MIL-HDBK-274(AS)
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MILITARY HANDBOOK

ELECTRICAL GROUNDING FOR AIRCRAFT SAFETY

NO DELIVERABLE DATA REQUIRED BY THIS DOCUMENT

EMCS

NAVAL AIR SYSTEMS COMMAND
WASHINGTON, DC 20361

Electrical Grounding for Aircraft Safety

MIL-HDBK-274(AS)
1 November 1983

1. This handbook was developed for use by the Naval Air Systems Command and will provide a single source reference to ensure that aircraft under its jurisdiction are properly grounded and bonded. This handbook is not intended to be referenced in purchase specifications, except for informational purposes, nor shall it supersede any specification requirements.

2. This document reflects the latest equipment and procedures used for the electrical grounding and bonding of Naval aircraft. It is the intent to review this handbook periodically to insure its completeness and currancy.

3. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to the Commanding Officer, Naval Air Engineering Center, Engineering Specifications and Standards Department (Code 9313), Lakehurst, New Jersey 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this handbook or by letter.

FOREWORD

This handbook has been prepared to provide a single, standard reference source to be used by naval aircraft operations and maintenance personnel (including public works department personnel) to ensure that the aircraft under their jurisdiction are properly and safely electrically grounded and bonded.

The philosophical position and technical information presented in this handbook are based upon results of a previous naval study documented in NAVAIR Report 5181-1000 titled, ''Airframe Electrical Grounding Requirements Program.'' That program clearly demonstrated that hazards exist during all aircraft evolutions, and established that there are valid technical reasons to electrically ground aircraft for all evolutions, including all aspects of maintenance, fueling, stores handling, and parking. It also recognized that a rigorous grounding philosophy is required which, when strictly followed, will maximize personnel and aircraft safety.

The grounding methods presented in this handbook make a clear distinction between static grounding and power grounding. Static grounds are defined as those points having impedances of less than 10,000 ohms referenced to earth. Power grounds are defined as those points having impedances of less than 10 ohms referenced to the power system neutral.

Grounding methods presented in this handbook require static grounding of aircraft during fueling/defueling, parked evolutions, stores loading, hot refueling, and all external power evolutions with diesel-generated (ac or dc) power sources. These requirements apply to both fixed wing and rotary wing aircraft evolutions (including hovering, HIFR, and RAST). Bonding and grounding by triangulation is required during fueling/defueling evolutions.

Hangar-based maintenance evolutions requiring external power (ac or dc) with grounded (earthed) neutral (eg, facility power or MMG-1A) must be connected to a power ground prior to the introduction of such power.

On board ship, tiedown chains cannot be used to static ground aircraft. Separate grounding cables must be used to connect the aircraft to the deck padeye. The deck padeye is an acceptable static grounding point.

During Flight Line Electrical Distribution System (FLEDS) operations, aircraft must be bonded to the FLEDS earthed neutral, such as connecting the airframe to the Distribution Box Assembly (DBA) hardware.

During Mobile Electrical Power Plant (MEPP) external power configuration, it is recommended that in addition to any required grounding, the aircraft be separately bonded to its mobile power source. Aircraft using 28V dc diesel-generated power only are exempt from this bonding requirement.

This handbook contains comprehensive grounding procedures on all active, operational type aircraft presently in the naval inventory. Information on aircraft still in use but not covered in this handbook can be obtained from the following agency:

NAVAIRSYSCOM
Electromagnetics Branch, 5161
Washington, DC 20361

Autovon: 222-7788
Commercial: (202) 692-7788

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FIGURES

FIGURES - Continued

FIGURES - Continued

FIGURES - Continued

FIGURES - Continued

FIGURES - Continued

FIGURES - Continued

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SECTION 1

1.0 SCOPE

1.1 Purpose. The purpose of this handbook is to provide aircraft maintenance personnel with the information required for electrical safety grounding of each type of operational aircraft in the U.S. Navy inventory.* In addition, this handbook provides background information pertaining to the opertional concerns for aircraft grounding, static electricity theory and how it affects aircraft, and techniques used for measurement of grounding points. This handbook is divided into five sections as follows:

SECTION 1 - SCOPE
SECTION 2 - AIRCRAFT GROUNDING AND BONDING METHODS
SECTION 3 - OPERATIONAL GROUNDING CONCERNS
SECTION 4 - THEORETICAL BASIS FOR AIRCRAFT GROUNDING
SECTION 5 - TESTING AND IDENTIFICATION OF GROUND POINTS

1.1.1 This handbook is intended for use by all U.S. Naval aircraft operational and maintenance personnel including maintenance officers and public works officials for the purpose of ensuring that each aircraft is properly grounded and that the grounding system is adequate for this purpose. Sections 1 and 2 are intended primarily for use by line maintenance personnel. Sections 3 and 4 contain material intended for those desiring to obtain additional theoretical and background information. Section 5 is essential for public works department personnel. Each section is designed to stand alone.

1.1.2 The information contained in Section 2 is intended to be used by line maintenance personnel. This section provides step-by-step instructions for grounding each of the aircraft in the Navy inventory during each of the following evolutions: parked, fueling/defueling, maintenance, and stores loading/unloading. Each evolution is shown in a separate illustration depicting the particular aircraft with proper grounding/bonding cables connected. The illustrations show primary grounding points and also provide alternate grounding points should the primary grounding point be inaccessible. Also provided on the illustrations are pertinent cautions and warnings to be observed during the grounding procedure. Accompanying each illustration is a step-by-step procedure for grounding/bonding the particular aircraft.

1.1.3 Section 3 provides background and general information necessary to understand the rationale behind the requirements for grounding and bonding. This section also discusses the grounding problems and hazards encountered in the everyday ground handling of aircraft during flight operations. Energy sources and grounding effects are identified. The aircraft scenarios or servicing situations (evolutions) are introduced and the aircraft safety problems associated with each are described. In addition, a brief discussion of static electricity and how it affects aircraft operation is provided.

*U.S. Navy aircraft use power equipment not equipped with ground fault interrupters (GFI).

1.1.4 Section 4 details basic electrostatic theory and its application to aircraft grounding. Sources of static electricity associated with aircraft operation are also described. These include triboelectric effects, fuel flow, induced charge, and friction. Hazards from ground power faults, rf energy, and lightning are presented. Also included in this section are descriptions of aircraft electrical parameters and a discussion of hazardous threshold and the possible dangers they present to personnel and aircraft safety. The section also illustrates that proper grounding will reduce these hazards.

1.1.5 Section 5 is intended for use by the public works department personnel and provides a description of the methods and techniques used to measure the resistance of the grounding system. Also included in Section V is a suggested schedule for accomplishing the measurement of ground points, identifying ground points, the use of mooring eyes as static ground points, and a discussion of the test equipment used to measure ground point resistance.

1.2 Referenced Documents. The following documents are referenced in this handbook.

Document No.	Title
MS27574	Cable Configurations, Grounding
MS3493	Connector, Plug and Cap Electric, Grounding
MS0090298	Connector, Receptacle, Electric, Grounding
MS33645	Receptacle, Grounding, Installation of
MS25083	Jumper Assembly, Electric Bonding and Current Return
MIL-C-83413	Connector, Electric Ground
MS25486	Connector, Plug, Attachable, Ext. Electric Power, Aircraft 115/200 volt 400 hertz
MS25488	Connector, Plug, Attachable, Ext. Electric Power, Aircraft, 28 Volt DC Operating Power
MS25487	Connector, Plug, Attachable, Ext. Electric Power, Aircraft, 28 Volt DC, Jet Starting.

Document No.	Title
NAVAIR AIR-5181-1000	Airframe Electrical Grounding Requirements Program Final Report, 17 Feb 1981
NAVAIR 00-80T-96	U.S. Navy Support Equipment, Basic Handling and Safety Manual, 1 April 1981
NAVAIR 19-45-1	Index and Applications Tables for Mobile Electric Power Plants, 1 September 1972
NAVSEA OP4 Vol. 2 (5th Rev.)	Ammunition Afloat, 15 February 1972
NAVSEA OP5 Vol. 1 (4th Rev.)	Ammunition and Explosives Ashore, 15 October 1974
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipments and Facilities, 21 January 1982

SECTION 2

2.0 AIRCRAFT GROUNDING AND BONDING METHODS

This section provides step-by-step procedures for grounding and bonding operational aircraft in the Navy inventory. Various handling evolutions, both land-based and carrier-based, of the different aircraft are described and illustrated with appropriate warnings and cautions. Note that the word ''carrier'' is meant to refer to any ship which supports aircraft flight operations.

