CHAPTER 1. GENERAL

1. BACKGROUND. Corrosion is the electrochemical deterioration of a metal because of its chemical reaction with the surrounding environment. While new and better materials are continuously being developed, this progress is offset, in part, by a more aggressive operational environment. This problem is compounded by the fact that corrosion is a complex phenomenon. It can take many different forms and the resistance of aircraft materials to corrosion can drastically change with only a small environmental change.

2. CATASTROPHIC CORROSION EVENTS. Corrosion is most often thought of as a slow process of material deterioration, taking place over a significant period of time (examples being general corrosion, pitting, exfoliation, etc.). Other forms of corrosion degradation can occur very quickly, in days or even hours, with catastrophic results. These forms (such as stress corrosion cracking, environmental embrittlement, and corrosion fatigue) depend on both the chemical and mechanical aspects of the environment and can cause catastrophic structural failure without warning.

3. CORROSION CONTROL PROGRAM.

a. The possibility of an in-flight mishap or excessive down time for structural repairs necessitates an active corrosion prevention and control program. The type and aggressiveness of the corrosion prevention and control program depend on the operational environment of the aircraft. Aircraft exposed to salt air, heavy atmospheric industrial pollution, and/or over water operations will require a more stringent corrosion prevention and control program than an aircraft that is operated in a dry environment.

b. In order to prevent corrosion, a constant cycle of cleaning, inspection, operational preservation, and lubrication must be followed. Prompt detection and removal of corrosion will limit the extent of damage to aircraft and aircraft components. The basic philosophy of a corrosion prevention and control program should consist of the following:

(1) Adequately trained personnel in the recognition of corrosion including conditions, detection and identification, cleaning, treating, and preservation;

(2) Thorough knowledge of corrosion identification techniques;

(3) Proper emphasis on the concept of all hands responsibility for corrosion control;

(4) Inspection for corrosion on a scheduled basis;

(5) Aircraft washing at regularly scheduled intervals;

(6) Routine cleaning or wipe down of all exposed unpainted surfaces;

(7) Keeping drain holes and passages open and functional;

(8) Inspection, removal, and reapplication of preservation compounds on a scheduled basis;

(9) Early detection and repair of damaged protective coatings.

(10) Thorough cleaning, lubrication, and preservation at prescribed intervals;

(11) Prompt corrosion treatment after detection;

(12) Accurate record keeping and reporting of material or design deficiencies; and

(13) Use of appropriate materials, equipment, and technical publications.

4.-199. RESERVED

CHAPTER 2. CORROSION THEORY

200. INTRODUCTION. This chapter briefly describes corrosion theory, the causes of corrosion, and the factors which influence its development. The various forms of corrosion and common corrosive agents are also described.

201. BACKGROUND.

a. Corrosion is a natural phenomenon which attacks metal by chemical or electrochemical action and converts it into a metallic compound, such as an oxide, hydroxide, or sulfate. Corrosion is to be distinguished from erosion, which is primarily destruction by mechanical action. The corrosion occurs because of the tendency for metals to return to their natural state. Noble metals, such as gold and platinum, do not corrode since they are chemically uncombined in their natural state. Four conditions must exist before corrosion can occur (see Figure 2-1):

(1) Presence of a metal that will corrode (anode);

(2) Presence of a dissimilar conductive material (cathode) which has less tendency to corrode;

(3) Presence of a conductive liquid (electrolyte); and

(4) Electrical contact between the anode and cathode (usually metal-to-metal contact, or a fastener.

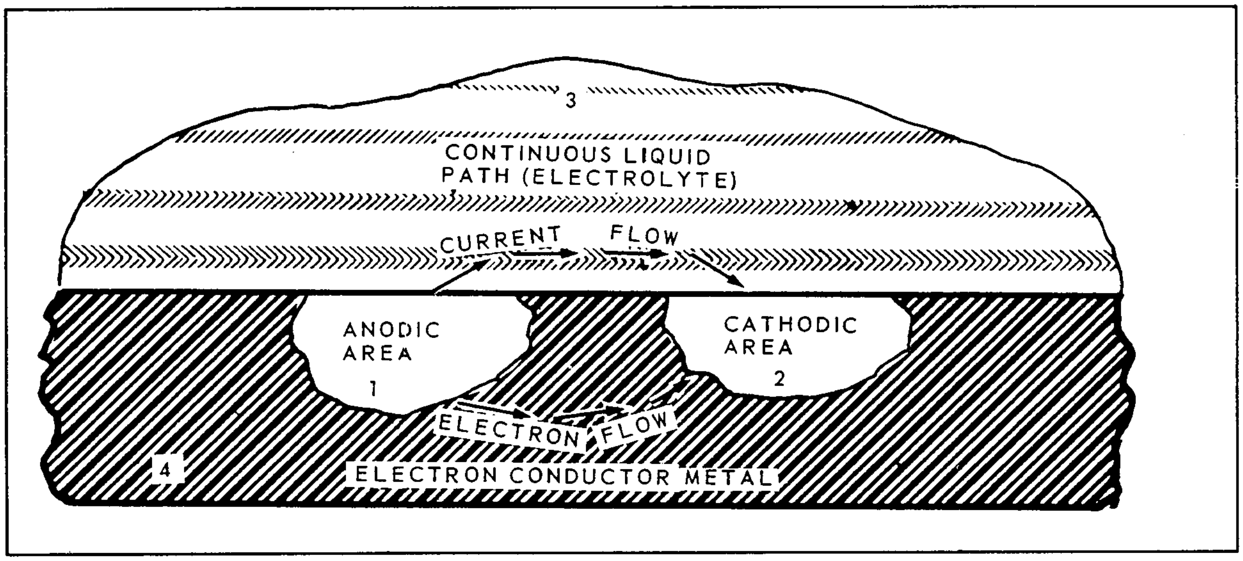

FIGURE 2-1. SIMPLIFIED CORROSION CELL SHOWING CONDITIONS WHICH MUST EXIST FOR ELECTROCHEMICAL CORROSION.

b. Elimination of any one of these conditions will stop corrosion. An example would be a paint film on the metal surface (see Figure 2-2). Some metals (such as stainless steel and titanium), under the right conditions, produce corrosion products that are so tightly bound to the corroding metal that they form an invisible oxide film (called a passive film), which prevents further corrosion. When the film of corrosion products is loose and porous (such as those of aluminum and magnesium), an electrolyte can easily penetrate and continue the corrosion process, producing more extensive damage than surface appearance would show.

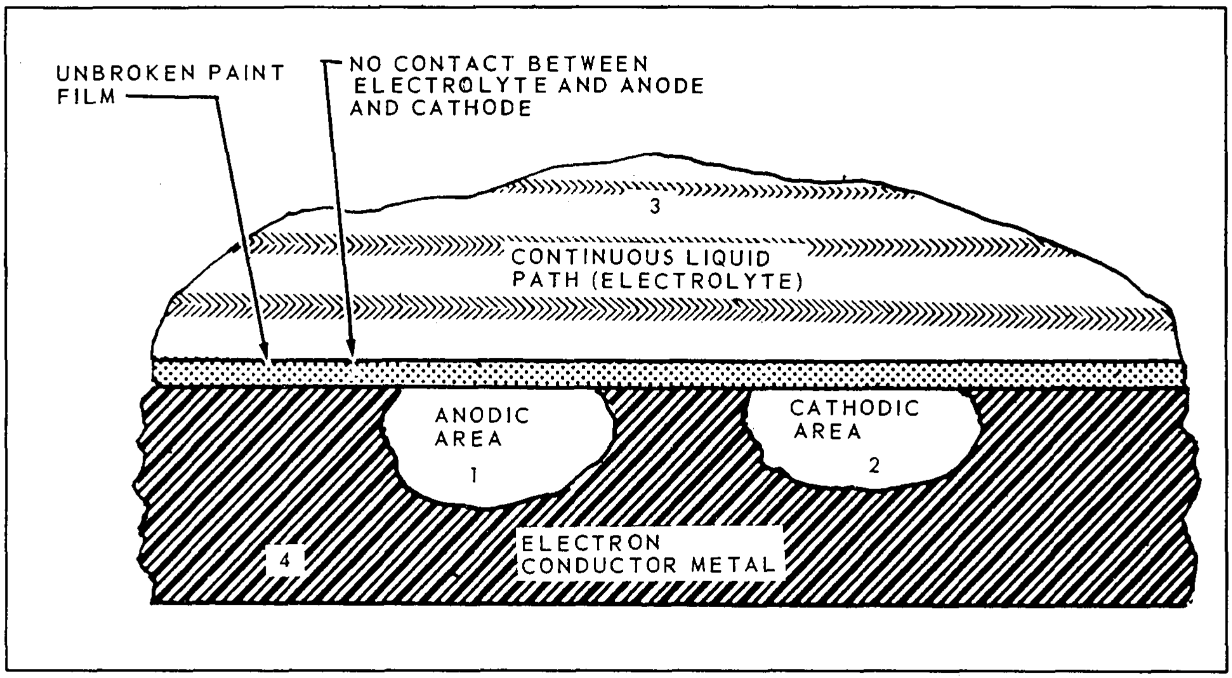

FIGURE 2-2. ELIMINATION OF CORROSION BY APPLICATION OF AN ORGANIC FILM TO METAL SURFACE.

