Loss of nosewheel on Ryanair Boeing 737-204 at Dublin Airport, Ireland, on December 3, 2000.

Micro-summary: **This Boeing 737 lost a nose wheel and tire while entering the runway.**

Event Date: **2000-12-03 at 1030 UTC**

Investigative Body: **Air Accident Investigation Unit (AAIU), Ireland**

Investigative Body's Web Site: **http://www.aaiu.ie/**

Cautions:

1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).

2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***

3. Reports may or may not represent reality. Many many non-scientific factors go into an investigation, including the magnitude of the event, the experience of the investigator, the political climate, relationship with the regulatory authority, technological and recovery capabilities, etc. It is recommended that the reader review all reports analytically. Even a "bad" report can be a very useful launching point for learning.

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FINAL REPORT

AAIU Report No: 2003-006
AAIU File No: 2000/0063
Published: 2 May 2003

Operator:	Ryanair
Manufacturer:	Boeing
Model:	737-204
Nationality:	Ireland
Registration:	EI-CJH
Location:	Dublin Airport
Date/Time (UTC):	3 December 2000, 10.30 hours

SYNOPSIS.

As the aircraft taxied onto the active runway in preparation for take-off, the right hand axle of the nose undercarriage leg failed, causing the wheel and axle to separate from the aircraft. There were no injuries or other damage.

NOTIFICATION

The operator notified the AAIU of this event shortly after it occurred. A call was also received from Dublin Air Traffic Control (ATC). The investigation commenced immediately. The Chief Inspector of Accidents, Mr. Kevin Humphreys, directed that a Formal Investigation be conducted into this incident and appointed Mr. Graham Liddy as Inspector-in-Charge, assisted by himself as Operations Inspector.

One Safety Recommendations has been made in this report.

1. FACTUAL INFORMATION

1.1 History of the Flight.

The aircraft left its stand at the terminal area and taxied to Runway 28 at Dublin Airport in preparation for a routine scheduled Public Transport flight to Paris. The flight crew heard a loud bang as the aircraft entered the runway. They also noted a slight difficulty in steering the aircraft after the bang. The crew, believing they had suffered a nose tyre puncture, sought and received clearance to return to the departure stand. On arrival at the stand the ground crew alerted the flight crew that the right nose wheel was missing. The flight crew informed ATC of this situation. In the meantime, another aircraft, approaching to land on Runway 28, observed the wheel on the runway, effected an overshoot, and reported debris on the runway to ATC.

The runway was then closed while a runway inspection was completed. This inspection recovered the wheel and axle as a single unit, along with a wheel bearing and a cover plate, which were located nearby.

1.2 Injuries To Persons

There were 81 passangers and 5 crew on board the aircraft at the time of the incident. No injuries were reported to this investigation.

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
None	5	81	

1.3 Damage To Aircraft

The right nose wheel axle fractured, causing the right nose wheel to depart from the aircraft. The aircraft suffered no further damage to the aircraft.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information:

Not applicable.

1.6 Aircraft Information

1.6.1 Leading Particulars

Aircraft type:	B737-204
Manufacturer:	Boeing
Constructor's number:	22057
Year of manufacturer:	1980
Certificate of registration:	Issued 30 March 1994
Certificate of airworthiness:	Renewed 19 April 2000
Total airframe hours:	66,264 hours
Total cycles:	37,352 cycles
Engines:	2 x Pratt & Whitney JD8D-15

1.6.2 General Information

The aircraft had completed its last "B" check in Dublin on 23 Nov 2000, and the last hanger visit, in Stanstead, was on 31 August 2000. The last maintenance event relating to the nose wheel was a wheel change on 14 November 2000.

1.6.3 Description of Nose Leg

The nose undercarriage leg of the B737 consists of an outer cylinder, which is fitted to the aircraft, and an inner cylinder, which slides vertically within the outer cylinder. A sketch of the inner cylinder is shown in **Appendix A**. Movement of the inner cylinder is resisted by compressed nitrogen, which provides shock absorption on the undercarriage. Two axles, integral with the inner cylinder, protrude from it at the bottom on either side. The left and right nose wheel assemblies are mounted on these axles. Each wheel is supported on its axle by an inner and outer ball-bearing. The section of the inner cylinder that slides within the outer cylinder and the sections of the axles supporting each of the wheel bearings are chrome plated for wear and corrosion resistance. The entire inner cylinder is made from steel.

1.6.4 History of The Nose Undercarriage

The Part Number of the nose undercarriage leg of the B737-200 is 65-73762-5. The serial number of the leg involved in this incident was B0010. The inner cylinder was part number 65-46215-4 and its serial number was W3616, and is one of twenty sub-components that make up the nose leg assembly. The inner cylinder has an overhaul life of 20,000 cycles or 10 years, whichever expires first. It has a life limit of 90,000 cycles, when the component is retired. The inner cylinder of EI-CJH had completed 45,990 cycles at the time of this event, and 17,471 cycles since it's last overhaul which was accomplished in September 1993. It therefore had 2,529 cycles and/or 20 months to run before the next overhaul was due.

1.6.5 Component Record

During the course of this investigation the component records held by the aircraft operator, relating to the failed nose leg, were examined. These records gave a history of this component, detailing all shop visits undergone by this component. This documentation was in the form of component log cards and Certificates for Release for Service.

The investigation obtained a copy of the Certificate for Release for Service relating to the last overhaul of the nose undercarriage leg fitted to this aircraft, which was signed off on 23 September 1993.

1.6.6 History of Shop Visits

The history of the nose undercarriage leg assembly shows that it had completed five shop visits during its service life. The records show that the same inner cylinder remained in this particular undercarriage leg throughout its service life.

It was first overhauled in Canada in July 1979 at Time Since New (TSN) 33,243 hours and Cycles Since New (CSN) 11,932 cycles.

The leg next had a shop visit in the UK in April 1983. The component times and cycles, and the work specification for this visit are not available. It is not known if this visit was for repair or overhaul.

It was then overhauled in the U.K in 1986; again the component times for this overhaul are not available.

The unit was next overhauled in the U.K. at CSN 24,752 cycles in May 1990.

It was again, and finally, overhauled in the U.K. in September 1993 at TSN 65,121 hours and CSN 28,519 cycles.

All of these overhauls/shop visits were completed at different maintenance facilities. It should be noted that such components may be overhauled because of cycle or flight hours limitations, or because significant repairs are required. Frequently such components requiring repair are overhauled, as opposed to repaired, as an overhaul that restores its service life potential. An overhaul may, in the long term, be more economical, compared with simply repairing a specific defect.

