual readings.

NOTE:
Aircraft equipped with an auxiliary power unit should shut down the unit and close the APU doors before entering the rinse rack (Procedure at NAS Brunswick).

CONCLUSION Lt. Morris' rain machine is a rinse rack, nothing more or less. Use of a rinse rack does not supplant the ordinary washing requirements for aircraft or engines, nor can it miraculously restore corroded surfaces to their original state. However, prior to installation of the rinse rack it was not uncommon to see an aircraft returning from patrol taxi into the line with the windshield area outside the wiper arc covered with as much as 1/16-inch deposit of salt. Similar deposits could be seen below the engine inlet scoops, at wing fillets, and at various other spots on the aircraft. This sight is no longer evident at the flight line, but the salt deposits are still on the aircraft before they pass through the rinse rack.

As a final testimonial to the rinse rack, its usage has not been limited to P-3 Orions. Other aircraft that have found the rinse rack beneficial are the C-54 support aircraft for the Blue Angels aerobatic team, C-121's, C-130's, C-45's and F-4's. Furthermore, it is not uncommon for transient aircraft to make "passenger stops" at Patuxent River NAS as often as possible to use the rinse rack.

The rinse rack concept has also generated interest at other Naval facilities. An interim rinse rack installation (see Figure 4), built through the efforts of Mr. Sam Webster of NAS Brunswick's Public Works Department, has been in use at that base for some time. Assessment of the rinse rack's worth in their corrosion control program has resulted in Brunswick's submission of plans to BuWeps for funding a permanent rinse rack installation.

On the other coast NAS Alameda has conducted an engineering study for BuWeps to develop an installation for cleaning large patrol and transport aircraft. This installation, presently under construction at NAS Moffett, will serve the twofold purpose of controlling corrosion and assisting in radiological recovery. From preliminary reports, there are several design differences between the NAS Moffett rinse rack installation and the others discussed previously. Among the most significant of these differences is the incorporation of overhead booms and the substitution of two smaller motor-driven pumps for the single larger motor-driven pump. Since rinse rack facilities may be constructed at other Naval Air Stations under Military Construction Programs, interested personnel should contact NAVAIRSYSCOM (formerly BuWeps) for pertinent technical data. ▲▲