202. DEVELOPMENT OF CORROSION.

a. All corrosive attack begins on the surface of the metal. The corrosion process involves two chemical changes. The metal that is attacked or oxidized undergoes an anodic change, with the corrosive agent being reduced and undergoing a cathodic change. The tendency of most metals to corrode creates one of the major problems in the maintenance of the aircraft, particularly in areas where adverse environmental or weather conditions exist.

b. Paint coatings can mask the initial stages of corrosion. Since corrosion products occupy more volume than the original metal, paint surfaces should be inspected often for irregularities such as blisters, flakes, chips, and lumps.

203. FACTORS INFLUENCING CORROSION.

a. Some factors which influence metal corrosion and the rate of corrosion are the:

(1) Type of metal;

(2) Heat treatment and grain direction;

(3) Presence of a dissimilar, less corrodible metal (galvanic corrosion);

(4) Anode and cathode surface areas (in galvanic corrosion);

(5) Temperature;

(6) Presence of electrolytes (hard water, salt water, battery fluids, etc.);

(7) Availability of oxygen;

(8) Presence of different concentrations of the same electrolyte;

(9) Presence of biological organisms;

(10) Mechanical stress on the corroding metal; and

(11) Time of exposure to a corrosive environment.

b. <u>Most pure metals</u> are not suitable for aircraft construction and are used only in combination with other metals to form alloys. Most alloys are made up entirely of small crystalline regions, called grains. Corrosion can occur on surfaces of those regions which are less resistant and also at boundaries between regions, resulting in the formation of pits and intergranular corrosion. Metals have a wide range of corrosion resistance. The most active metals (those which tend to lose electrons easily), such as magnesium and aluminum, corrode easily. The most noble metals (those which do not lose electrons easily), such as gold and silver, do not corrode easily.

c. <u>Corrosion is accelerated</u> by higher temperature environments which accelerate chemical reactions and allow greater moisture content at saturation in air.

d. <u>Electrolytes</u> (electrically conducting solutions) form on surfaces when condensation, salt spray, rain, or rinse water accumulate. Dirt, salt, acidic gases, and engine exhaust gases can dissolve on wet surfaces, increasing the electrical conductivity of the electrolyte, thereby increasing the rate of corrosion.

e. <u>When some of the electrolyte</u> on a metal surface is partially confined (such as between faying surfaces or in a deep crevice), metal in this confined area corrodes more rapidly than other metal surfaces of the same part outside this area. This type of corrosion is called an oxygen concentration cell. Corrosion occurs more rapidly than would be expected, because the reduced oxygen content of the confined electrolyte causes the adjacent metal to become anodic to other metal surfaces on the same part immersed in electrolyte exposed to the air.

f. Slimes, molds, fungi, and other living organisms (some microscopic) can grow on damp surfaces. Once they are established, the area tends to remain damp, increasing the possibility of corrosion.

g. Manufacturing processes such as machining, forming, welding, or heat treatment can leave stresses in aircraft parts. This residual stress can cause cracking in a corrosive environment when the threshold for stress corrosion is exceeded.

h. Corrosion, in some cases, progresses at the same rate no matter how long the metal has been exposed to the environment. In other cases, corrosion can decrease with time, due to the barrier formed by corrosion products, or increase with time if a barrier to corrosion is being broken down.

204. FORMS OF CORROSION. There are many different types of corrosive attack and these will vary with the metal concerned, corrosive media location, and time exposure. For descriptive purposes, the types are discussed under what is considered the most commonly accepted titles.

a. Uniform Etch Corrosion. Uniform etch corrosion results from a direct chemical attack on a metal surface and involves only the metal surface (see Figure 2-3). On a polished surface, this type of corrosion is first seen as a general dulling of the surface, and if the attack is allowed to continue, the surface becomes rough and possibly frosted in appearance. The discoloration or general dulling of metal created by exposure to elevated temperatures is not to be considered as uniform etch corrosion.

b. Pitting Corrosion. The most common effect of corrosion on aluminum and magnesium alloys is called pitting (see Figure 2-4). It is first noticeable as a white or gray powdery deposit, similar to dust, which blotches the surface. When the deposit is cleaned away, tiny pits or holes can be seen in the surface. Pitting corrosion may also occur in other types of metal alloys. The combination of small active anodes to large passive cathodes causes severe pitting. The principle also applies to metals which have been passivated by chemical treatments, as well as for metals which develop passivation due to environmental condition.