During the course of this investigation efforts were made to contact all five component maintenance facilities that had performed work on this particular component. This was done to obtain the detailed records of maintenance operations they had performed on the component. The information obtained by this exercise varied from the provision of full and accurate records to nothing at all. Only two facilities were able to supply the required records. These records did not relate to the more recent shop visits. The most complete set of records were those relating to the first overhaul of the leg, completed in 1979.

In the case of several shop visits, reference was made in the available records to the replacement of damaged/worn chrome plating. However in most cases it was impossible to determine from the records if this referred to the chrome on the barrel section and/or to some or all of the chromed sections on the axles.

1.7 Meteorological Information

Not applicable.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome Information

Not applicable.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The aircraft was equipped with a Fairchild 93A100-30 Cockpit Voice Recorder (CVR), serial number 51472. The initial bang heard by the crew could be clearly heard on the CVR. There was no other relevant information on the CVR.

1.11.2 Flight Data Recorder

The aircraft was equipped with a Sunstrand Digital Flight Data Recorder (DFDR), serial number 7848. The records of the DFDR were examined to find any evidence of a heavy landing or other occurrence, which may have had a bearing on this incident. No such evidence was found in the 25 hours of available data. No other useful information was found on the DFDR.

1.12 Wreckage and Impact Information

The A.A.I.U. team arrived shortly after the event and inspected the damaged nose undercarriage on the aircraft and the separated wheel and axle. The axle was found to have failed at a point corresponding to the inner face of the inner nose wheel support bearing.

A preliminary visual inspection of the fracture surface indicated that a crack had originated at the bottom (6 o'clock) portion of the axle (See **Appendix A** and **Appendix B)**. Initial visual inspection indicated a crack of a fatigue nature.

1.13 Medical Information

Not applicable.

1.14 Fire

There was no fire.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

1.16.1 After initial on-site examination the leg was removed from the aircraft. The fracture face was subjected to detailed metallurgical examination.

1.16.2 **Appendix B** shows the fracture surface of the failed axle. The component is orientated as it would be in service. The initial fracture can be clearly seen at the bottom. The examination indicated that the crack initiated at the bottom outer surface of the axle and slowly grew until it reached a surface length of about 14 mm and a depth of about 6 mm, which is slightly less than the wall thickness of the axle. When the crack reached this size, it then spread rapidly, causing the axle to fail.

1.17 Organizational and Management Information

All of the shop visits of this undercarriage leg and its associated inner cylinder, and the installation of this assembly in this particular aircraft, took place before the aircraft commenced operation with its current operator.

1.18 Additional Information

1.18.1 Repair Process

The chrome plating on the inner cylinder can become worn or damaged due to normal in-service wear. During routine maintenance the leg is inspected for damage to the chrome. If necessary, the inner cylinder is removed for re-plating. Re-plating is preceded by removal of worn or damaged chrome plating. The Boeing Component Maintenance Manual, section 32-00-05 “Repair of High Strength Steel Landing Gear Components” (**Appendix C**) details the procedures for the repair of such items.

The worn or damaged chrome plating can be removed by grinding or by chemical stripping. The unit is then re-plated with chrome, to achieve the required diameter. Chrome plating is used on the surface of the inner cylinder because its hard surface provides good wear and corrosion resistance, and protects the tougher, but softer, steel of the cylinder. The steel provides the strength of the component.

1.18.2 Repair Inspection

The Boeing Component Maintenance Manual, section 32-00-05 “Repair of High Strength Steel Landing Gear Components” also details the procedures for the inspection of such components in the repair process. This specifies Nital or Ammonium Persulfate etch examination of the plated areas, (in accordance with section 20-10-02), subsequent to chrome plating removal. The purpose of this examination is to detect surface cracks in steel under the areas where the plating has been removed.

1.18.3 Component Movements

Major aircraft serial number components, such as undercarriage units, frequently do not remain with a given aircraft for its service life. When such a component requires overhaul or repair, they are removed from the aircraft, and replaced by a serviceable unit, which is usually supplied by a component overhaul/repair specialist organisation. The repair organisation may take the removed unit in part exchange for the replacement unit, and then overhaul or repair the removed unit as required.

Following its repair or overhaul, the unit is then exchanged for another unserviceable unit from another aircraft. If the component is returned to the original operator, the component will be more than likely fitted to another aircraft in their fleet. It is also possible that the unit will be exchanged with another operator, and fitted to an aircraft of this operator's fleet. It is the experience of the operator of this particular aircraft that their components usually remain in their own fleet, albeit on different aircraft, following repair or overhaul.

1.18.4 Component Record Requirements

It should be noted that that the last overhaul of the nose-wheel leg was accomplished 16 months before the requirements of JAR 145, and many years before JAR-OPS (Commercial Aeroplanes) became effective. Thus none of the overhauls, which this leg underwent, were required to meet these current requirements in relation to record retention.

1.18.5 Component Records JAR 145

Major aircraft serial number components, such as undercarriage units, and some sub-components such as the inner cylinder, have their own log-cards that travel with the component during its service life. These component log-cards contain such details as the component's serial number, date of manufacture, and flying hours and cycles of the component at the time of installation and removal from aircraft. The log cards also identify which aircraft they have been fitted to. They also contain reasons for removal, such as overhaul required, or very limited details of repairs required. On this inner cylinder, the component log-card contained entries, such as "damage to chrome plating". However the entries are not sufficiently detailed to indicate if the chrome to be repaired is on the barrel section, or on either/both axles. Therefore it is impossible to determine the precise details of a given repair/overhaul action from component log-cards.

In relation to repairs accomplished prior to the implementation of JAR-OPS it is necessary to go to the records maintained by the overhaul/repair facility, in order to determine the exact details of the work performed on the component during a given shop visit, These records give considerable details of the nature of any damage and the repairs effected, in accordance with what procedures, by whom and when. However, the requirements of the Joint Aviation Authority, (JAA) as laid down in Joint Aviation Requirements (JAR), and specifically in JAR 145, only require such facilities to retain these records for two years. Specifically, paragraph JAR 145.55(c) states:

> "*The JAR-145 approved maintenance organisation must retain a copy of all detailed maintenance and any associated [maintenance] data for two years from the date the aircraft or aircraft components to which the work relates was released from the JAR-145 approved maintenance organisation*."