Official Photograph, U.S. Navy

Figure 4 Rinse Rack Installation at Brunswick NAS

MLG Wheel Installation

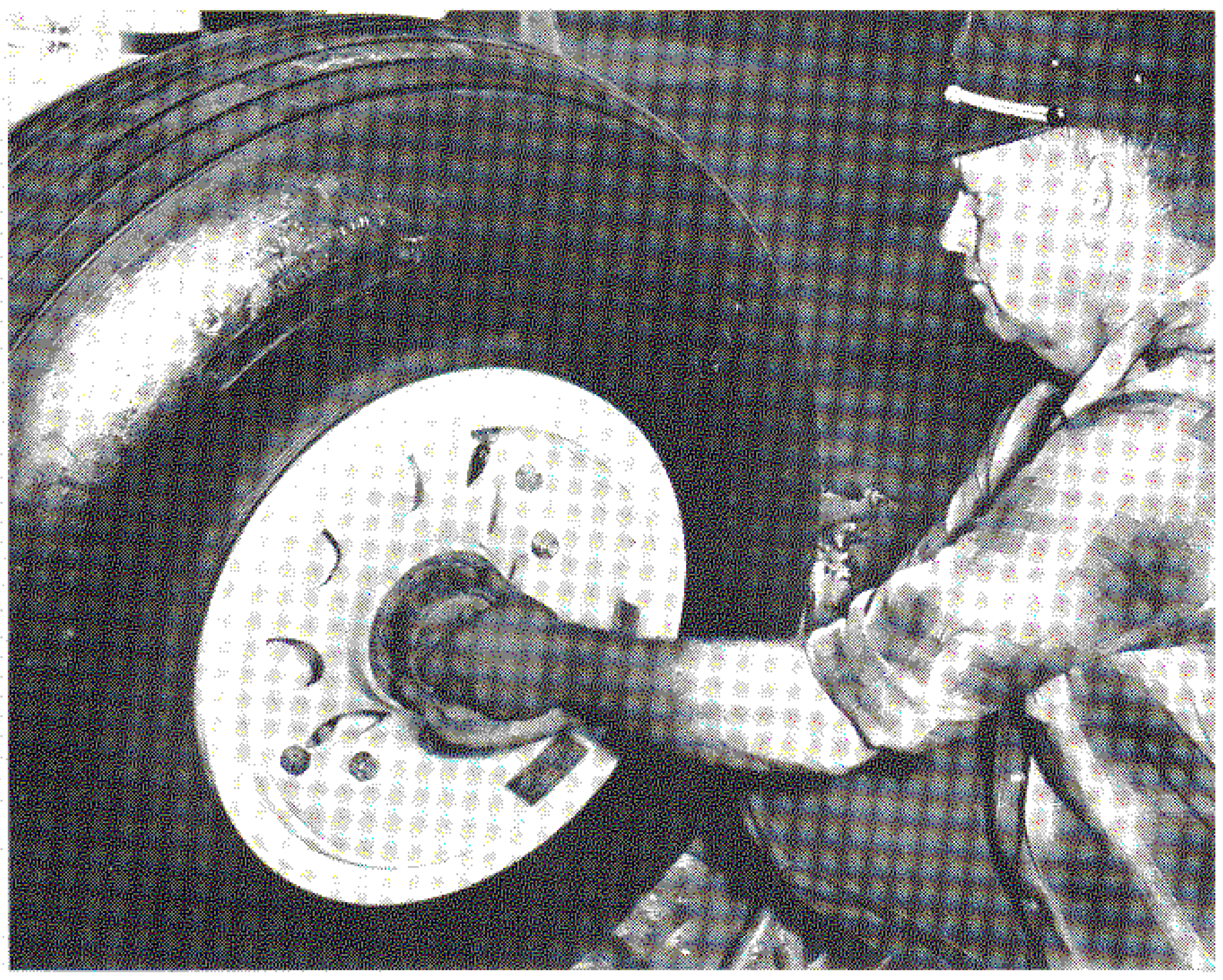


Figure 1 Engage Sleeve Tangs in Axle Slots with "TOP KEY" Index up, Then Hold Sleeve Firmly in Position While Hand-tightening Retainer Nut

Figure 2 After Torqueing Retainer Nut and Bolting it to Sleeve, Use Retainer Nut Wrench to Prove That Nut Cannot be Unscrewed, Then Apply Alternating Torque to Ensure That Tangs Have Full-width Engagement.

RECENTLY, a spate of incidents involving loss of a MLG wheel has occurred. Such incidents are very hazardous, for the remaining wheel is doubly loaded and the cast-off wheel can wreak havoc with the adjacent propellers or, if lost at high speed, it may flatten men and/or equipment anywhere within rolling range of the runway.

These failures are directly attributable to careless and incorrect wheel installation, but the reason such an epidemic should occur is not evident. There has been no history of comparable trouble with this design during eight years of Electra operation and four years of P-3 operation.

Most incidents involve loss of the retainer nut, generally from the LH axle on the strut. This is to be expected, because the normal CCW rotation of the LH wheel tends to loosen the wheel retainer nut if it is not positively locked to the axle.

The internal-wrenching retainer nut is secured by a 2-part lock. A bolt is used to pin the nut to a lock sleeve and the lock sleeve is keyed to slots at the top and bottom of the axle.

The incidents occur because the installer used poor technique in making the sleeve-and-retainer-nut installation. After inserting the sleeve, he should look inside the axle bore to observe that the tangs are positively entered into the axle slots, *then keep the sleeve pressed into position until he has turned the retainer nut down snug on its seat inside the sleeve.*

Starting the retainer nut into the axle bore conceals the tangs from the installer's view*, and if they are mislocated they will be loaded against the end of the axle when the retainer nut is tightened. In this case, the tangs may either be sheared off—leaving the collar (and nut) free to rotate—or they will prevent the sleeve from going into position against the outer bearing—leaving so much end-play that the wheel will batter against the retainer until a failure occurs.

Probably, the retainer was torqued properly, when the cast-off wheels were installed, and certainly every lock-bolt was religiously inserted and secured, but the bolt is useless if the sleeve tangs are not engaged. In fact, it may be worse than useless, for those not acquainted with the P-3 installation may assume that the lock bolt is self-sufficient and conclude that a wheel is properly secured when in fact it is not.

From the evidence at hand, it is glaringly obvious that line personnel are failing to carry out the installation procedure in its entirety. A cautionary note in the MIM procedure requires that after adjusting the retainer nut and installing the lock bolt in it, the installer must *re-engage the retainer nut wrench and demonstrate that it is impossible to turn the nut.* There is no other way to prove the integrity of the installation and it is absolutely mandatory to do so.

If the lock tangs are not mated to the axle slots, it will be possible to unscrew the nut/sleeve assembly. If a partial mismatch exists, the hardened steel corners of the axle slots will have broached away a part of the lock tangs (thus reducing the effective width of the tangs) and an appreciable "slop" will be evident when repeated torque reversals are applied to the retainer nut. ▲▲

**An index notch in the outer sleeve wall, identified "TOP KEY," remains in view. If the sleeve is appreciably misoriented the notch provides visual indication, but a slight mislocation cannot be positively detected by this means.*

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