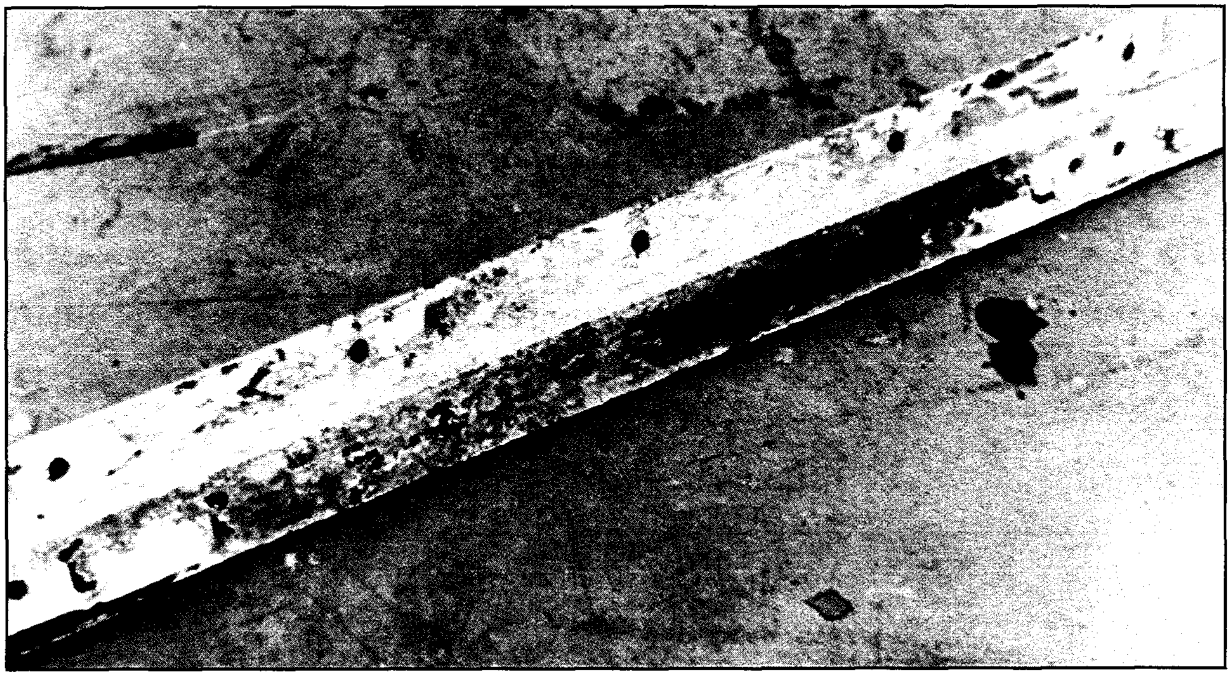

FIGURE 2-3. UNIFORM ETCH CORROSION

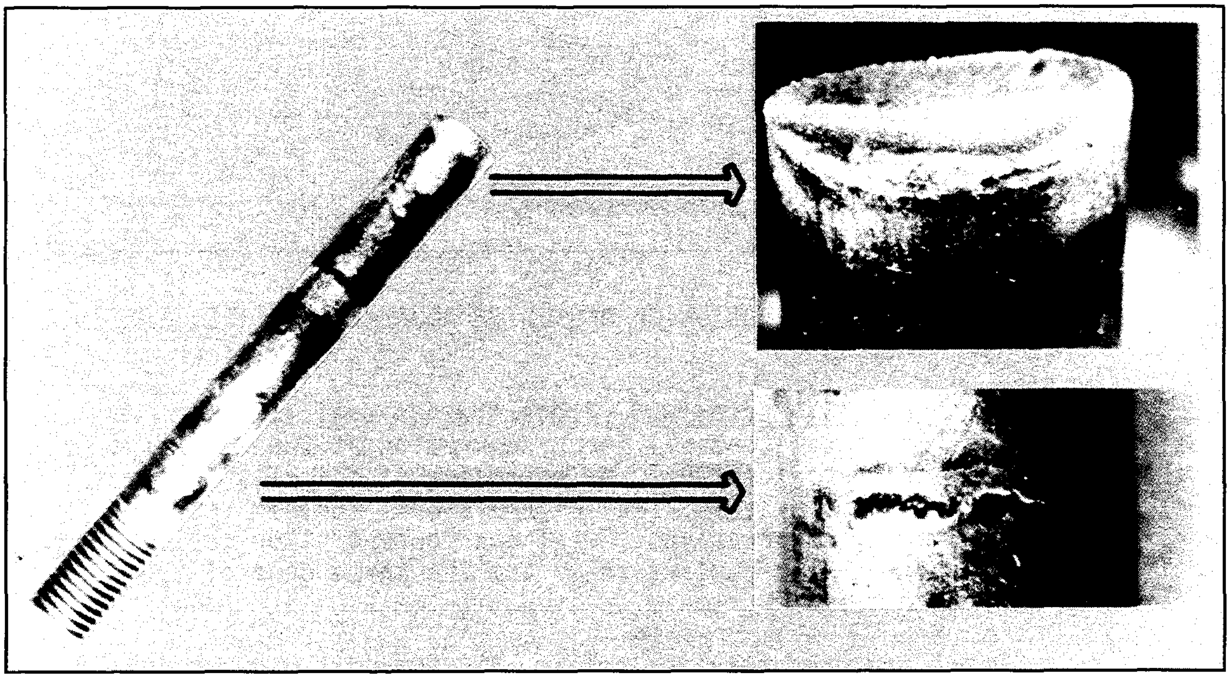

FIGURE 2-4. PITTING CORROSION

c. Galvanic Corrosion. Galvanic corrosion occurs when two dissimilar metals make electrical contact in the presence of an electrolyte (see Figure 2-5). The rate which corrosion occurs depends on the difference in the activities. The greater the difference in activity, the faster corrosion occurs. For example, magnesium would corrode very quickly when coupled with gold in a humid atmosphere, but aluminum would corrode very slowly in contact with cadmium. The rate of galvanic corrosion also depends on the size of the parts in contact. If the surface area of the corroding metal (the anode) is smaller than the surface area of the less active metal (the cathode), corrosion will be rapid and severe. When the corroding metal is larger than the less active metal, corrosion will be slow and superficial. For example, an aluminum fastener in contact with a relatively inert Monel structure may corrode severely, while a Monel bracket secured to a large aluminum member would result in a relatively superficial attack on the aluminum sheet.

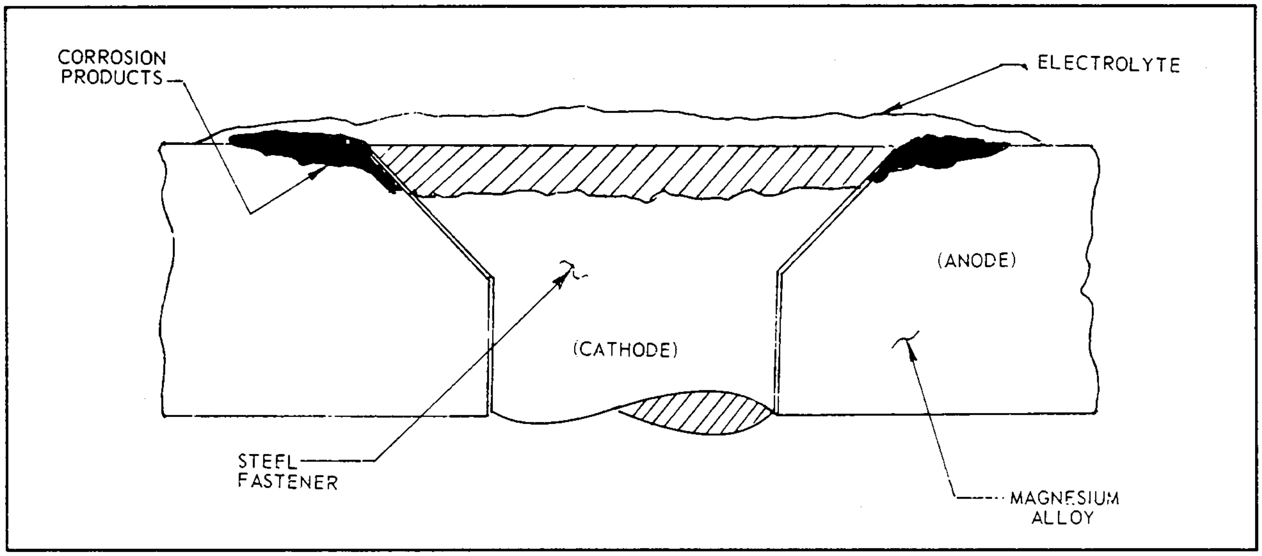

FIGURE 2-5. GALVANIC CORROSION OF MAGNESIUM ADJACENT TO STEEL FASTENER

d. Concentration Cell Corrosion. Concentration cell corrosion is corrosion of metals in a metal-to-metal joint, corrosion at the edge of a joint even though joined metals are identical, or corrosion of a spot on the metal surface covered by a foreign material (see Figure 2-6). Another term for this type of corrosion is crevice corrosion. Metal ion concentration cells, oxygen concentration cells, and active-passive cells are the three general types of concentration cell corrosion.

(1) Metal ion concentration cells. The solution may consist of water and ions of the metal which is in contact with water. A high concentration of the metal ions will normally exist under faying surfaces where

the solution is stagnant, and a low concentration of metal ions will exist adjacent to the crevice which is created by the faying surface. An electrical potential will exist between the two points; the area of the metal in contact with the low concentration of metal ions will be anodic and corrode, and the area in contact with the high metal ions concentration will be cathodic and not show signs of corrosion. Figure 2-6 illustrates metal ion concentration cell corrosion.

(2) Oxygen concentration cells. The solution in contact with the metal surface will normally contain dissolved oxygen. An oxygen cell can develop at any point where the oxygen in the air is not allowed to diffuse into the solution, thereby creating a difference in oxygen concentration between two points. Typical locations of oxygen concentration cells are under either metallic or nonmetallic deposits on the metal surface and under faying surfaces such as riveted lap joints. Oxygen cells can also develop under gaskets, wood, rubber, and other materials in contact with the metal surface. Corrosion will occur at the area of low oxygen concentration (anode) as illustrated in Figure 2-6. Alloys, such as stainless steel, which owe their corrosion resistance to surface passivity, are particularly susceptible to this type of crevice corrosion.

(3) Active-passive cells. Metals which depend on a tightly adhering passive film, usually an oxide for corrosion protection, such as corrosion resistant steel, are prone to rapid corrosive attack by active-passive cells. The corrosive action usually starts as an oxygen concentration cell. As an example, salt deposits on the metal surface in the presence of water containing oxygen can create the oxygen cell. The passive film will be broken beneath the dirt particle. Once the passive film is broken, the active metal beneath the film will be exposed to corrosive attack. An electrical potential will develop between the large area of the cathode (passive film) and the small area of the anode (active metal). Rapid pitting of the active metal will result as shown in Figure 2-6.

e. Intergranular Corrosion. Intergranular corrosion is an attack along the grain boundaries of a material. Each grain has a clearly defined boundary which, from a chemical point of view, differs from the metal within the grain center. The grain boundary and grain center can react with each other as anode and cathode when in contact with an electrolyte. Rapid selective corrosion at the grain boundary can occur with subsequent delamination (see Figure 2-7). High-strength aluminum alloys such as 2014 and 7075 are more susceptible to intergranular corrosion if they have been improperly heat-treated and are then exposed to a corrosive environment.