By referring to the particular aircraft procedures in this section, organizational maintenance personnel will be able to properly determine aircraft grounding requirements before beginning other servicing. Recommended grounding and bonding locations are illustrated. If conditions prevent the use of these locations, a resistance check using a milliohmmeter must be performed to verify that the alternate location is an acceptable grounding or bonding attachment point. A location is an acceptable grounding or bonding point if the resistance measured from the point to the airframe is less than 10 milliohms. Using a milliohmmeter (Shallcross Model 670A or equivalent), connect one probe to the known aircraft grounding point and the other probe to the proposed grounding point. Observe the milliohmmeter for a reading of less than 10 milliohms. If the milliohmmeter reading is less than 10 milliohms, the proposed grounding point is acceptable. Painted, corroded, dirty, greasy areas or areas of composite materials should not be used for grounding points. In addition, if the intended grounding point is loosely connected to the aircraft structure by way of bearings or springs, an unacceptable intermittent ground or bond could result.

When employing grounding cables, the specific type of connector required on the ends will be determined by the aircraft type. Many Navy aircraft do not have grounding receptacles available in other than the fueling area, and they are therefore not readily available for use as the static grounding point on the aircraft. In these instances a cable having an M83413-1 connector on each end may be used, one end attached to an approved static ground point, the other to a clean metal area of the aircraft.

Cables shall be of 7 x 7 construction, .094 nominal diameter wire rope with M83413-1 connectors at each end. Cable length shall be determined by user requirements. The maximum resistance shall not exceed 0.5 ohms for the cable configuration (MS27574).

2.1 Land-Based Aircraft. The following paragraphs provide step-by-step procedures for grounding land-based aircraft.

Evolutions requiring external power are detailed in paragraphs 2.4 through 2.6.

Fueling evolutions shown here do not indicate external electrical power. These illustrations apply to gravity fueling as well as hot fueling from fuel trucks. Figures 2-160 and 2-161 illustrate grounding and bonding procedures for the A-6 using external electrical power during fueling. The grounding and bonding procedures for other aircraft requiring external electrical power during fueling are similar.

The fuel hose bond cable must be connected to an appropriate ground on the aircraft prior to attaching the fuel hose.

NOTE: For purposes of clarity and practicality electrical grounds in this handbook will be defined as follows:

Power ground: An approved ground point with an impedance less than 10 ohms to the power system neutral.

Static Ground: An approved ground point that has an impedance of less than 10,000 ohms referenced to earth.

When performing maintenance in the FLEDS area, airframes must be grounded and bonded as indicated in figure 2-155. Where a bonding cable is required between the MEPP and the aircraft, the illustrations contained in this handbook show separate bonding and power cables for the purpose of clarity only. In actual practice, however, these two cables should be tied together.

2.1.1 A-3 parked evolution. To ground A-3 aircraft when in the parked evolution, proceed as follows (see figure 2-1):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.2 A-3 fueling/defueling evolution. To ground A-3 aircraft when fueling or defueling, proceed as follows (see figure 2-2):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to nose landing gear.
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.3 A-3 hangar-based maintenance evolution. To ground A-3 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-3):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

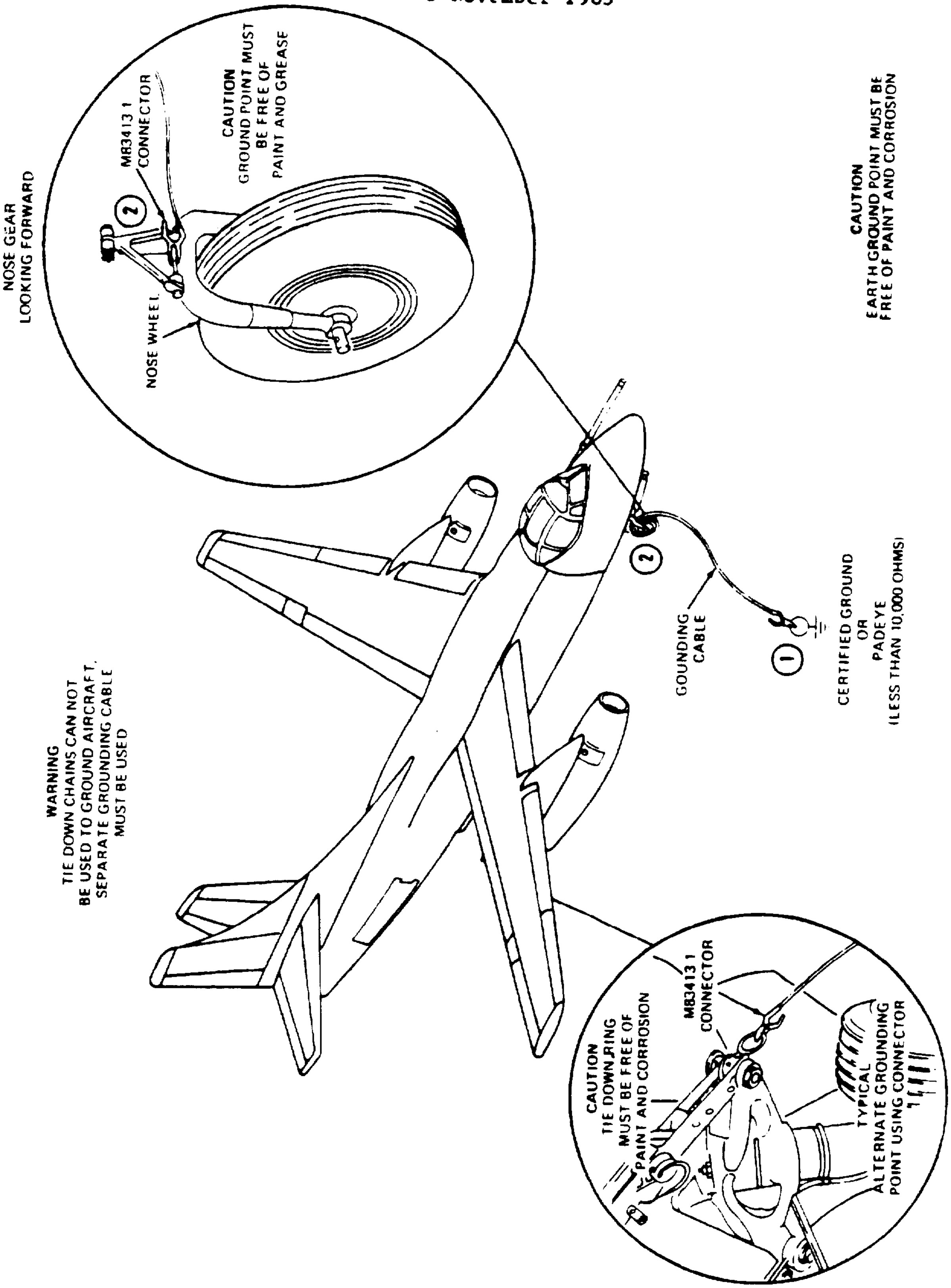

FIGURE 2-1. A-3 aircraft grounding, parked evolution.