1.18.6 Component Records JAR OPS

The JAR Operations Standard, JAR-OPS 1 details the requirements for an aircraft operator to hold the detailed maintenance records. Specifically paragraph JAR-OPS 1.920 (B) states:

"*An operator shall ensure that a system has been established to keep, in a form acceptable to the Authority, the following records for the periods specified:*

(1) All detailed maintenance records of the aeroplane and aeroplane components fitted thereto – 24 months after the aeroplane or aeroplane component was released to service;"

…………………………………………

(6) Details of Current modifications and repairs to the aeroplane, engine(s), propellor(s)and any other components vital to flight safety – 12 months after the aeroplane has been permanently withdrawn from service. [(see IEM OPS 1.920(b)(6))]

IEM OPS 1.920(b)(6) specifies further: *For the purpose of this paragraph a "component vital to flight safety" means a component that includes life limited parts… such as undercarriage and flight controls."*

1.18.7 Discussions with JAA

In discussions with AAIU in response to the draft report of this investigation, the JAA indicated that they believed the records of this component would not meet current JAA requirements. The JAA also stressed that, under current JAR-OPS requirements, it is the aircraft operator, not the maintenance facility, who was required to ensure that required documentation was provided and maintained in order to fully trace the maintenance history of a component. This would particularly apply to the period following two years or more years since the component was overhauled or repaired and until two years after the aircraft has retired from service.

1.18.8 Information from Aircraft Manufacturer

The aircraft manufacturer was asked to provide information on similar occurrences and provided the following:
"Boeing was asked to advise the number of world fleet occurrences of 737 NLG axle failures to date and the primary causes which have been identified for each. We provided general information in reference /B/ which indicated that there have been a limited number of 737 NLG axle fractures which have led to wheel departures. Most commonly, these fractures were due to cadmium embrittlement as a direct result of loss of a wheel bearing, due to grinding abuse or corrosion that was not completely removed.
For the cases that we have performed a metallurgical analysis, the fractures are summarized as follows:
One known case due to abusive chrome grinding on the journal.
One known case due to bearing failure and heat on the journal.

One-known case due to arc burn left at overhaul.
One known case due chrome chicken wire cracks and grinding burns from overhaul.
One known case of stress corrosion cracking at the chrome plate runout (improper) after overhaul.
One other suspected case of bearing failure and heat on the journal. (Operator did not follow up with information.)

We have had at least six reports of hard landings which bent the NLG axles upward. These parts were scrapped due to the plastic deformations, but did not result in a fracture/separation.

Our records also indicate that there have been approximately 7 cases of bearing journal heat damage caused by wheel bearing failure. Five were salvaged by removing the gouges or heat damage indications during complete overhaul. None of these cases led to wheel loss. "

2. ANALYSIS

2.1 The metallurgical examination shows that the right hand axle was subjected to localised overheating, in the area of the failure. This overheating may have occurred during grinding operations to remove damaged, scored or worn chrome plating. Alternatively, the overheating could also have occurred in the post-replating grinding, when the axle was being ground to achieve the final dimensional requirements. However the absence of burn marks on the cadmium plating would indicate that the overheating probably occurred when the damaged plating was being removed. The cause of the localised overheating was, most probably, due to an excessive rate of grinding or insufficient application of cooling, or a combination of both these factors, during the grinding operation.

2.2 The axle suffered overheating damage in the 6 o'clock position, which is the point of maximum bending-induced tensile loads in the axle. These loads result from normal landing impacts in the vertical direction.

2.3 The result of the localised overheating was to cause change in the temper of the steel from normal tempered martensite to over-tempered martensite (OTM). Another effect of the localised overheating was to produce heat-induced cracks in the surface of the steel.

2.4 The heat-induced cracks in the surface of the steel served as initiation sites for the fracture that was propagated by fatigue. The axle was then liable to failure at a service life well below the specified service/overhaul life.

2.5 If the localised overheating had arisen while the chrome plating was being removed by grinding, then the subsequent etch examination, if performed prior to re-plating, should have detected the surface cracks caused by overheating.

2.6 Once the surface was re-plated, it is impossible to detect the induced cracks, as there is no inspection method currently available to detect overheating in the base material, after re-plating.

2.7 Because of the absence of detailed shop records, it was impossible, in the course of this investigation, to trace the shop visit when the right axle was subject to chrome removal. Furthermore it is impossible to determine the steps of the last re-plating of this axle, and to determine detailed steps of the repair process, such as the following:

a) Was the damaged chrome plating removed by grinding or by chemical stripping?

b) Was the etch test performed on the base steel after removal of the plating and if so which etch process was used?

2.8 Due to the fact that it was impossible to establish where the defective grinding had been performed, it was impossible to trace other similar components to determine if the localised overheating was a once-off error, or if one operator had made this error with several components, possibly not recognising the seriousness of the effects of localised overheating.

2.9 It cannot be assumed that the damage to the axle occurred in the last shop visit. The lack of detailed records, relating to the more recent shop visits, means that it was impossible to determine on which visit the last re-plating of the right axle was performed.

2.10 The possibility therefore exists that there are a small number of other axles in service with the same defect, which have not yet failed, but which may do so before their next overhaul. Due to the lack of detailed records, it is not possible to identify such components, or to locate them.

2.11 The data of previous nose axle failures indicated that there have been several such events due to poor or incorrectly performed repair/overhaul operations. This indicated that the current incident is not an isolated event. If the paperwork trail in these other cases is similar to the current incident (as is probably the case), then it is probable that in some or all of these others cases, the ability to trace the exact where, when, how and why of the other repair/overhaul failures would be equally unsuccessful.

2.12 **Appendix C** details the large number of steps involved in the overhaul of undercarriage leg components. It is essential that the records relating to each step of such an overhaul be available to an accident/incident investigation.

2.13 It is the viewpoint of the JAA that the current JAR–145 and JAR-OPS requirements, if correctly applied by an operator, would fully meet the history requirements of an accident/incident investigation. Consequently in the case of a component overhauled/repaired since these requirements came into force, the aircraft operator should be able to provide the investigation with all the required data.

2.14 In view of the criticality of such completeness of records to the success of an investigation, and the fact that the previous regulatory system failed to provide the data required by this investigation, there is merit in verifying that the new requirements, as practised, will provide the required information to an investigation.

2.15 The manufacturer's experience is that the type of damage (plastic deformation or bending) suffered by nose wheel axles involved in heavy landing events is totally different to the type of failure observed in this incident. This indicates that a heavy landing was not a factor in this incident.

3. CONSLUSIONS

3.1 Findings

3.1.1 The aircraft had been correctly maintained in accordance with the appropriate schedules.

3.1.2 The failed axle had suffered localised overheating during grinding operations during repair/overhaul shop maintenance. The overheating induced surface cracks in the axle that significantly reduced its fatigue resistance. This resulted in fatigue crack propagation and subsequent axle failure.

3.1.3 The failure of the nose wheel axle did not result from a heavy landing event.

3.1.4 Most of the overhaul/repair facility records relating to maintenance on this component were not available to the investigation.

3.1.5 The component records held by the aircraft operator satisfied the requirements in force at the time of the component overhauls. However this level of record keeping did not meet the data requirements of this investigation; neither would they meet the requirements of JAR-OPS which would apply to components overhauled or repaired since the implementation of these requirements.

3.1.6 It is the opinion of the JAA that the current JAA requirements with regard to component record, when correctly maintained, would meet the record traceability requirements of investigations such as this investigation.