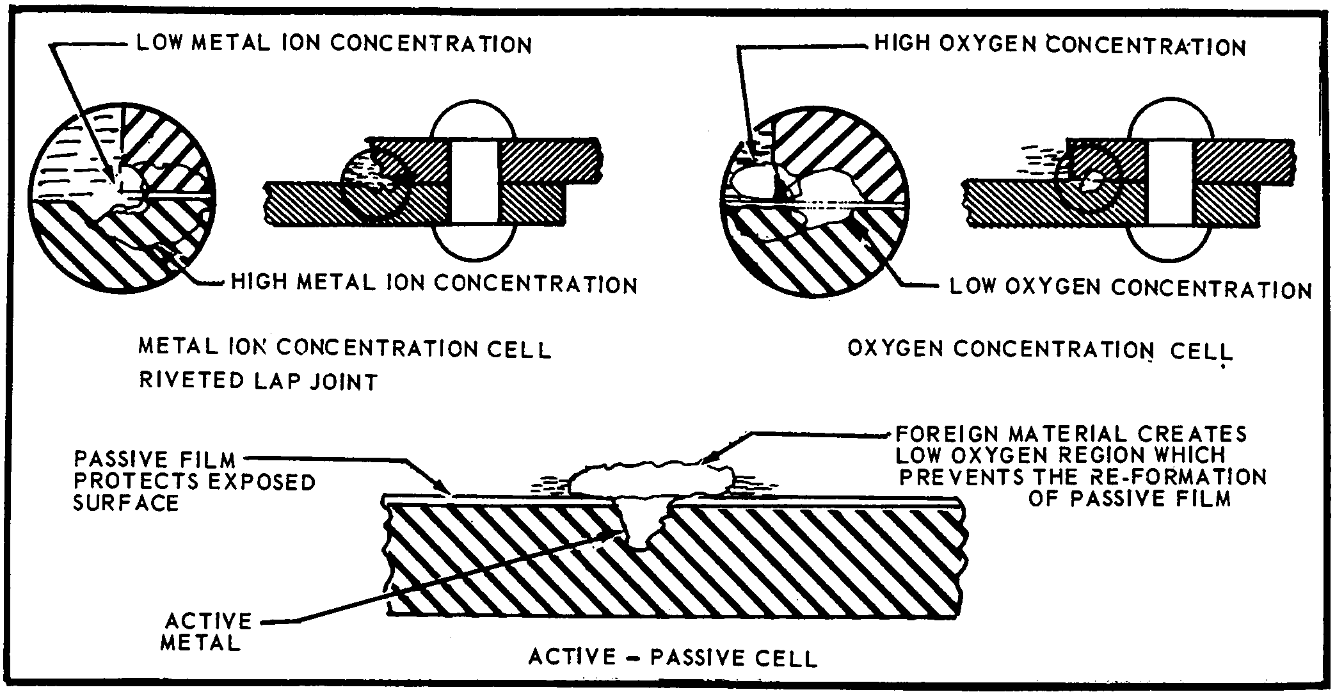

FIGURE 2-6. CONCENTRATION CELL CORROSION

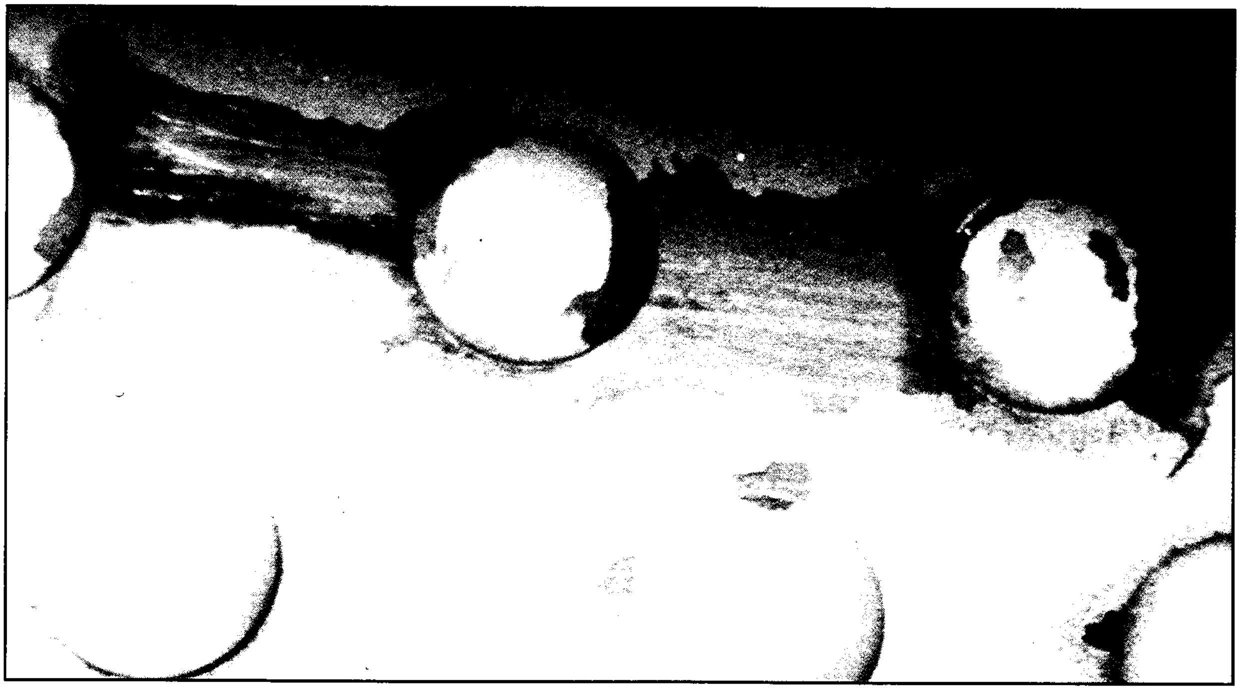

FIGURE 2-7. INTERGRANULAR CRACKING AND CORROSION ON A WING SPAR CHORD

f. Exfoliation Corrosion. Exfoliation corrosion is an advanced form of intergranular corrosion where the surface grains of a metal are lifted up by the force of expanding corrosion products occurring at the grain boundaries just below the surface. The lifting up or swelling is visible evidence of exfoliation corrosion (see Figures 2-8 and 2-9). Exfoliation is most prone to occur in wrought products such as extrusions, thick sheet, thin plate and certain die-forged shapes which have a thin, highly elongated platelet type grain structure. This is in contrast with other wrought products and cast products that tend to have an equiaxed grain structure.