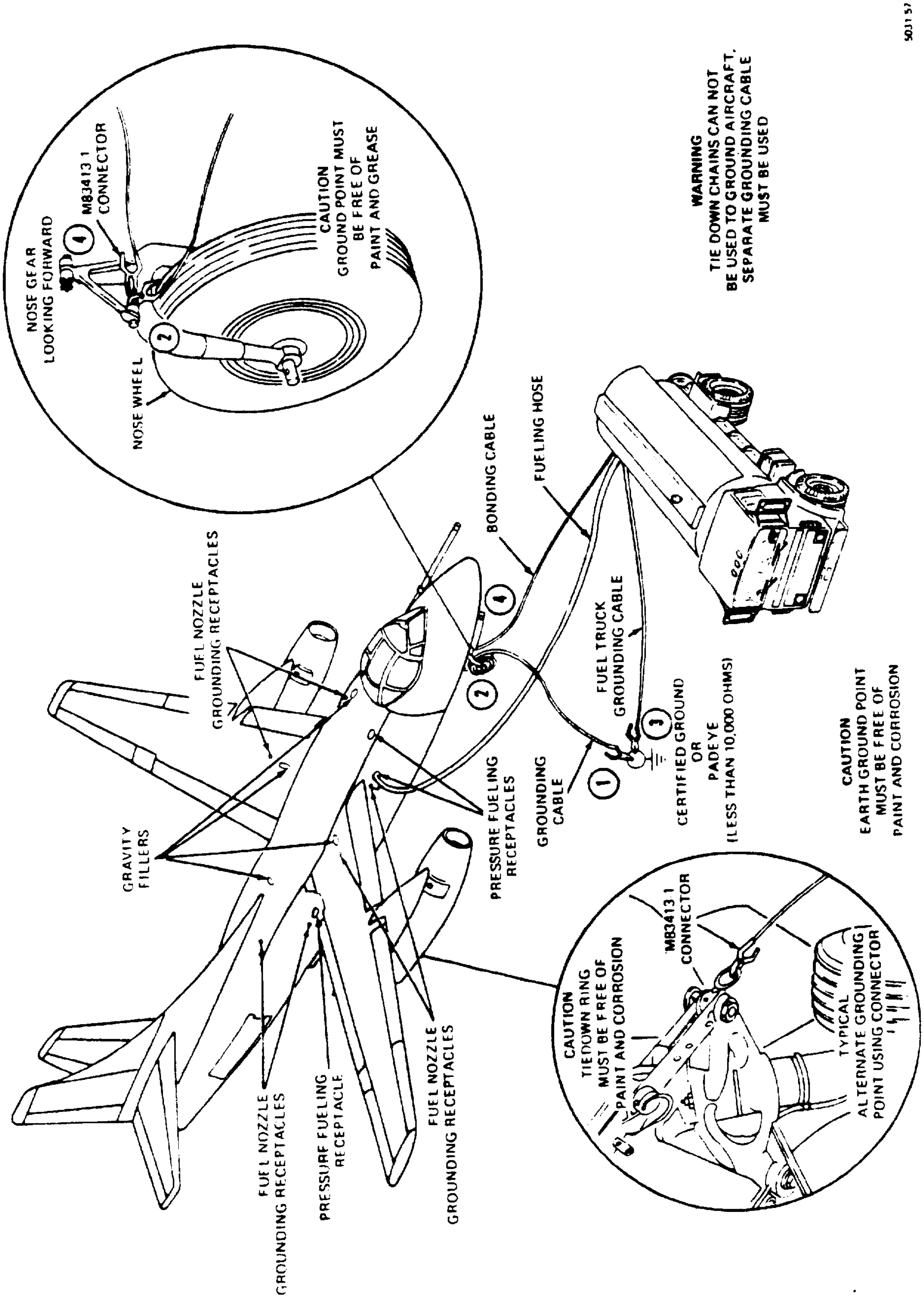

FIGURE 2-2. A-3 aircraft grounding, fueling/defueling evolution.

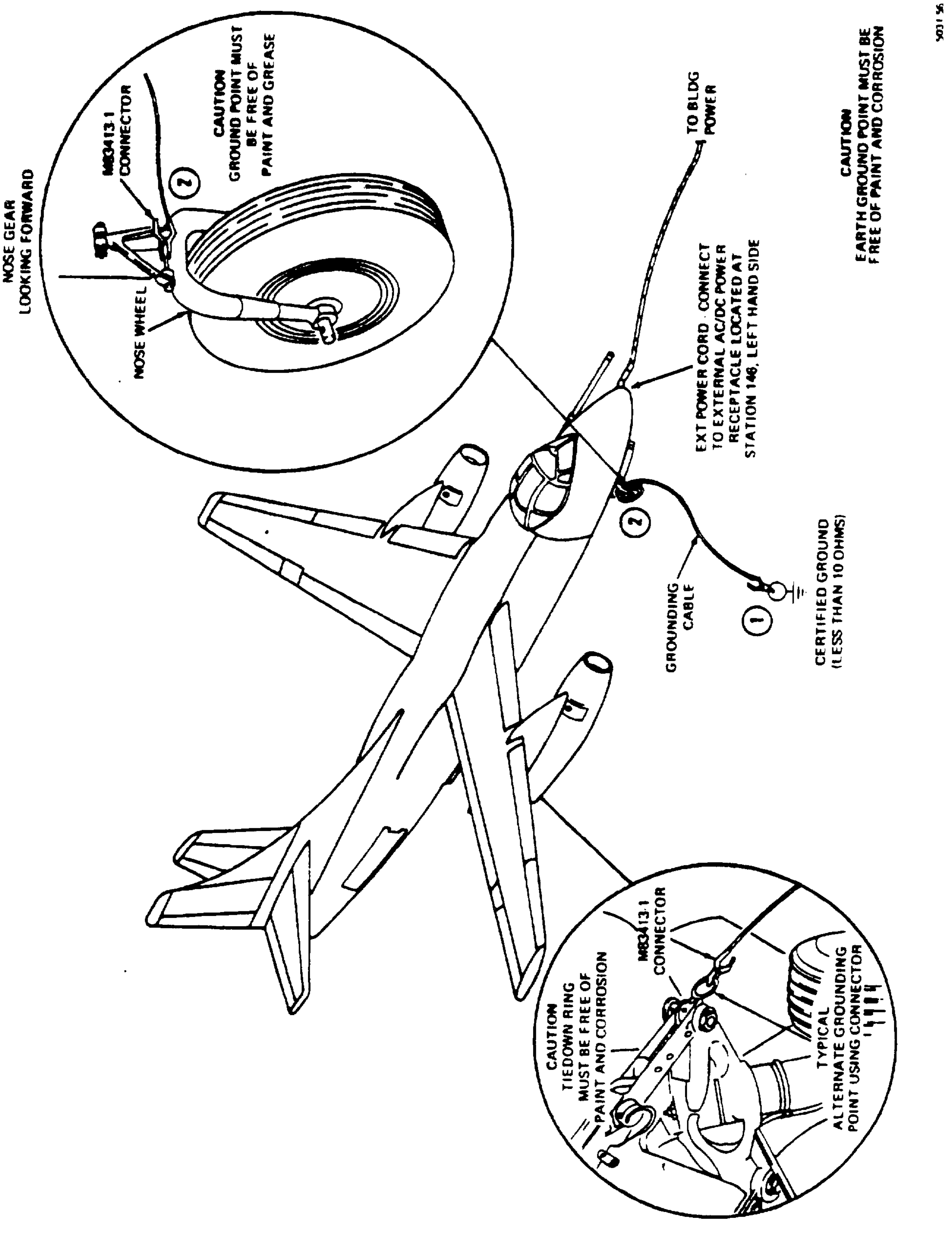

FIGURE 2-3. Hangar-based A-3 aircraft grounding, maintenance evolution.