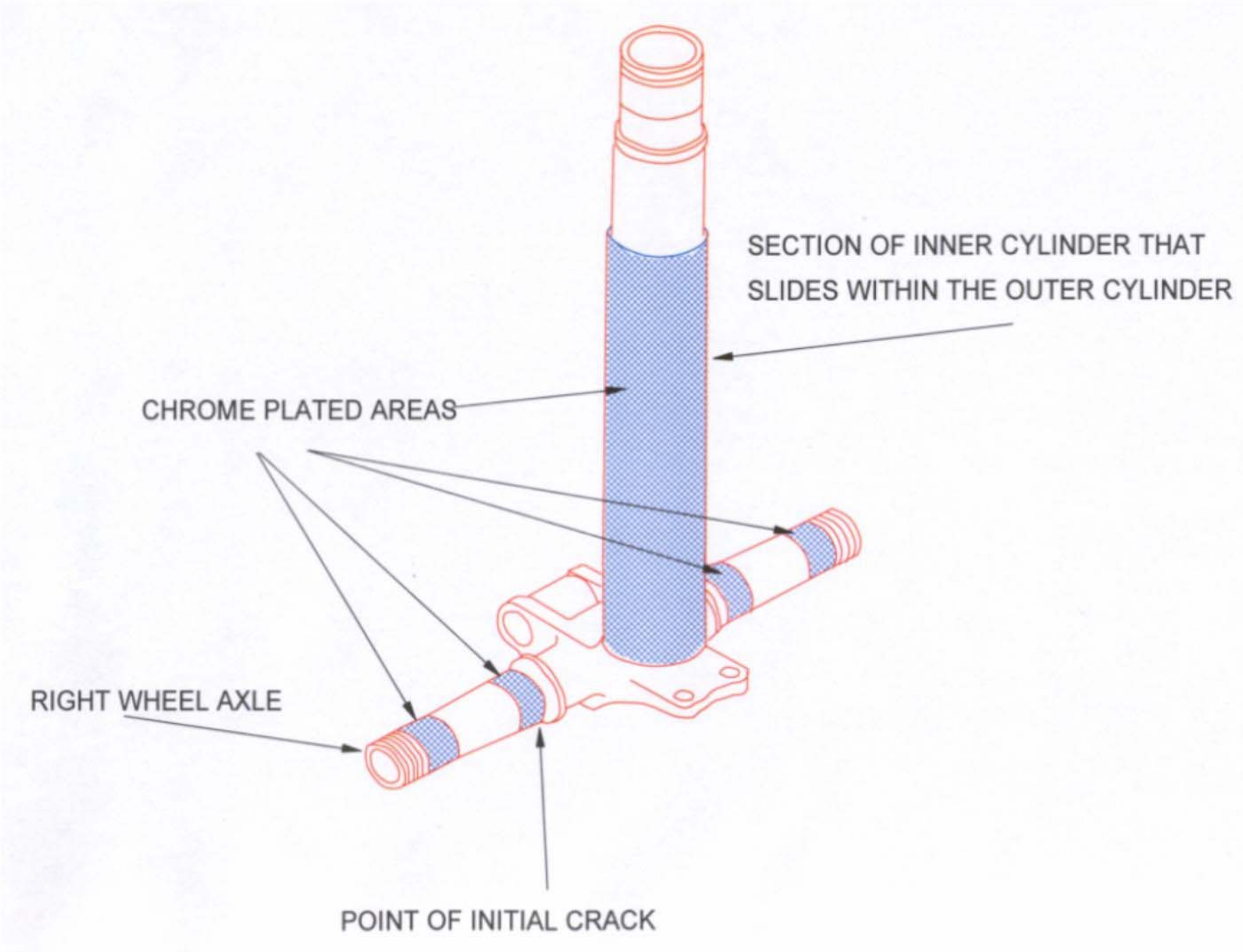
3.2 Causes

3.2.1 The failure of the axle was caused by overheating which occurred while the axle was undergoing grinding during a shop visit.

4. SAFETY RECOMMENDATIONS

4.1 The Irish Aviation Authority (I.A.A.) should consider conducting an audit of the practical implementation and practise of current JAA requirements to ensure the adequacy of component records to meet the component history requirements of future investigations, and report the outcome of such an audit to the JAA. **(SR 16 of 2003)**