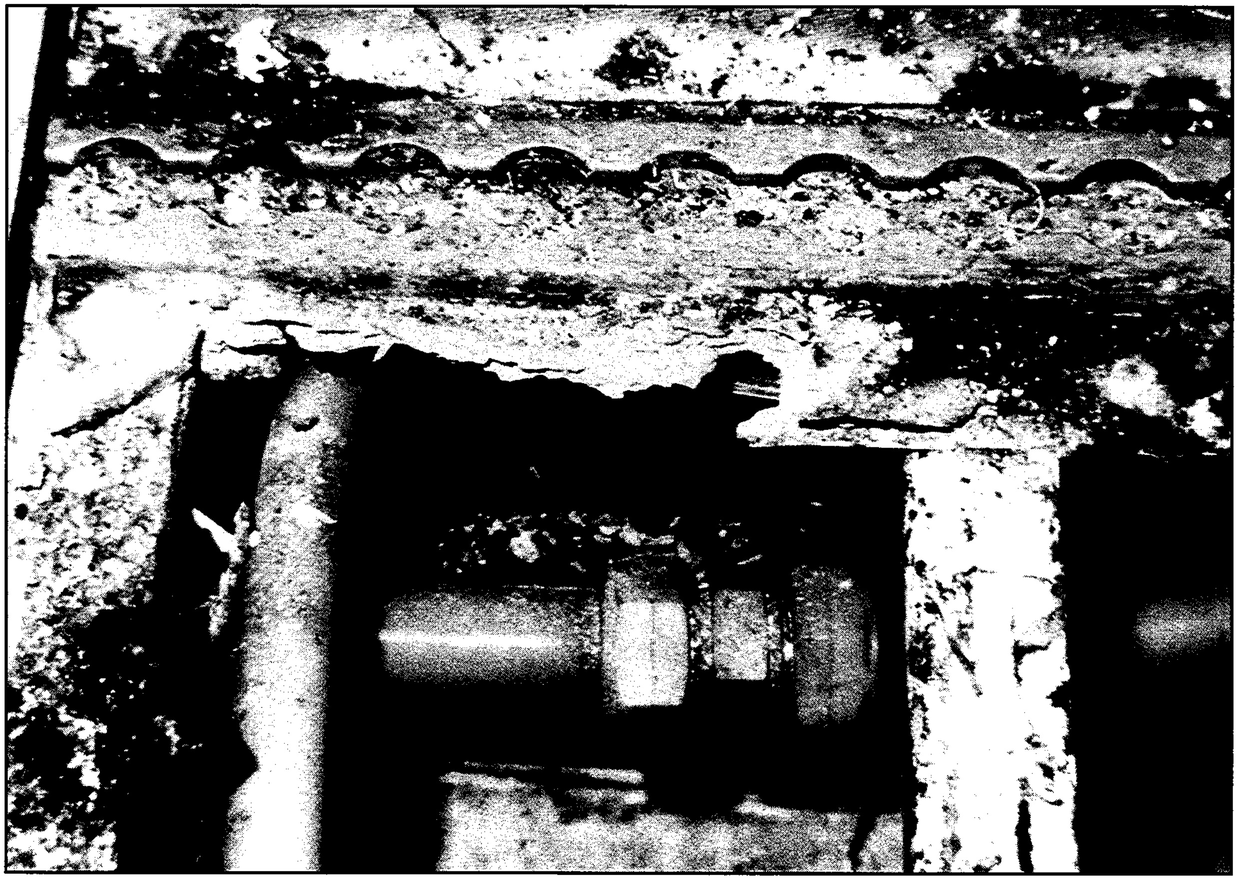

FIGURE 2-8. SEVERE EXFOLIATION CORROSION OF A SEAT TRACK

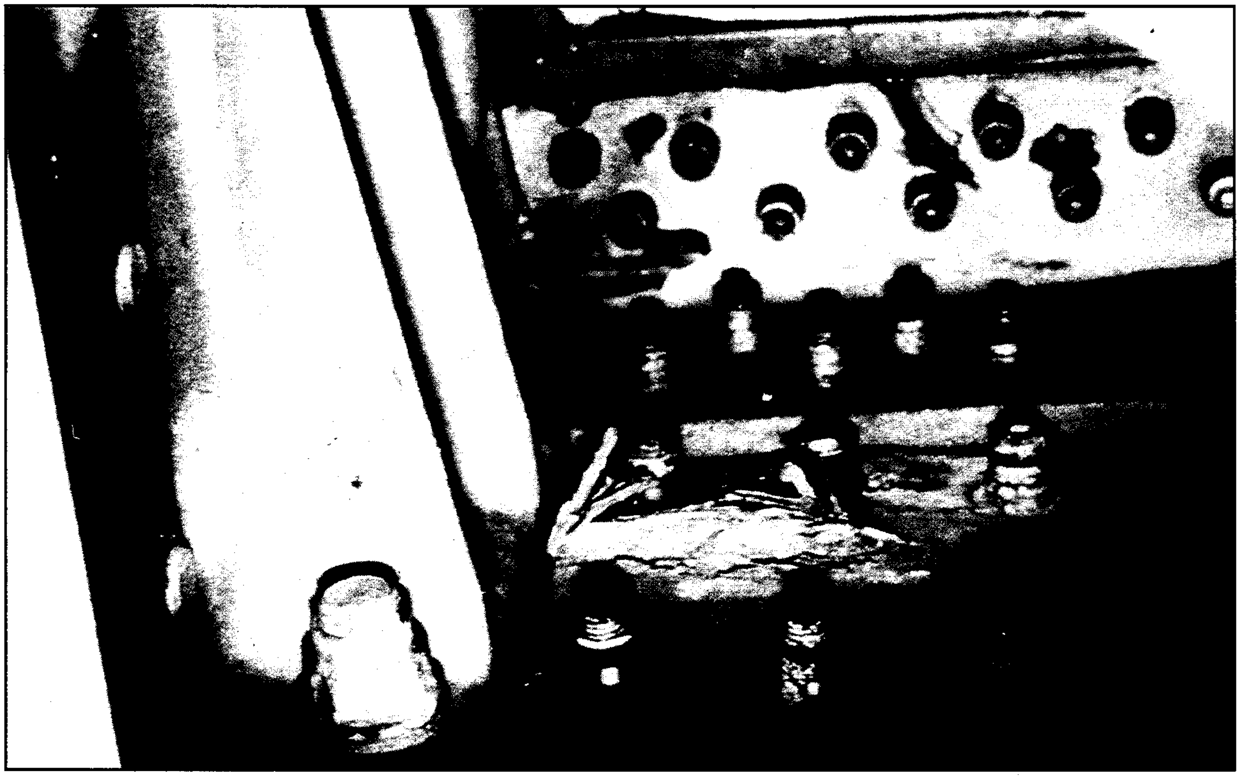

FIGURE 2-9. SEVERE EXFOLIATION CORROSION

g. Filiform Corrosion. Filiform corrosion is a special form of oxygen concentration cell corrosion or crevice corrosion which occurs on metal surfaces having an organic coating system. It is recognized by its characteristic worm-like trace of corrosion products beneath the paint film (see Figures 2-10 and 2-11). Filiform occurs when the relative humidity of the air is between 78 and 90 percent and the surface is slightly acidic. Corrosion starts at breaks in the coating system and proceeds underneath the coating due to the diffusion of water vapor and oxygen from the air through the coating. Filiform corrosion can attack steel and aluminum surfaces. The traces never cross on steel, but they will cross under one another on aluminum which makes the damage deeper and more severe for aluminum. If filiform corrosion is not removed and the area treated and a protective finish applied, the corrosion can lead to intergranular corrosion, especially around fasteners and at seams. Filiform corrosion can be removed using glass bead blasting material with portable abrasive blasting equipment and/or mechanical means such as buffing or sanding. Filiform corrosion can be prevented by storing aircraft in an environment with a relative humidity below 70 percent, using coating systems having a low rate of diffusion for oxygen and water vapors, and by washing aircraft to remove acidic contaminants from the surface, such as those created by pollutants in the air.