2.1.4 A-3 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground A-3 aircraft when in the maintenance evolution on the apron with the mobile electrical power plant (MEPP) plugged into aircraft, proceed as follows (see figure 2-4):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to nose landing gear (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.5 A-3 apron-based maintenance evolution (using FLEDS). To ground A-3 aircraft when in the maintenance evolution on the apron using the flight line electrical distribution system (FLEDS), proceed as follows (see figure 2-4):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to nose landing gear (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.6 A-4 parked evolution. To ground A-4 aircraft when in the parked evolution, proceed as follows (see figure 2-5):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

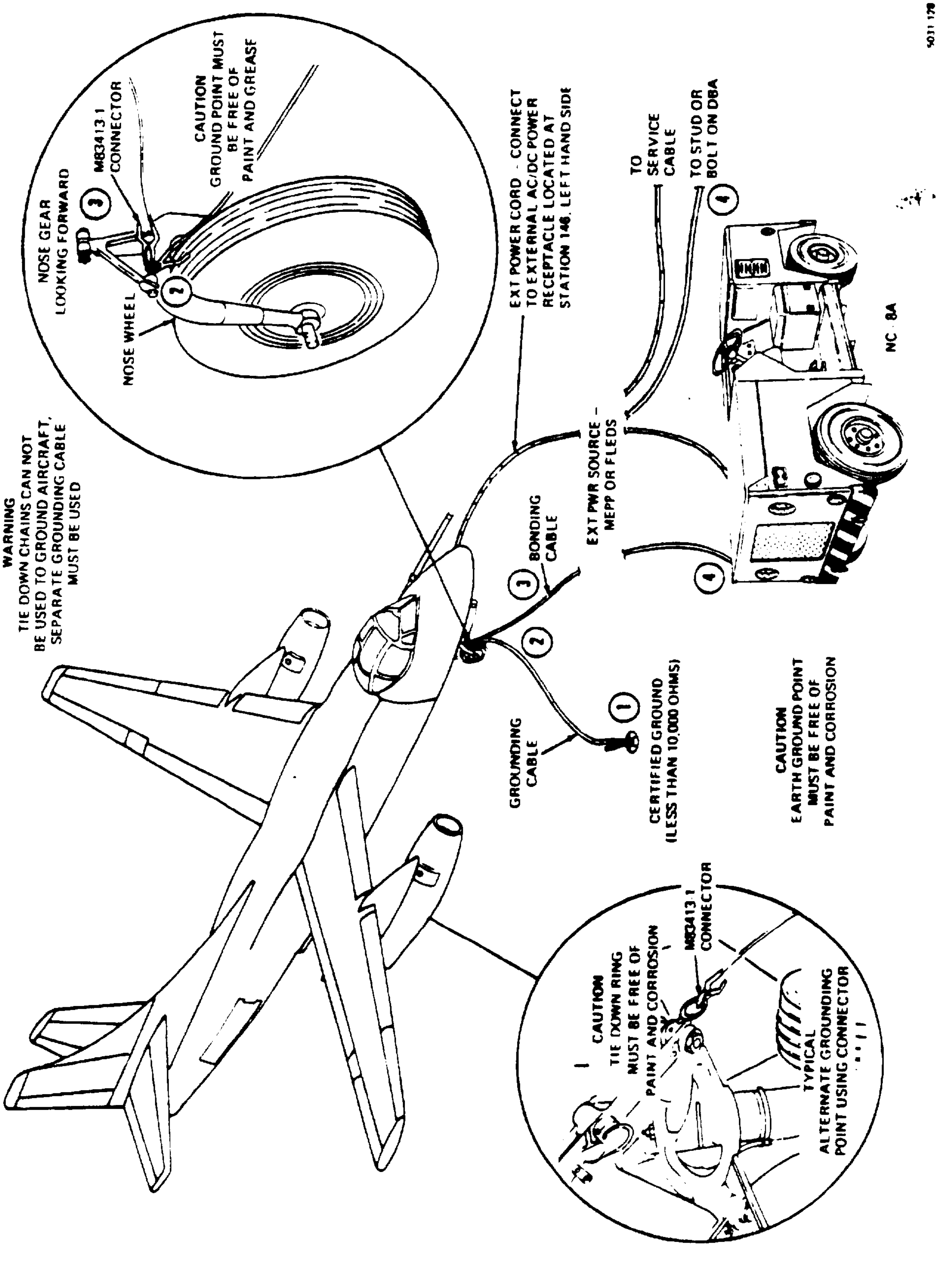

FIGURE 2-4. Apron-based A-3 aircraft grounding, maintenance evolution.

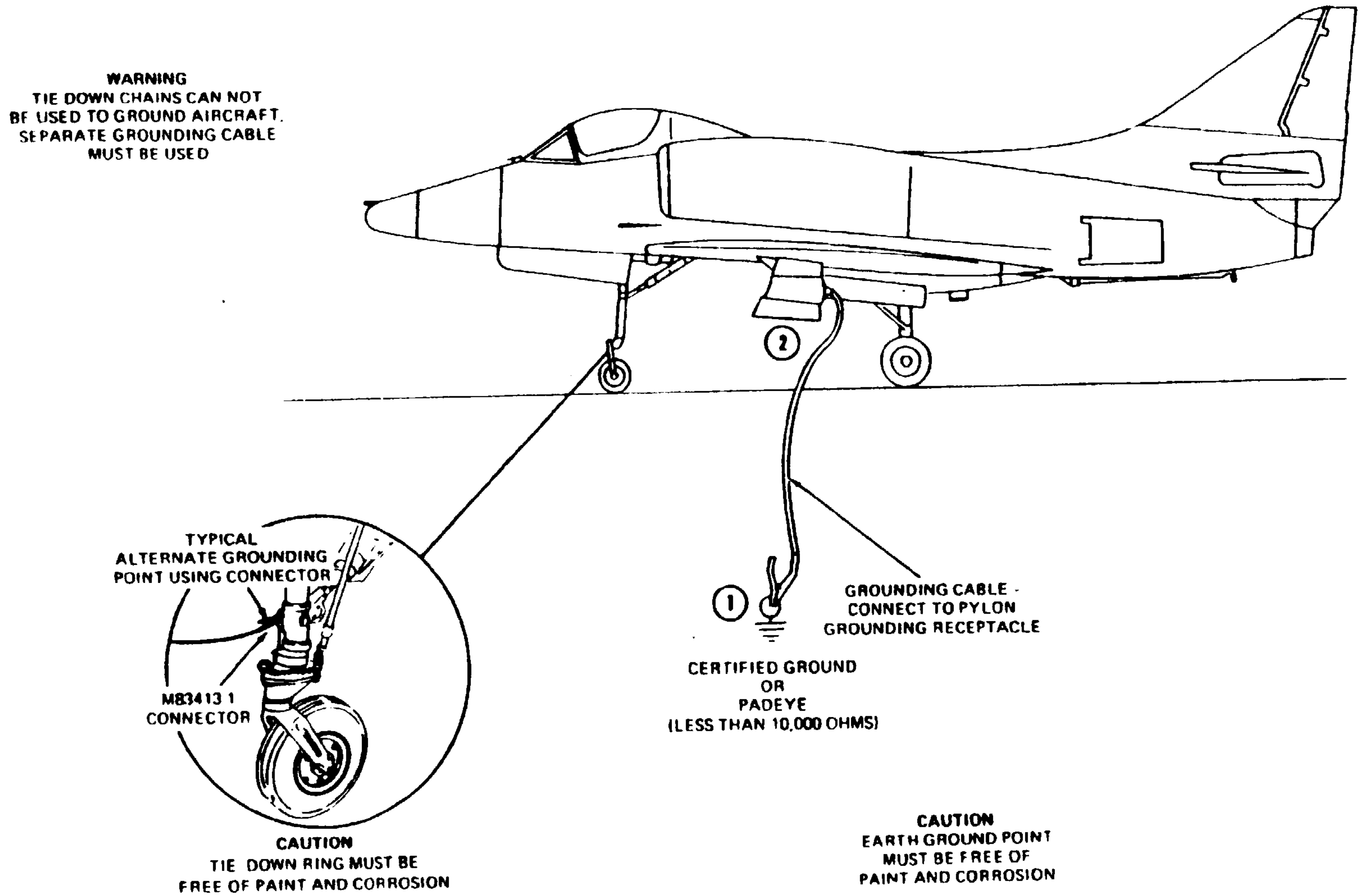

FIGURE 2-5. <u>A-4 aircraft grounding, parked evolution.</u>

2.1.7 A-4 fueling/defueling evolution. To ground A-4 aircraft when fueling or defueling, proceed as follows (see figure 2-6):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to nose gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove bonding or grounding cable, reverse above procedures.