Appendix A



SKETCH OF INNER CYLINDER

Appendix B

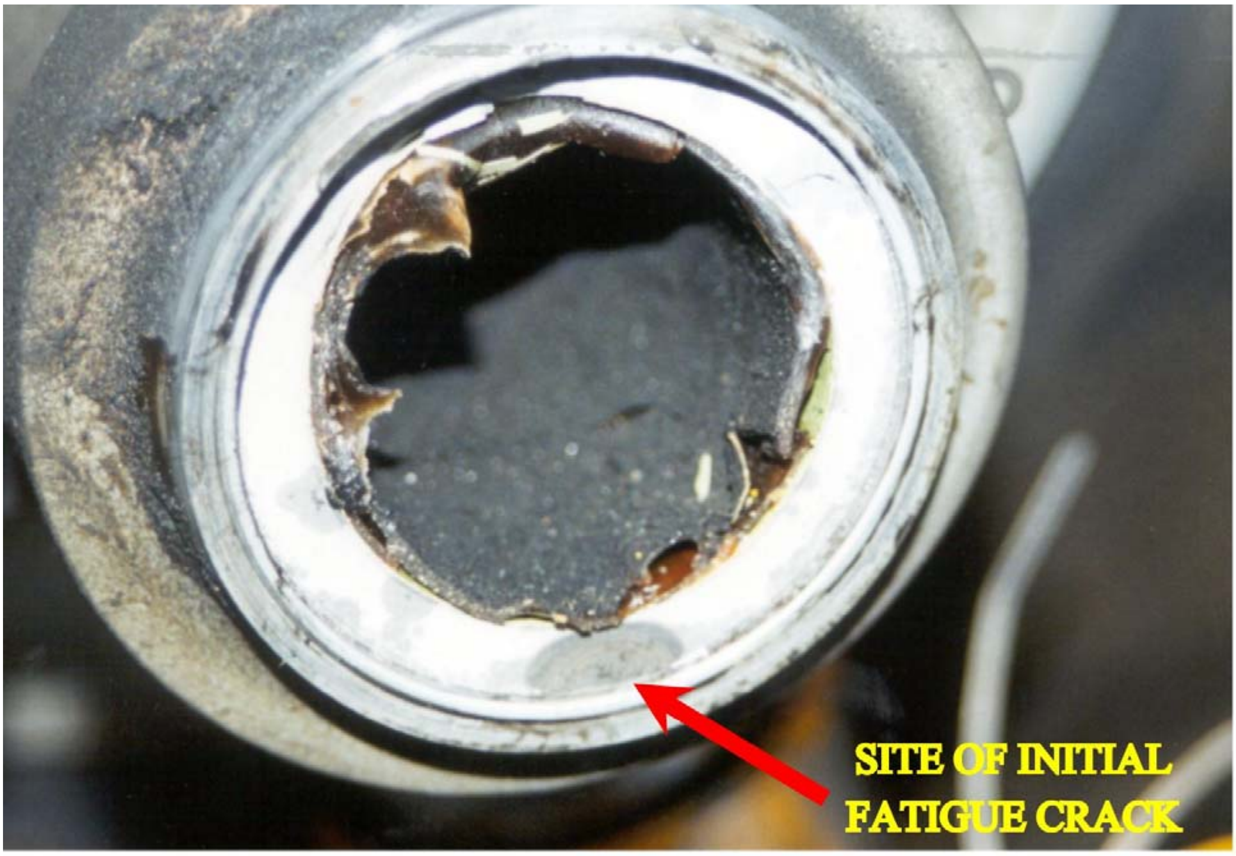


PHOTO OF AXLE FRACTURE
(INNER CYLINDER END)

Appendix C

Page 1

REPAIR OF HIGH-STRENGTH STEEL LANDING GEAR PARTS

DESCRIPTION AND OPERATION

1. The procedures in this subject are for alloy steel landing gear parts heat-treated 180 ksi or above.

2. The data is general. It is not about specific parts or installations. Use this data as a guide to help you write minimum standards.

3. These procedures refer to the more general procedures in the Standard Overhaul Practices Manual (Chapter 20), document D6-51702. If the procedures in this subject do not agree with those in the Standard Overhaul Practices Manual, use the procedures in this subject.

4. These procedures start with parts which are removed from the airplane and disassembled for overhaul, but not yet put through shop processes such as stress relief, finish removal or material removal. Refer to the applicable overhaul instructions for details about specific repairs or refinish for a part. If the procedures in this subject do not agree with those in the overhaul instructions, use the procedures in the overhaul instructions.

5. These procedures are typical for all parts. The repair instructions for the specific part will tell you when to use these procedures.

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Appendix C

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REPAIR OF
HIGH-STRENGTH STEEL
LANDING GEAR PARTS

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REPAIR

1. Use the flow charts (Fig. 601, 602) as a guide when you repair steel landing gear parts.

2. Refer to the following standard practices, as applicable:

20-10-02	Machining of Alloy Steel
20-10-03	Shot Peening
20-10-04	Grinding of Chrome Plated Parts
20-20-01	Magnetic Particle Inspection
20-20-02	Penetrant Methods of Inspection
20-30-02	Stripping of Protective Finishes
20-30-03	General Cleaning Procedures
20-41-01	Decoding Table for Boeing Finish Codes
20-42-01	Low Hydrogen Embrittlement Cadmium Plating
20-42-02	Low Hydrogen Embrittlement Cadmium-Titanium Alloy Plating
20-42-03	Hard Chrome Plating
20-42-05	Bright Cadmium Plating
20-42-09	Electrodeposited Nickel Plating
20-50-03	Bearing Removal, Installation and Retention

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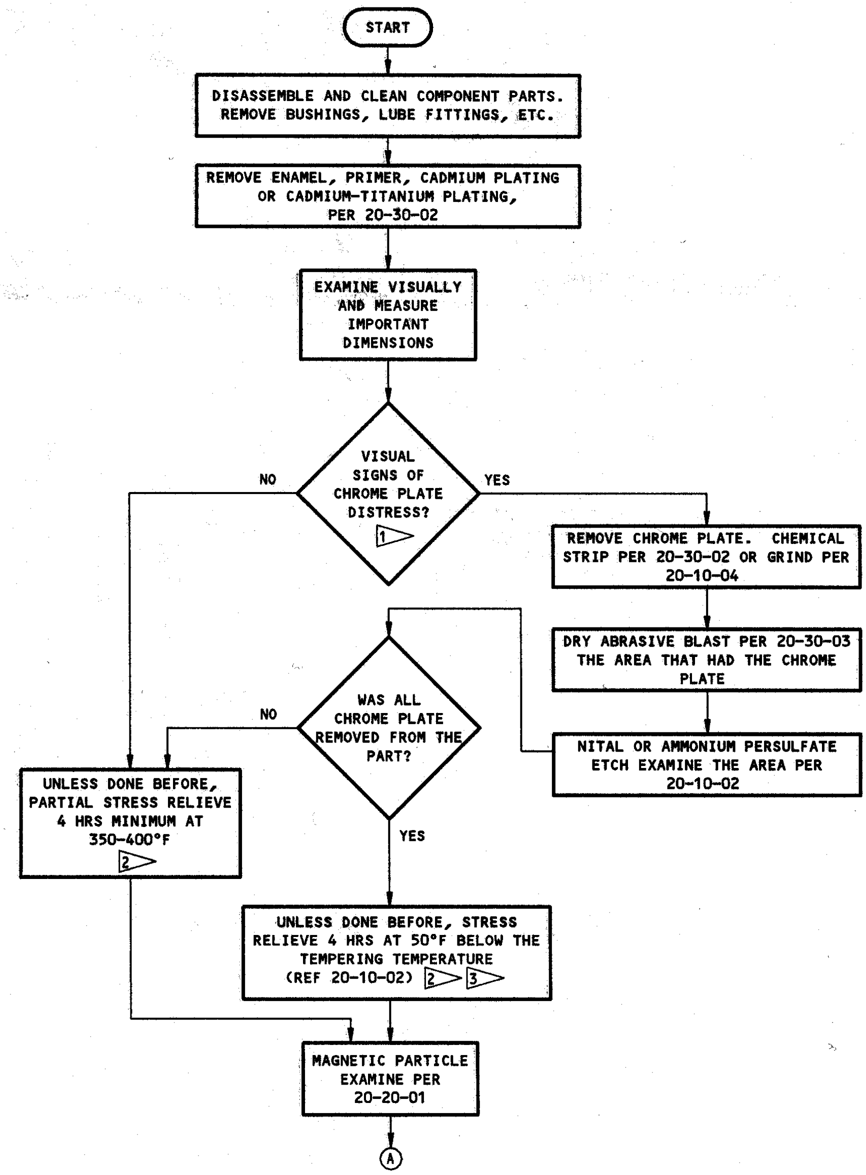
COMPONENT MAINTENANCE MANUAL

REPAIR OF
HIGH-STRENGTH STEEL
LANDING GEAR PARTS



Basic Repair Procedure
Figure 601 (Sheet 1)

32-00-05
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REPAIR OF
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LANDING GEAR PARTS