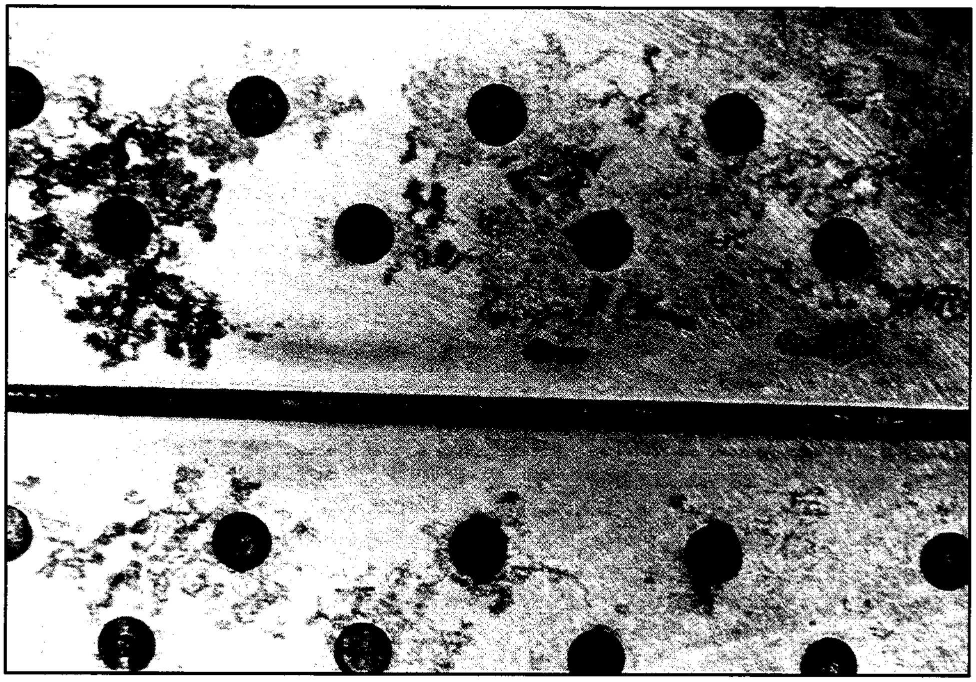

FIGURE 2-10. FILIFORM CORROSION

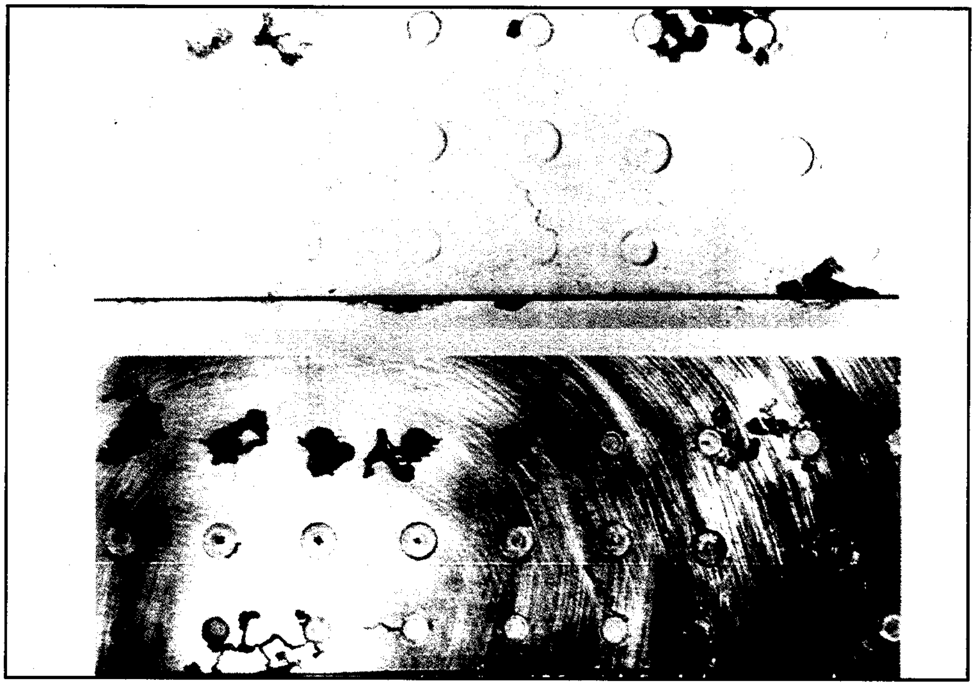

FIGURE 2-11. FILIFORM CORROSION BEFORE AND AFTER PAINT REMOVAL

205. CORROSION AND MECHANICAL FACTORS. Corrosive attack is often aggravated by mechanical factors that are either within the part (residual) or applied to the part (cyclic service loads). Erosion by sand and/or rain and mechanical wear will remove surface protective films and contribute to corrosive attack of underlying metal surfaces. Corrosive attack that is aided by some mechanical factor usually causes the part to degenerate at an accelerated rate compared to the rate at which the same part would deteriorate if it were subjected solely to corrosive attack. Environmental conditions and the composition of the alloy also influence the extent of attack. Examples of this kind of alliance are stress-corrosion cracking, corrosion fatigue, and fretting corrosion.

a. Stress-Corrosion Cracking. Stress-corrosion cracking is an intergranular cracking of the metal which is caused by a combination of stress and corrosion (see Figures 2-12 through 2-14). Stress may be caused by internal or external loading. Internal stresses are produced by nonuniform deformation during cold working, by unequal cooling from high temperatures, and by internal structural rearrangement involving volume changes. Internal stresses are induced when a piece of structure is deformed during an assembly operation, (i.e., during pressing in bushings, shrinking a part for press fit, installing interference bolts, installing rivets, etc.). Concealed stress is more important than design stress, because stress-corrosion is difficult to recognize before it has overcome the design safety factor. The level of stress varies from point to point within the metal. Stresses near the yield strength are generally necessary to promote stress-corrosion cracking, but failures may occur at lower stresses. Specific environments have been identified which cause stress-corrosion cracking of certain alloys. Salt solutions and seawater may cause stress-corrosion cracking of high strength heat-treated steel and aluminum alloys. Methyl alcohol-hydrochloric acid solutions will cause stress-corrosion cracking of some titanium alloys. Magnesium alloys may stress-corrode in moist air. Stress-corrosion may be reduced by applying protective coatings, stress relief heat treatment, using corrosion inhibitors, or controlling the environment. Shot peening a metal surface increases resistance to stress-corrosion cracking by creating compressive stresses on the surface which should be overcome by applied tensile stress before the surface sees any tension load. Therefore, the threshold stress level is increased.