2.1.8 A-4 hangar-based maintenance evolution. To ground A-4 aircraft during maintenance in the hangar, proceed as follows (see figure 2-7):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with a M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.9 A-4 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground A-4 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-8):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

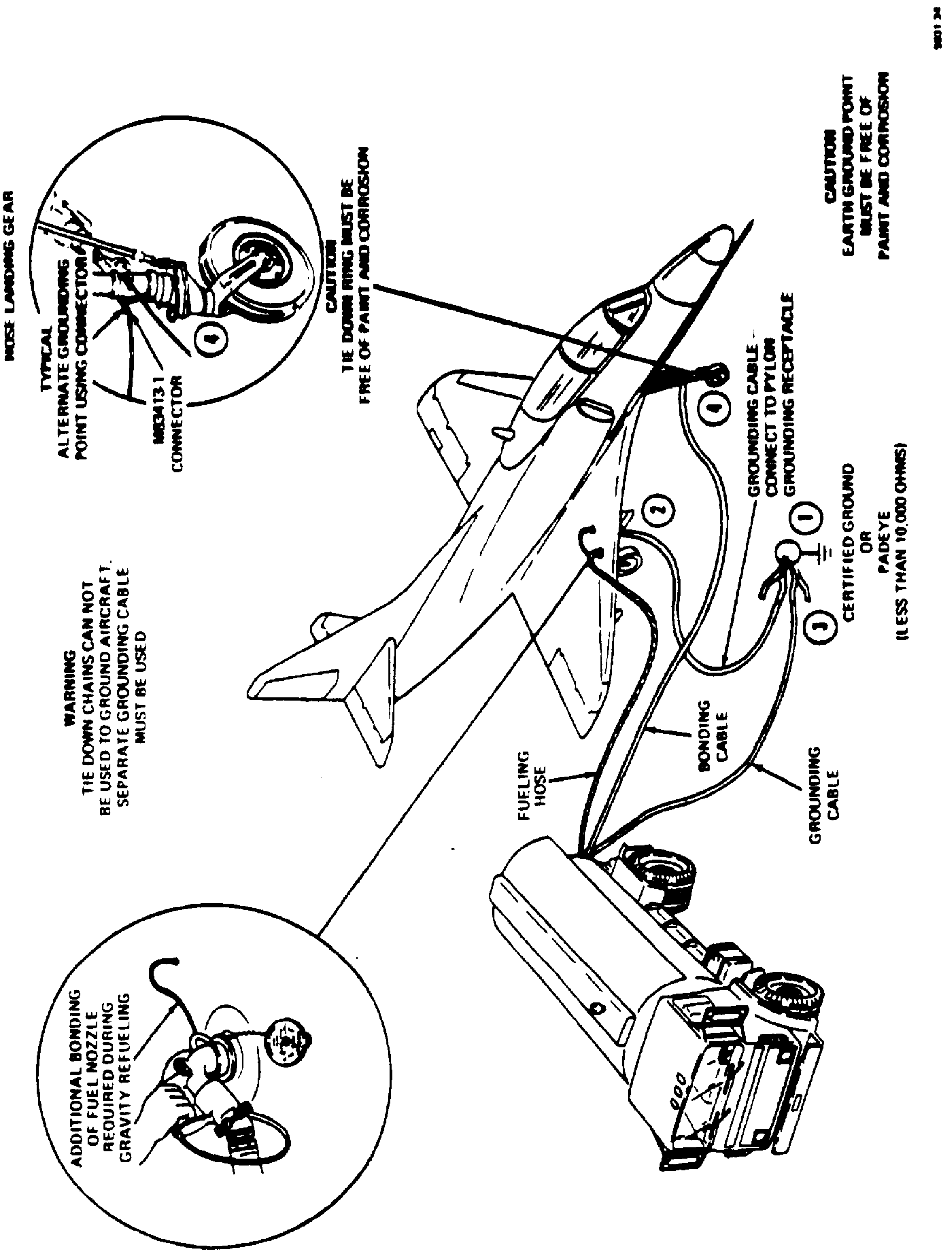

FIGURE 2-6. A-4 aircraft grounding, fueling/defueling evolution.

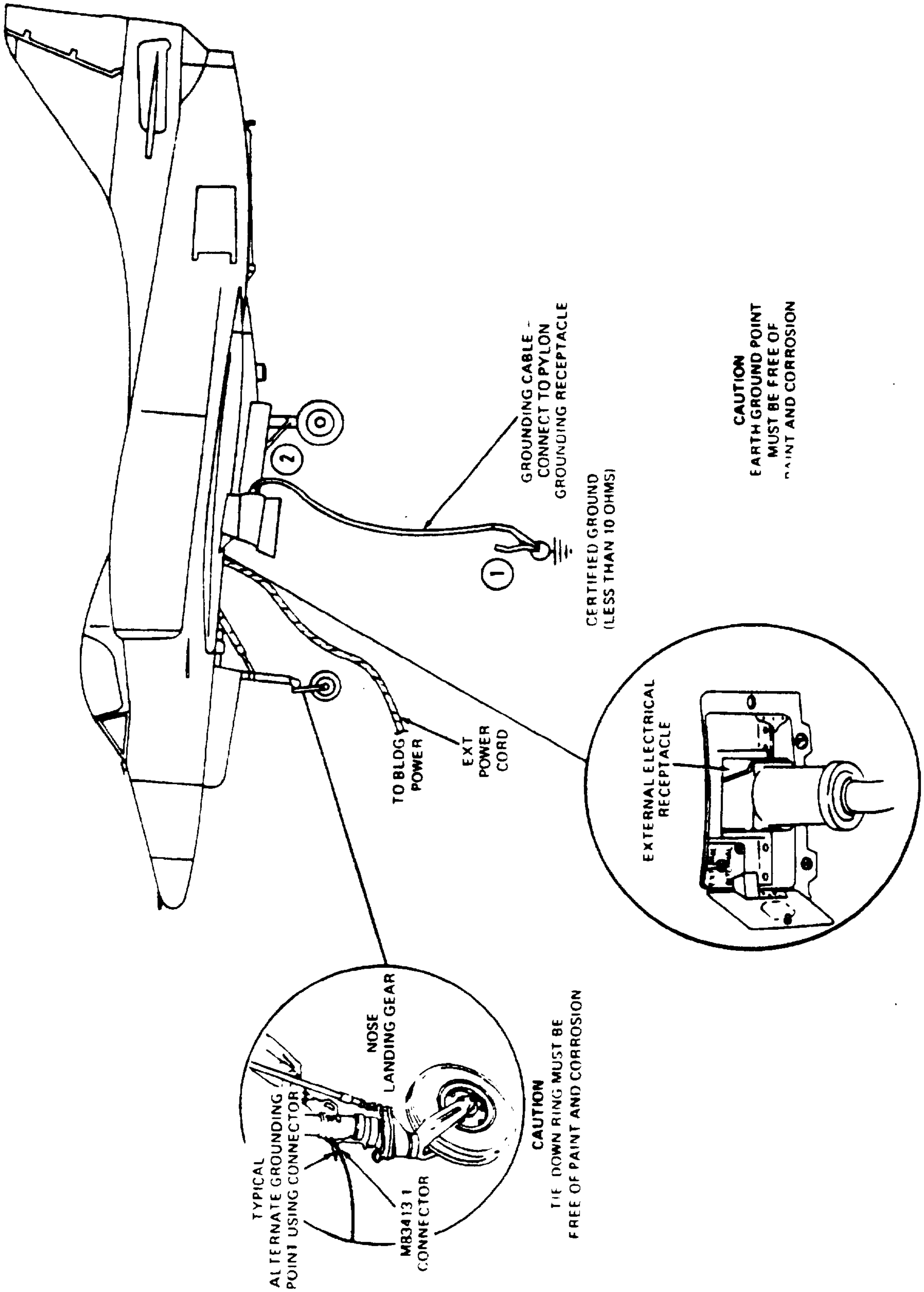

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FIGURE 2-7. Hangar-based A-4 aircraft grounding, maintenance evolution.