BOEING
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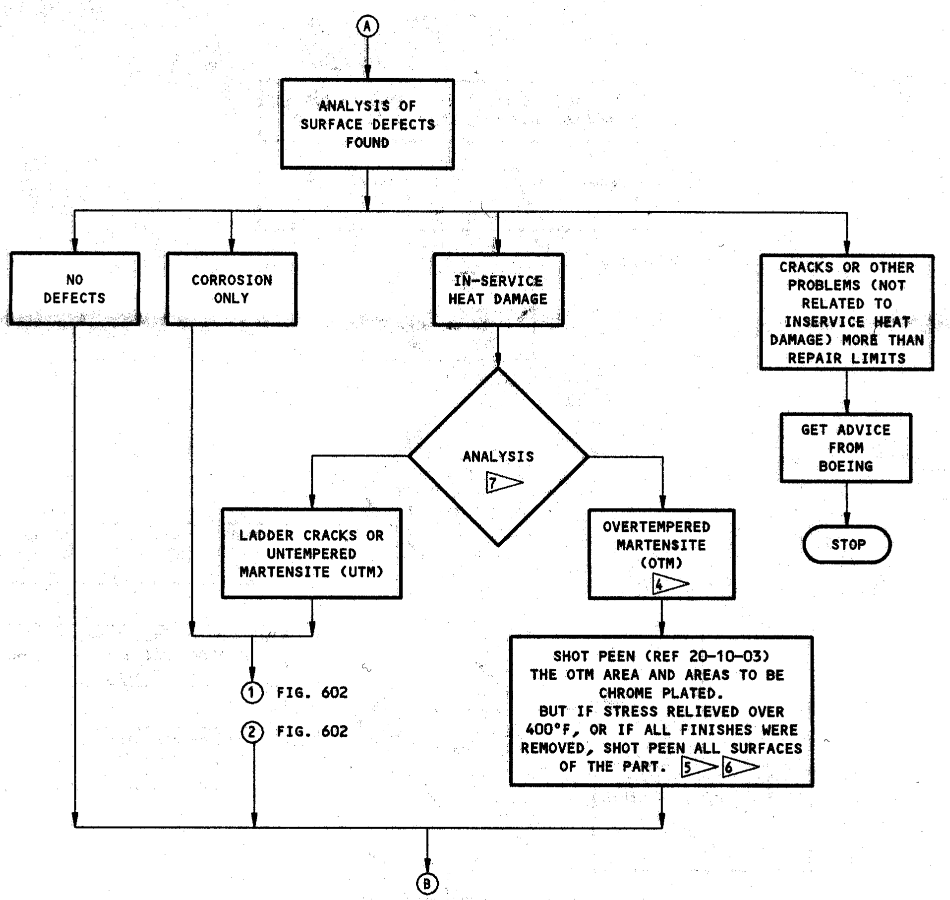

Basic Repair Procedure
Figure 601 (Sheet 2)

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REPAIR-GENERAL
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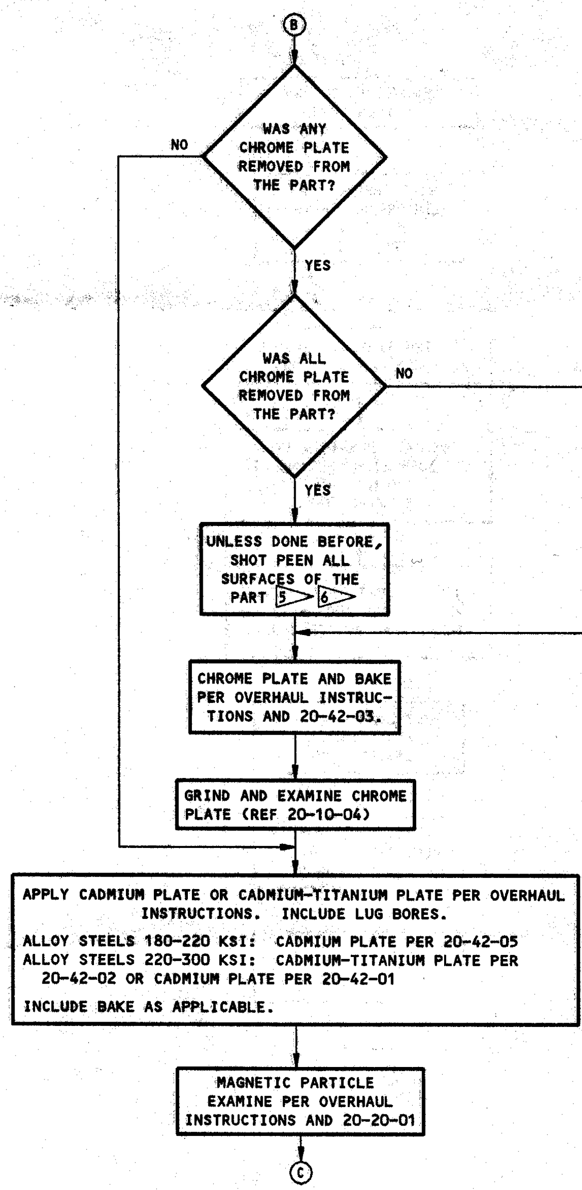
REPAIR OF
HIGH-STRENGTH STEEL
LANDING GEAR PARTS



Basic Repair Procedure
Figure 601 (Sheet 3)

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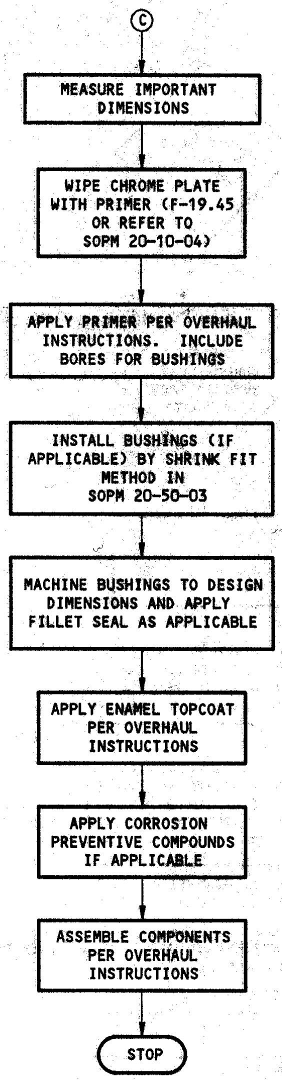

Basic Repair Procedure
Figure 601 (Sheet 4)

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COMPONENT MAINTENANCE MANUAL

REPAIR OF
HIGH-STRENGTH STEEL
LANDING GEAR PARTS

[1] SIGNS OF CHROME PLATE DISTRESS INCLUDES LADDER CRACKS, MATERIAL OR BRONZE TRANSFER, DARKENED STREAKS, PLATING WHICH IS SMEARED, CHIPPED, CRACKED, FLAKED, A DIFFERENT COLOR, OR GONE. VISUALLY EXAMINE THE PLATED SURFACES WITH LIGHT AT AN ANGLE, BUT DO NOT USE MAGNIFICATION. LOOK AT THE SURFACES FROM DIFFERENT ANGLES. YOU CAN ALSO FIND CRACKS IN THE PLATING WITH THE SHARP POINT OF A DENTAL EXPLORER.