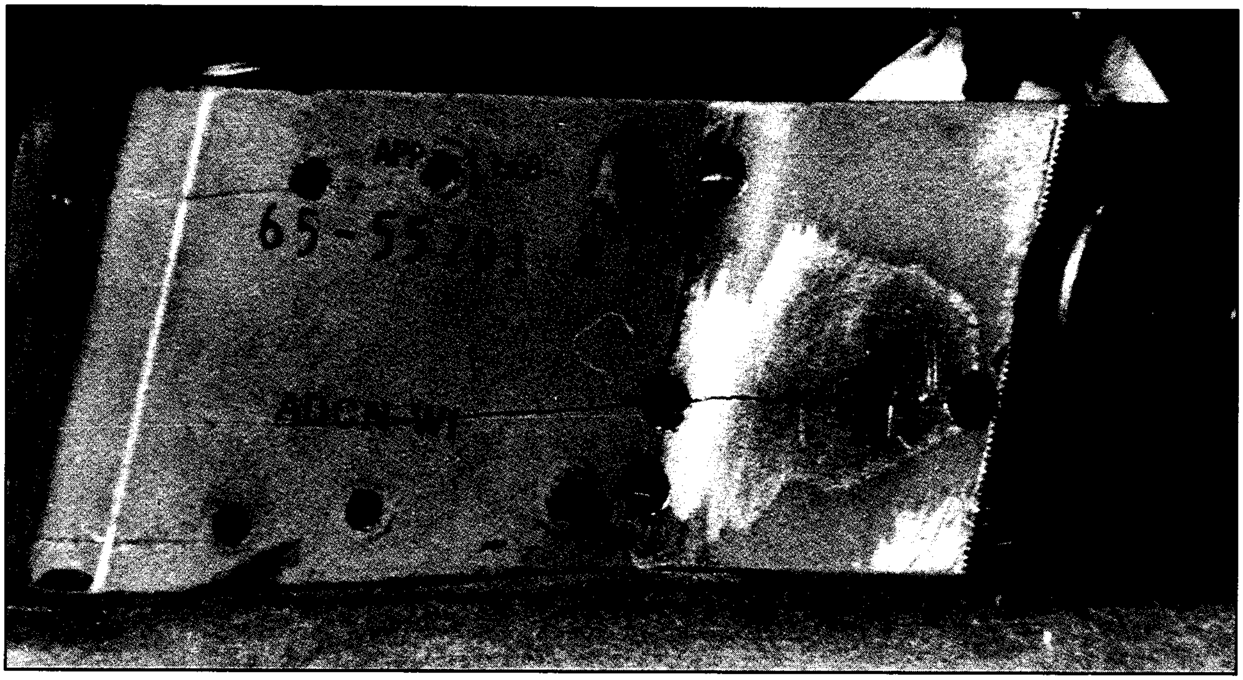

FIGURE 2-12. STRESS-CORROSION CRACKING OF 7079-T6 FITTING

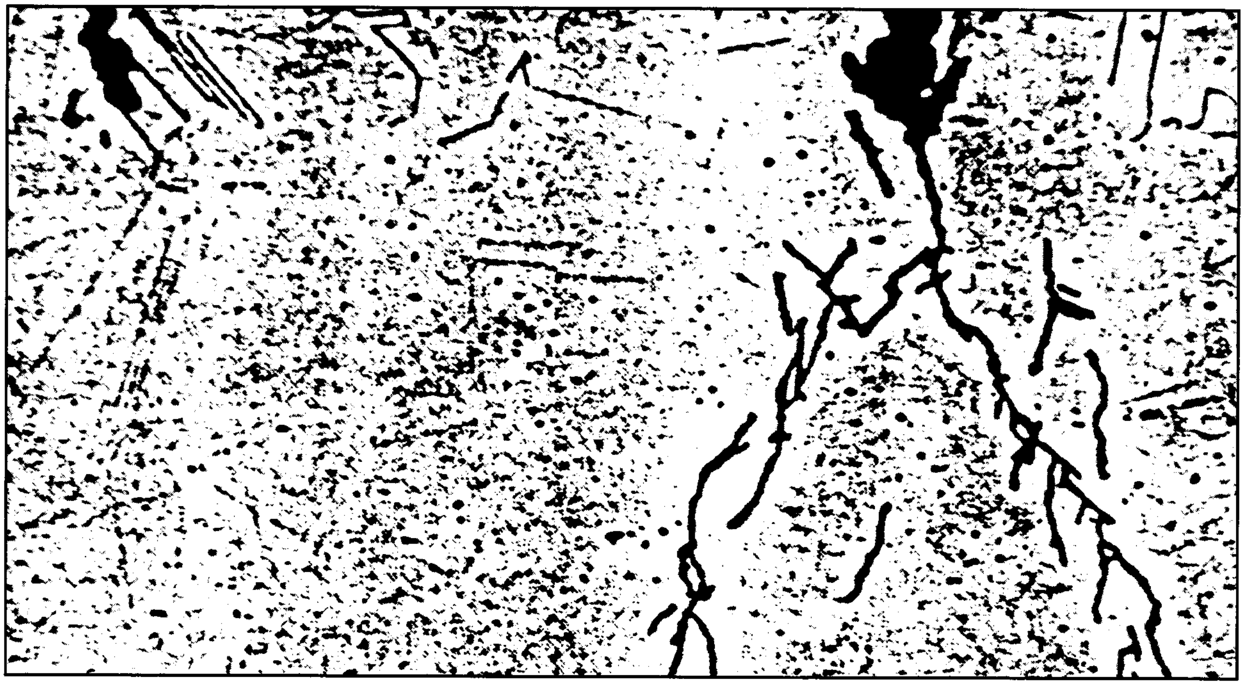

FIGURE 2-13. STRESS-CORROSION CRACKING STARTING AT A PIT IN CRES MATERIAL

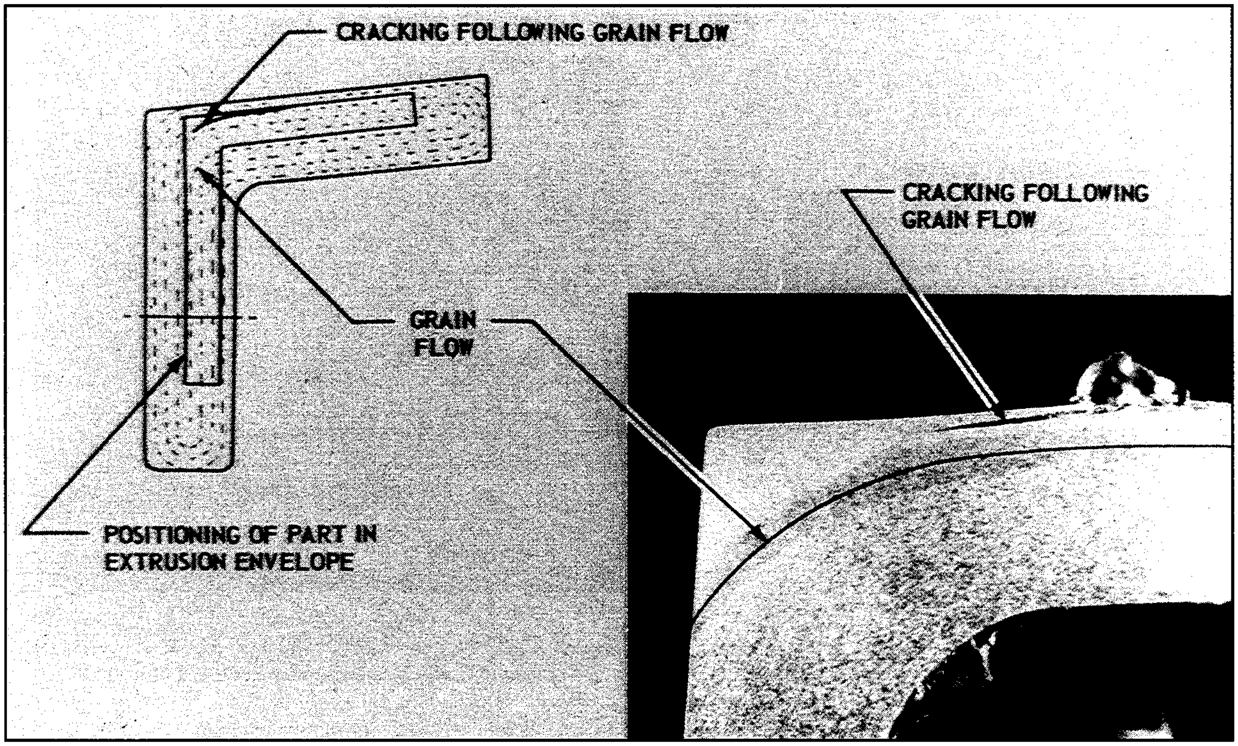

FIGURE 2-14. STRESS-CORROSION CRACKING OF AN EXTRUDED SECTION

b. Corrosion Fatigue. Corrosion fatigue is caused by the combined effects of cyclic stress and corrosion. No metal is immune to some reduction in its resistance to cyclic stressing if the metal is in a corrosive environment. Damage from corrosion fatigue is greater than the sum of the damage from both cyclic stresses and corrosion. Corrosion fatigue failure occurs in two stages. During the first stage, the combined action of corrosion and cyclic stress damages the metal by pitting and crack formation to such a degree that fracture by cyclic stressing will ultimately occur, even if the corrosive environment is completely removed. The second stage is essentially a fatigue stage in which failure proceeds by propagation of the crack (often from a corrosion pit or pits) and is controlled primarily by stress concentration effects and the physical properties of the metal. Fracture of a metal part, due to fatigue corrosion, generally occurs at a stress level far below the fatigue limit in laboratory air, even though the amount of corrosion is relatively small. For this reason, protection of all parts subject to alternating stress is particularly important, even in environments that are only mildly corrosive.

c. Fretting Corrosion. Damage can occur at the interface of two highly loaded surfaces which are not supposed to move against each other. However, vibration may cause the surfaces to rub together resulting in an abrasive wear known as fretting. The protective film on the metallic surfaces is removed by the rubbing action. The continued rubbing of the two surfaces prevents formation of protective oxide film and exposes fresh active metal to the atmosphere. Fretting can cause severe pitting (see Figure 2-15). Dampening of vibration, tightening of joints, application of a lubricant, or installation of a fretting resistant material between the two surfaces can reduce fretting corrosion.

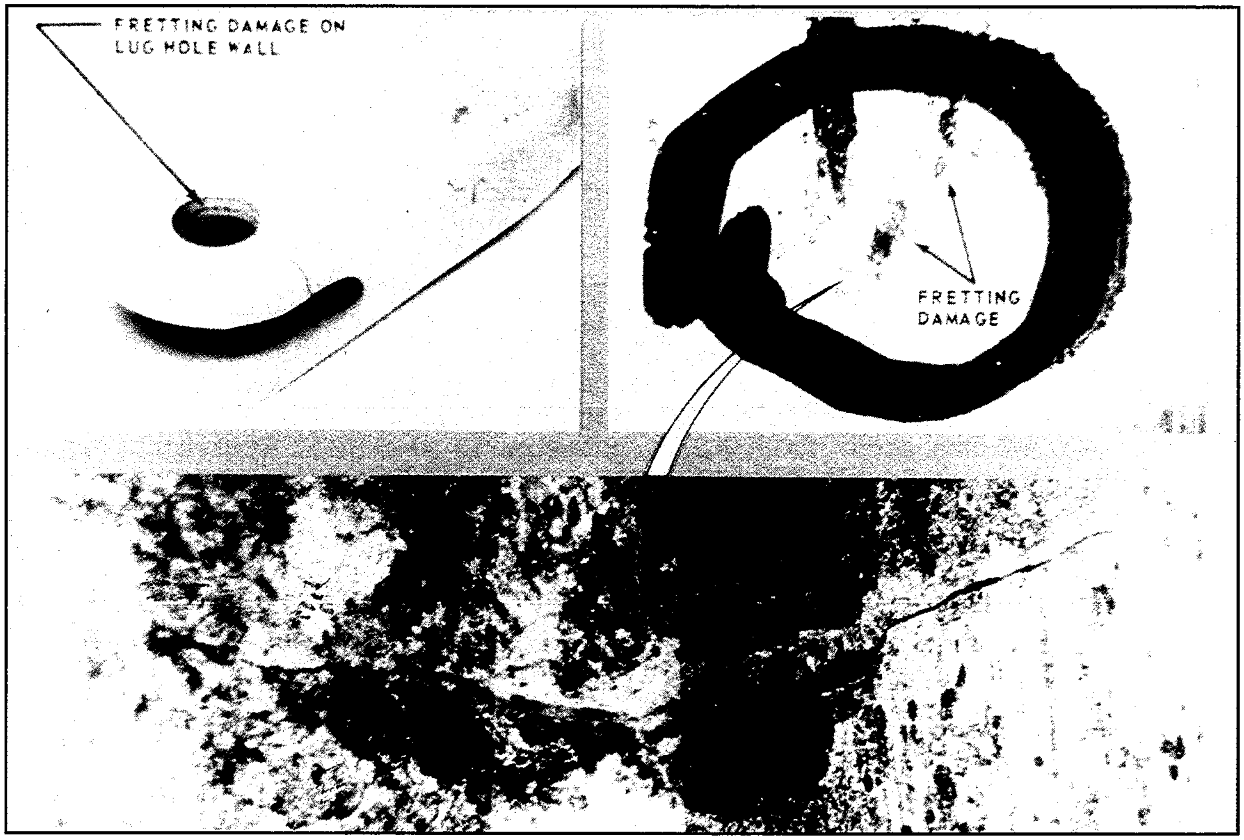

FIGURE 2-15. FRETTING CORROSION AND CRACKING FROM CYCLIC LOADING OF LUG

d. Heat Treatment. Heat treatment of airframe materials should be rigidly controlled to maintain their corrosion resistance as well as to improve their essential mechanical properties. For example, improper heat treatment of clad aluminum alloy may cause the cladding to incur excessive diffusion because the solution heat treatment is too long or at too high a temperature. This degrades the inherent resistance of the cladding itself, and reduces its ability to provide protection to the core aluminum alloy. Aluminum alloys which contain appreciable amounts of copper and zinc are highly vulnerable to intergranular corrosion attack if not quenched rapidly during heat treatment or other special treatment. Stainless steel alloys are susceptible to carbide sensitization when slowly cooled after welding or high temperature heat treatment. Post-weld heat treatments are normally advisable for reduction of residual stress.

e. Hydrogen Embrittlement.