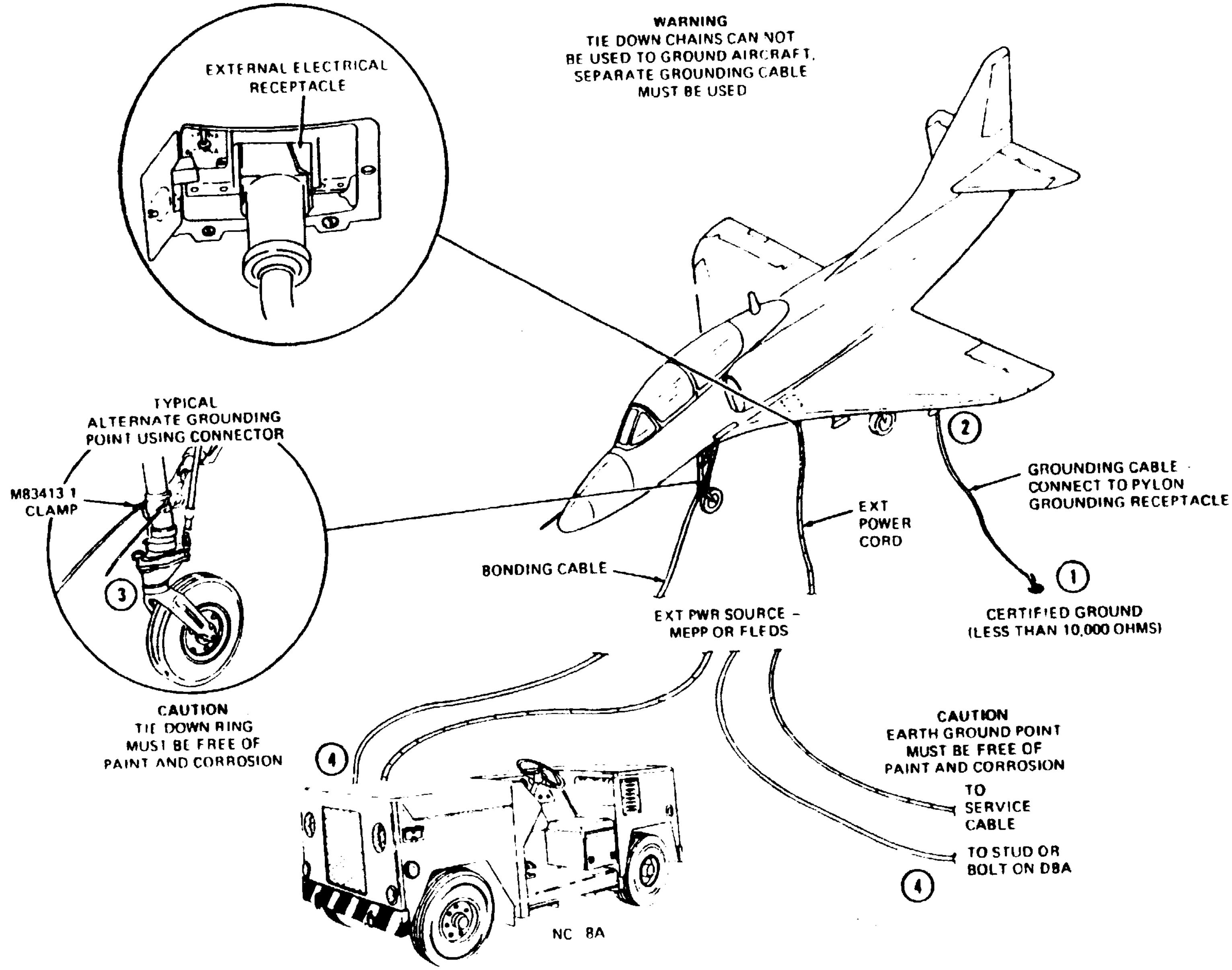

FIGURE 2-8. Apron-based A-4 aircraft grounding, maintenance evolution.

2.1.10 A-4 apron-based maintenance evolution (using FLEDS). To ground A-4 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-8):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.11 A-4 stores loading/unloading evolution. To ground A-4 aircraft during stores loading or unloading, proceed as follows (see figure 2-9):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.12. A-6 parked evolution. To ground A-6 aircraft when in the parked evolution, proceed as follows (see figure 2-10):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.13 A-6 fueling/defueling evolution. To ground A-6 aircraft when fueling or defueling, proceed as follows (see figure 2-11):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).

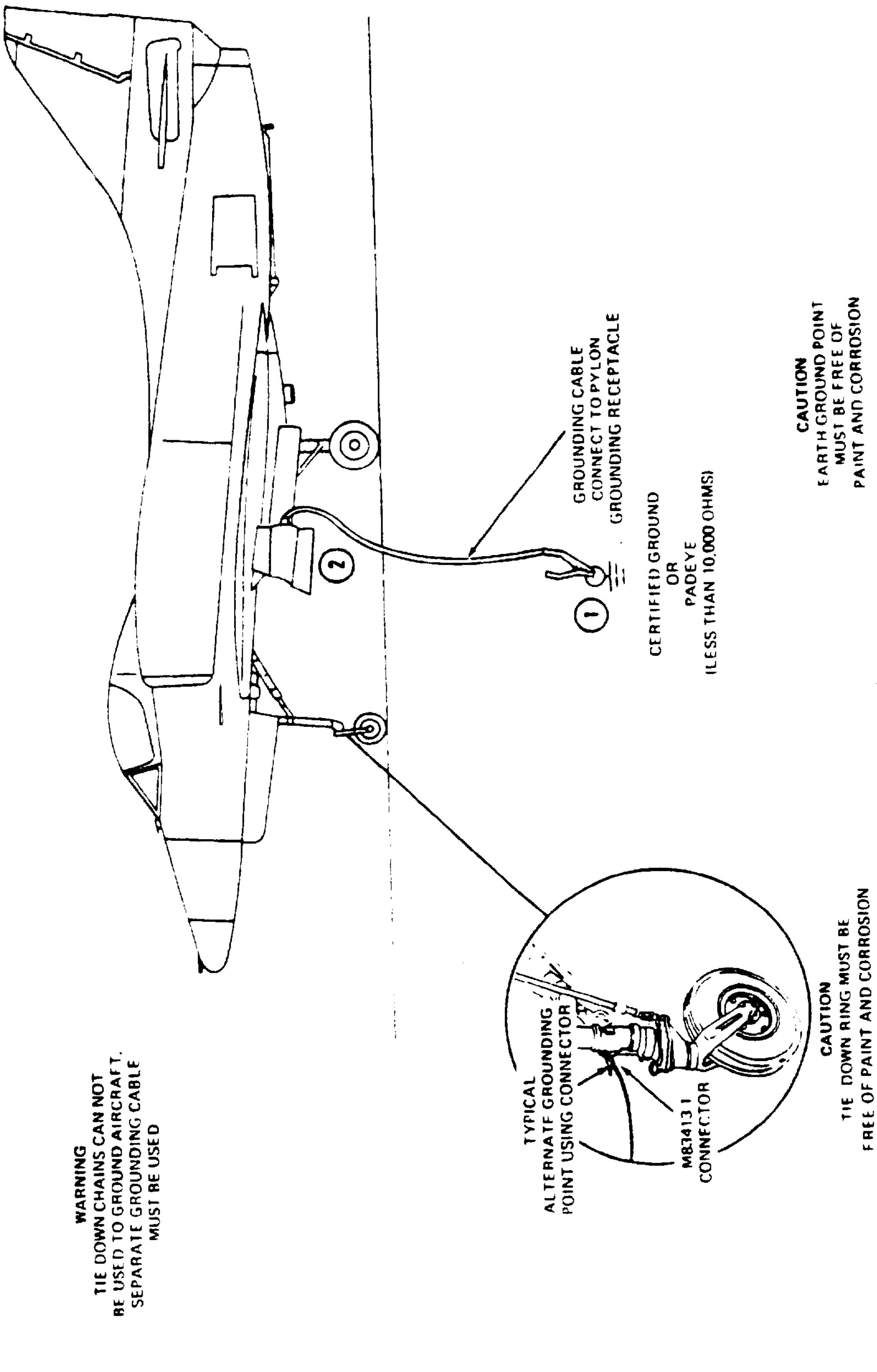

FIGURE 2-9. A-4 aircraft grounding, stores loading/unloading evolution.