[2] SET THE FURNACE TEMPERATURE TO STAY IN THE SPECIFIED RANGE. START THE TIMER WHEN ALL THE THERMOCOUPLES ARE BACK INTO THE SPECIFIED TEMPERATURE RANGE AFTER YOU PUT THE PARTS INTO THE FURNACE.

[3] AS AN ALTERNATIVE, PARTIAL STRESS RELIEVE 4 HRS AT 350-400°F. [2]

[4] FOR STRESS ANALYSIS ONLY, MAKE THE ASSUMPTION THAT THE ETCHED AREA THAT INDICATES OTM IS 0.010 INCH DEEP AND DOES NOT SUPPORT LOADS. THIS ASSUMPTION WILL HELP YOU FIND OUT IF THE DEFECTS ARE MORE THAN THE REPAIR LIMITS IN THE OVERHAUL INSTRUCTIONS. (IF THEY ARE, BOEING APPROVAL OF THE REPAIR IS NECESSARY.) OVERTEMPERED MATERIAL CAN STAY ON FLAT OR LIGHTLY ROUNDED SURFACES, SUCH AS THE ID OR OD OF LANDING GEAR CYLINDERS. OVERTEMPERED MATERIAL MUST BE REMOVED PER FIG. 602 IF THE OTM EXTENDS INTO AN EDGE, CHAMFER, CORNER, RADIUS, FILLET, OR HOLE, OR IF IT IS MADE DURING MACHINING, GRINDING, OR OTHER OVERHAUL OPERATIONS.

[5] IF THE SHOT HAS CADMIUM CONTAMINATION, CLEAN THE SHOT PEENED SURFACES AFTER THE PEEN AND BEFORE YOU PLATE. USE ABRASIVE GRIT BLAST OR AMMONIUM NITRATE.

[6] FOR AREAS NOT TO BE SHOT PEENED, REFER TO APPLICABLE OVERHAUL INSTRUCTIONS.

[7] REFER TO SOPM 20-10-02 FOR DESCRIPTIONS OF OVERTEMPERED AND UNTEMPERED MARTENSITE.

Basic Repair Procedure
Figure 601 (Sheet 5)

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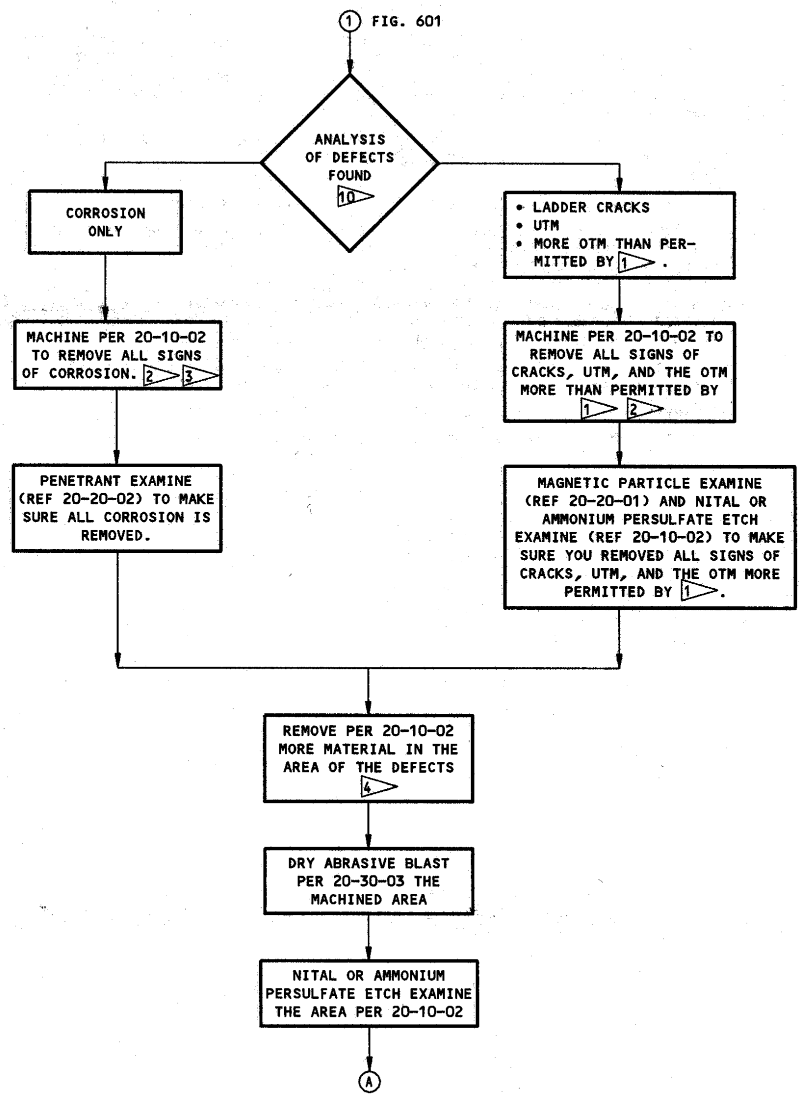
LANDING GEAR PARTS

BOEING
COMPONENT
MAINTENANCE MANUAL



Removal of Corrosion or In-Service Heat Damage
Figure 602 (Sheet 1)