(1) Environmentally induced failure processes may often be the result of hydrogen damage rather than oxidation. Atomic hydrogen is a cathodic

product of many electrochemical reactions, forming during naturally occurring corrosion reactions as well as during many plating or pickling processes. Whether hydrogen is liberated as a gas, or atomic hydrogen is absorbed by the metal, depends on the surface chemistry of the metal.

(2) Atomic hydrogen, due to its small size and mass, has very high diffusivity in most metals. It will therefore penetrate most clean metal surfaces easily and migrate rapidly to favorable sites where it may remain in solution, precipitate as molecular hydrogen to form small pressurized cavities, cracks or large blisters, or it may react with the base metal or with alloying elements to form hydrides.

(3) The accumulation of hydrogen in high strength alloys often leads to cracking, and this often occurs in statically loaded components several hours or even days after the initial application of the load or exposure to the source of hydrogen. Cracking of this type is often referred to as hydrogen stress cracking, hydrogen delayed cracking, or hydrogen induced cracking. Similar fracture processes can occur in new and unused parts when heat treatments or machining have left residual stresses in the parts, and have then been exposed to a source of hydrogen. For this reason, all processes such as pickling or electroplating must be carried out under well controlled conditions to minimize the amount of hydrogen generated.

206. COMMON CORROSIVE AGENTS. Substances that cause corrosion of metals are called corrosive agents. The most common corrosive agents are acids, alkalies, and salts. The atmosphere and water, the two most common media for these agents, may act as corrosive agents too.

a. Acids. In general, moderately strong acids will severely corrode most of the alloys used in airframes. The most destructive are sulfuric acid (battery acid), halogen acids (i.e., hydrochloric, hydrofluoric, and hydrobromic), nitrous oxide compounds, and organic acids found in the wastes of humans and animals.

b. Alkalies. Although alkalies, as a group, are generally not as corrosive as acids, aluminum and magnesium alloys are exceedingly prone to corrosive attack by many alkaline solutions unless the solutions contain a corrosion inhibitor. Particularly corrosive to aluminum are washing soda, potash (wood ashes), and lime (cement dust). Ammonia, an alkali, is an exception because aluminum alloys are highly resistant to it.

c. Salts. Most salt solutions are good electrolytes and can promote corrosive attack. Some stainless steel alloys are resistant to attack by salt solutions but aluminum alloys, magnesium alloys, and other steels are extremely vulnerable. Exposure of airframe materials to salts or their solutions is extremely undesirable.

d. The Atmosphere. The major atmospheric corrosive agents are oxygen and airborne moisture, both of which are in abundant supply. Corrosion often results from the direct action of atmospheric oxygen and moisture on metal, and the presence of additional moisture often accelerates corrosive attack, particularly on ferrous alloys. However, the atmosphere may also contain other corrosive gases and contaminants, particularly industrial and marine environments, which are unusually corrosive.

(1) Industrial atmospheres contain many contaminants, the most common of which are partially oxidized sulfur compounds. When these sulfur compounds combine with moisture, they form sulfur-based acids that are highly corrosive to most metals. In areas where there are chemical industrial plants, other corrosive atmospheric contaminants may be present in large quantities, but such conditions are usually confined to a specific locality.

(2) Marine atmospheres contain chlorides in the form of salt particles or droplets of salt-saturated water. Since salt solutions are electrolytes, they corrosively attack aluminum and magnesium alloys which are vulnerable to this type of environment.

e. Water. The corrosivity of water will depend on the type and quantity of dissolved mineral and organic impurities and dissolved gasses (particularly oxygen) in the water. One characteristic of water which determines its corrosivity is the conductivity or its ability to act as an electrolyte and conduct a current. Physical factors, such as water temperature and velocity, also have a direct bearing on the corrosivity.

(1) The most corrosive of natural waters (sea and fresh waters) are those that contain salts. Water in the open sea is extremely corrosive due to the presence of chloride ions, but waters in harbors are often even more so because they are contaminated by industrial waste.

(2) The corrosive effects of fresh water varies from locality to locality due to the wide variety of dissolved impurities that may be present in any particular area. Some municipal waters (potable water) to which chlorine and fluorides have been added can be quite corrosive. Commercially softened water and industrially polluted rain water are usually considered to be very corrosive.

207. MICRO-ORGANISMS.

a. Microbial attack includes actions of bacteria, fungi, or molds. Micro-organisms occur nearly everywhere. Those organisms causing the greatest corrosion problems are bacteria and fungi.

b. Bacteria may be either aerobic or anaerobic. Aerobic bacteria require oxygen to live. They accelerate corrosion by oxidizing sulfur to produce sulfuric acid. Bacteria living adjacent to metals may promote corrosion by depleting the oxygen supply or by releasing metabolic products. Anaerobic bacteria, on the other hand, can survive only when free oxygen is not present. The metabolism of these bacteria requires them to obtain part of their sustenance by oxidizing inorganic compounds, such as iron, sulfur, hydrogen, and carbon monoxide. The resultant chemical reactions cause corrosion.

c. Fungi are the growths of micro-organisms that feed on organic materials. While low humidity does not kill microbes, it slows their growth and may prevent corrosion damage. Ideal growth conditions for most micro-organisms are temperatures between 68 and 104 °F (20 and 40 °C) and relative humidity between 85 and 100 percent. It was formerly thought that fungal attack could be prevented by applying moisture-proofing coatings to nutrient materials or by drying the interiors of compartments with desiccants. However, some moisture-proofing coatings are attacked by mold, bacteria, or other microbes, especially if the surfaces on which they are used are contaminated. Microbial growth occurs at the interface of water and fuel, where the fungus feeds on fuel. Organic acids, alcohols, and esters are produced by growth of the fungus. These by-products provide even better growing conditions for the fungus. The fungus typically attaches itself to the bottom of the tank and looks like a brown deposit on the tank coating when the tank is dry. The fungus growth may start again when water and fuel are present.

d. The spore form of some micro-organisms can remain dormant for long periods while dry, and can become active when moisture is available. When desiccants become saturated and unable to absorb moisture passing into the affected area, micro-organisms can begin to grow. Dirt, dust, and other airborne contaminants are the least recognized contributors to microbial attack. Unnoticed, small amounts of airborne debris may be sufficient to promote fungal growth.

e. Fungi nutrients have been considered to be only those materials that have been derived from plants or animals. Thus, wool, cotton, rope, feathers, and leather were known to provide sustenance for microbes, while metals and minerals were not considered fungi nutrients. To a large extent this rule of thumb is still valid, but the increasing complexity of synthetic materials makes it difficult or impossible to determine from the name alone whether a material will support fungus. Many otherwise resistant synthetics are rendered susceptible to fungal attack by the addition of chemicals to change the material's properties.

f. Damage resulting from microbial growth can occur when any of three basic mechanisms, or a combination of these, is brought into play. First, fungi are damp and have a tendency to hold moisture, which contributes to other forms of corrosion. Second, because fungi are living organisms, they need food to survive. This food is obtained from the material on which the fungi are growing. Third, these micro-organisms secrete corrosive fluids that attack many materials, including some that are not fungi nutrient.

g. Microbial growth must be removed completely to avoid corrosion. Microbial growth should be removed by hand with a firm nonmetallic bristle brush and water. Removal of microbial growth is easier if the growth is kept wet with water. Microbial growth may also be removed with steam at 100 psi and steam temperatures not exceeding 150 °F (66 °C). Protective clothing must be used when using steam for removing microbial growth.

208. METALLIC MERCURY CORROSION ON ALUMINUM ALLOYS. Spilled mercury on aluminum should be cleaned immediately because mercury causes corrosion attack which is rapid in both pitting and intergranular attack and is very difficult to control. The most devastating effect of mercury spillage on aluminum alloys is the formation of an almagem which proceeds rapidly along grain boundaries, causing liquid metal embrittlement. If the aluminum alloy part is under tension stress, this embrittlement will result in splitting with an appearance similar to severe exfoliation. X-ray inspection may be an effective method of locating the small particles of spilled mercury because the dense mercury will show up readily on the x-ray film.

209.-299. RESERVED.