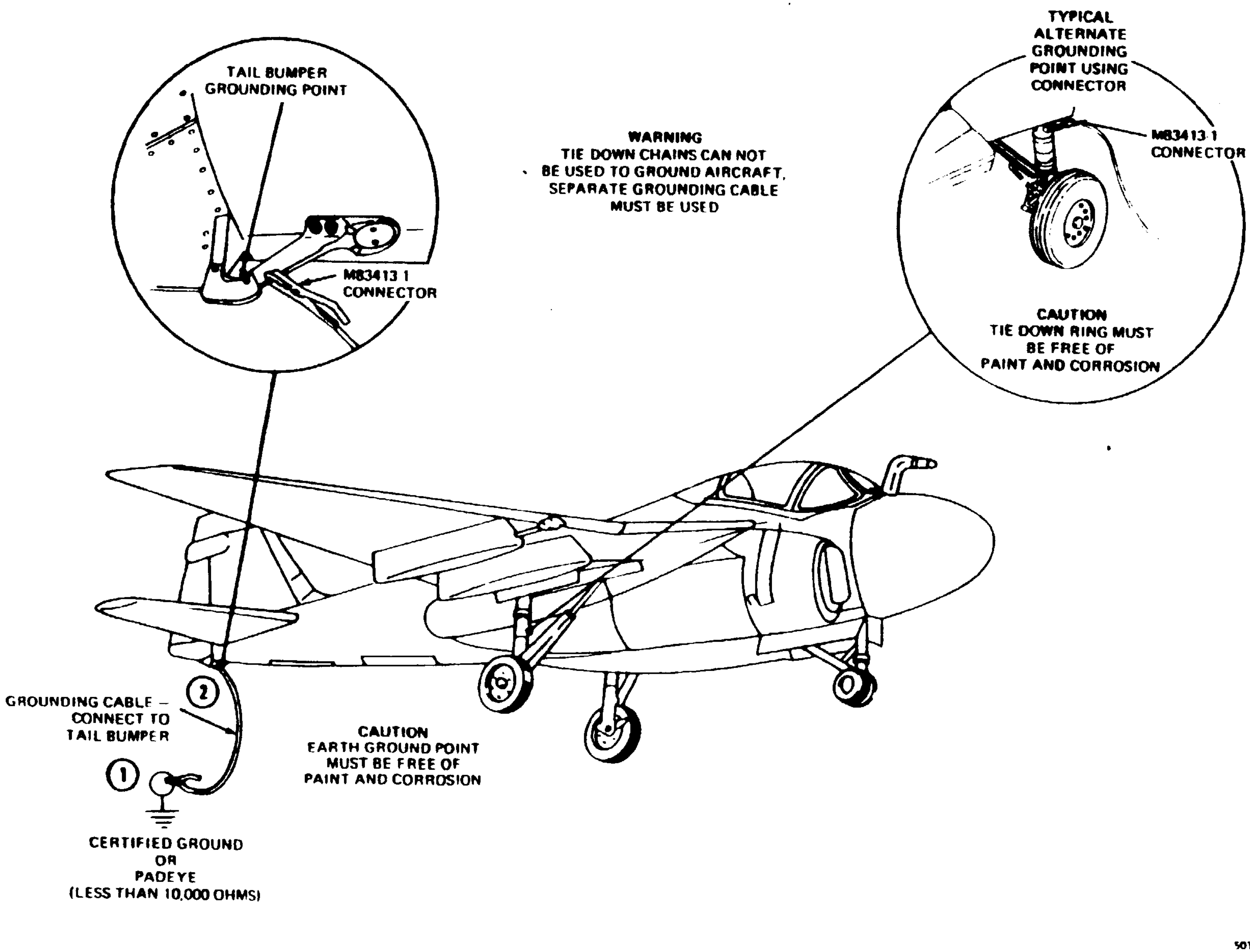

FIGURE 2-10. A-6 aircraft grounding, parked evolution.

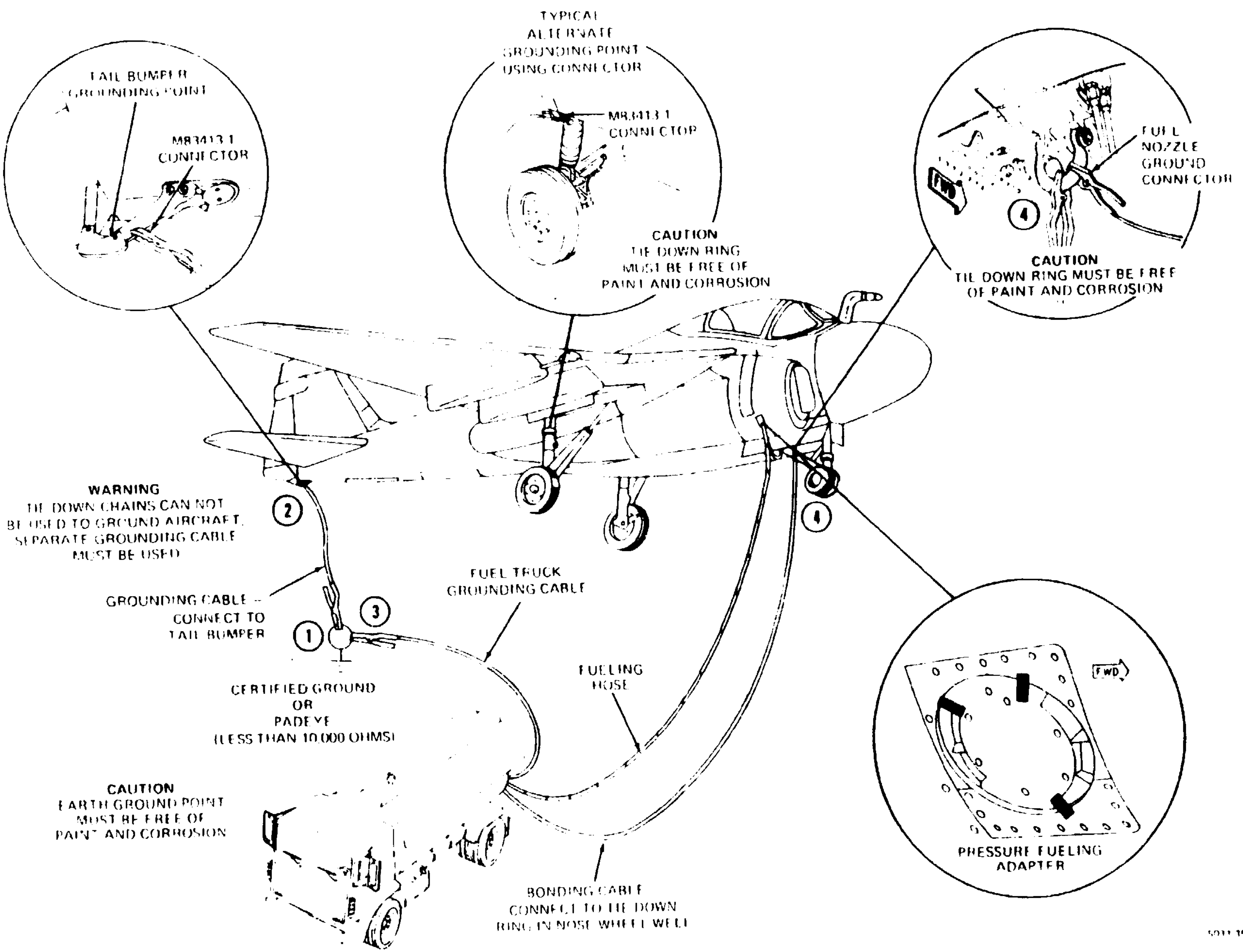

FIGURE 2-11. A-6 aircraft grounding, fueling/defueling evolution.

d. Connect fuel truck bonding cable to nose landing gear (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.14 A-6 hangar-based maintenance evolution. To ground A-6 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-12):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.15 A-6 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground A-6 aircraft when in the maintenance evolution on the apron the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-13):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse the above procedures.