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REPAIR OF
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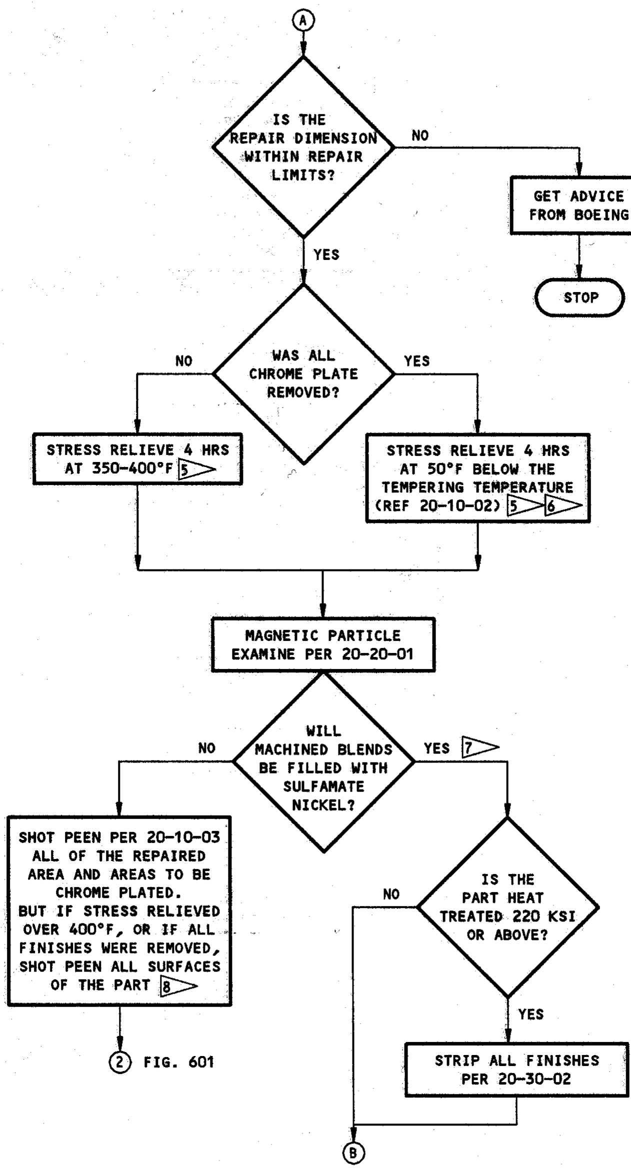

Removal of Corrosion or In-Service Heat Damage
Figure 602 (Sheet 2)

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BOEING
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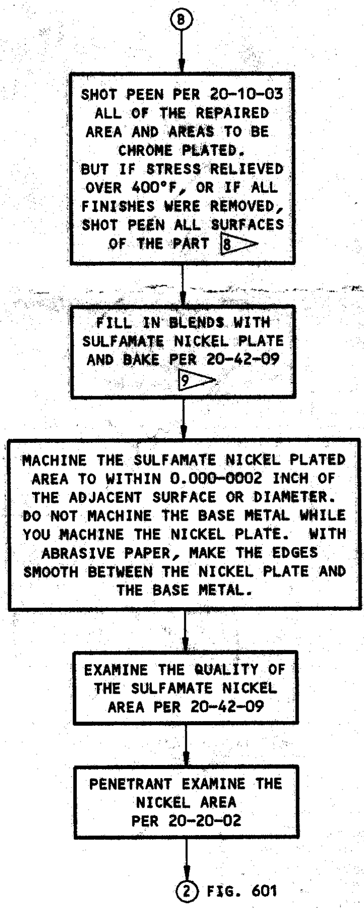

Removal of Corrosion or In-Service Heat Damage
Figure 602 (Sheet 3)

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COMPONENT MAINTENANCE MANUAL

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1 FOR STRESS ANALYSIS ONLY, MAKE THE ASSUMPTION THAT THE ETCHED AREA THAT INDICATES OTM IS 0.010 INCH DEEP AND DOES NOT SUPPORT LOADS. THIS ASSUMPTION WILL HELP YOU FIND OUT IF THE DEFECTS ARE MORE THAN THE REPAIR LIMITS IN THE OVERHAUL INSTRUCTIONS. (IF THEY ARE, BOEING APPROVAL OF THE REPAIR IS NECESSARY). OVERTEMPERED MATERIAL CAN STAY ON FLAT OR LIGHTLY ROUNDED SURFACES, SUCH AS THE ID OR OD OF LANDING GEAR CYLINDERS. OVERTEMPERED MATERIAL MUST BE REMOVED IF THE OTM EXTENDS INTO AN EDGE, CHAMFER, CORNER, RADIUS, FILLET OR HOLE, OR IF IT WAS MADE DURING MANUFACTURE.

2 FOR APPROVED REPAIRS AND LIMITS, REFER TO APPLICABLE OVERHAUL INSTRUCTIONS. MATERIAL REMOVAL MUST INCLUDE ALLOWANCE FOR INSURANCE CUTS PER 4.

3 REMOVAL OF LIGHT CORROSION WITH HAND HELD TOOLS WITHOUT POWER (ABRASIVE CLOTH, FILES, ETC.) IS ACCEPTABLE IF ALL ACTIVE CORROSION IS REMOVED AND THE TASK IS COMPLETED WITH THE CORRECT SURFACE FINISH.

4 WE HIGHLY RECOMMEND YOU REMOVE 0.003-0.005 INCH MORE MATERIAL FROM A SURFACE WHERE KNOWN HEAT DAMAGE, CRACKS, OR CORROSION WAS REMOVED. BUT BEFORE YOU DO THIS, MAKE SURE THE REPAIR WILL NOT BE MORE THAN THE LIMIT IN THE OVERHAUL INSTRUCTIONS. (IF THEY WILL BE, BOEING APPROVAL WILL BE NECESSARY BEFORE YOU CAN REPAIR THE PART).

5 SET THE FURNACE TEMPERATURE TO STAY IN THE SPECIFIED RANGE. START THE TIMER WHEN ALL THE THERMOCOUPLES ARE BACK INTO THE SPECIFIED TEMPERATURE RANGE AFTER YOU PUT THE PARTS INTO THE FURNACE.

6 AS AN ALTERNATIVE, PARTIAL STRESS RELIEVE 4 HRS AT 350-400°F. 5

7 SULFAMATE NICKEL (REF 20-42-09) CAN BE USED TO BUILD UP SURFACES WHERE MATERIAL WAS LOCALLY REMOVED MORE THAN THE DESIGN DIMENSIONS. THE THICKNESS OF THE NICKEL AREA IS LIMITED ONLY BY THE AMOUNT OF BASE METAL THAT CAN BE REMOVED AND KEEP THE PART STRUCTURALLY ACCEPTABLE. IF THIS NICKEL REPAIR IS NOT IN THE APPLICABLE OVERHAUL INSTRUCTIONS, GET APPROVAL FROM BOEING STRUCTURES ENGINEERING. IMPORTANT FACTORS ARE LOCATION, EFFECT ON FATIGUE, BEARING STRESSES IN THE REPAIRED AREA, AND SUFFICIENT HYDROGEN BAKE-OUT PATH.

8 FOR AREAS NOT TO BE SHOT PEENED, REFER TO APPLICABLE OVERHAUL INSTRUCTIONS.

9 BLENDS CAN BE FILLED WITH CHROME PLATE IF THE SURFACE WAS CHROME PLATED AND THE TOTAL DEPTH OF PLATING REQUIRED TO GET BACK TO DESIGN DIMENSION IS NOT MORE THAN 0.015 INCH.

10 REFER TO 20-10-02 FOR DESCRIPTION OF OVERTEMPERED AND UNTEMPERED MARTENSITE.

Removal of Corrosion or In-Service Heat Damage
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