2.1.16 A-6 apron-based maintenance evolution (using FLEDS). To ground A-6 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-13):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to nose landing gear (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

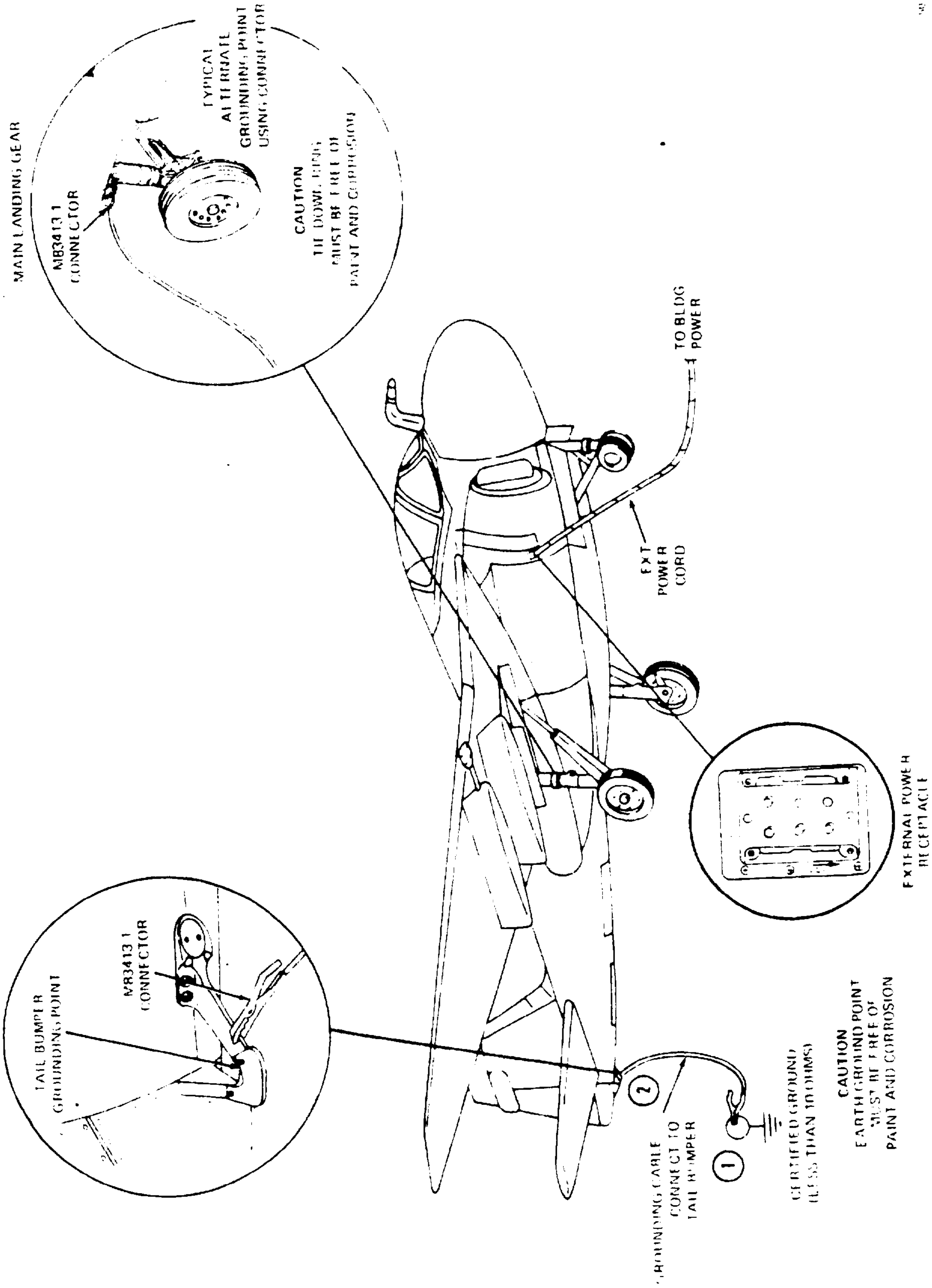

FIGURE 2-12. **Hangar-based A-6 aircraft grounding, maintenance evolution.**

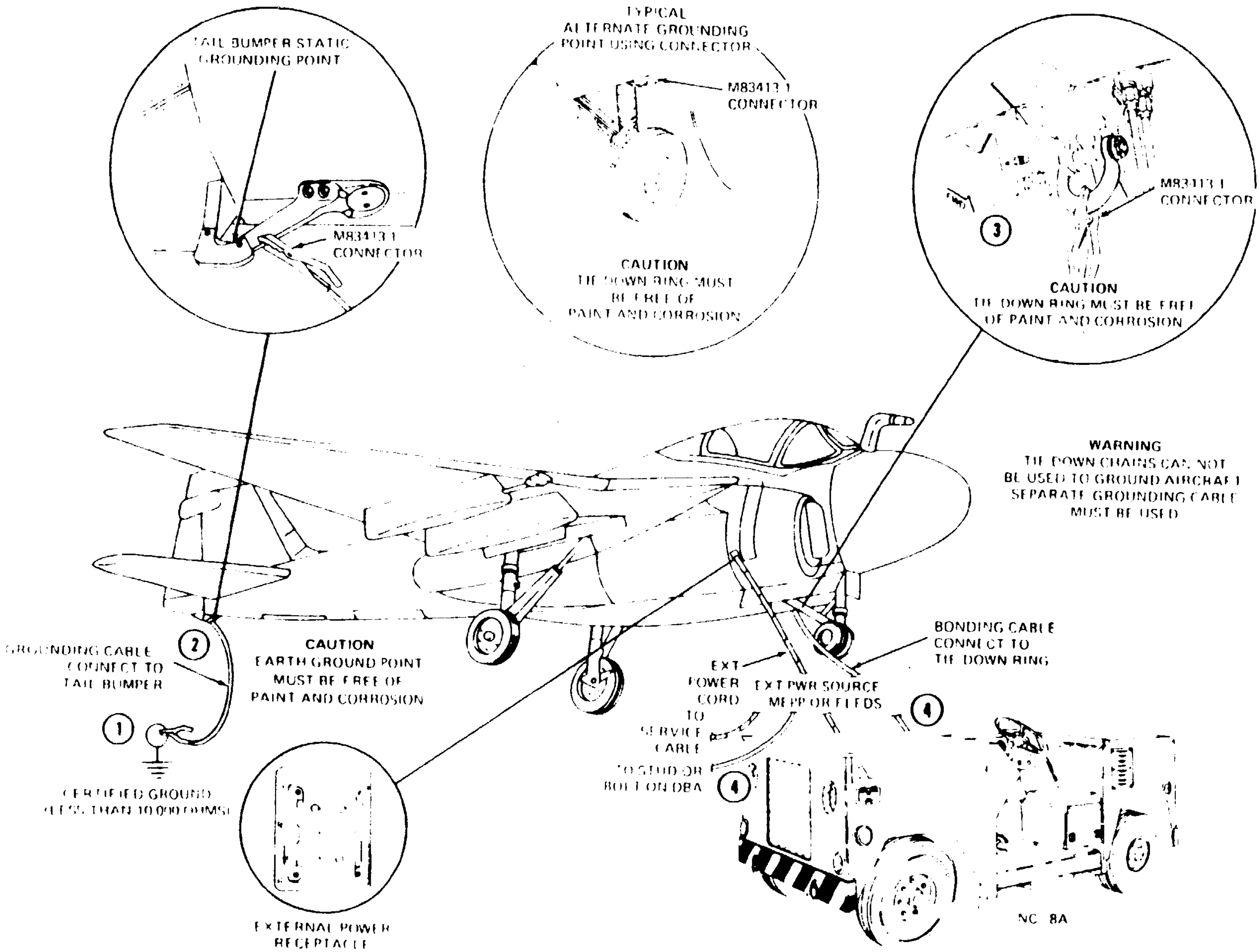

FIGURE 2-13. Apron-based A-6 aircraft grounding, maintenance evolution.

2.1.17 A-6 stores loading/unloading evolution. To ground A-6 aircraft during stores loading or unloading, proceed as follows (see figure 2-14):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.18 A-7 parked evolution. To ground A-7 aircraft when in the parked evolution, proceed as follows (see figure 2-15):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.19 A-7 fueling/defueling evolution. To ground A-7 aircraft when fueling or defueling, proceed as follows (see figure 2-16):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to nose gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove bonding or grounding cable, reverse above procedures.

2.1.20 A-7 hangar-based maintenance evolution. To ground A-7 aircraft during maintenance in the hangar, proceed as follows (see figure 2-17):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).

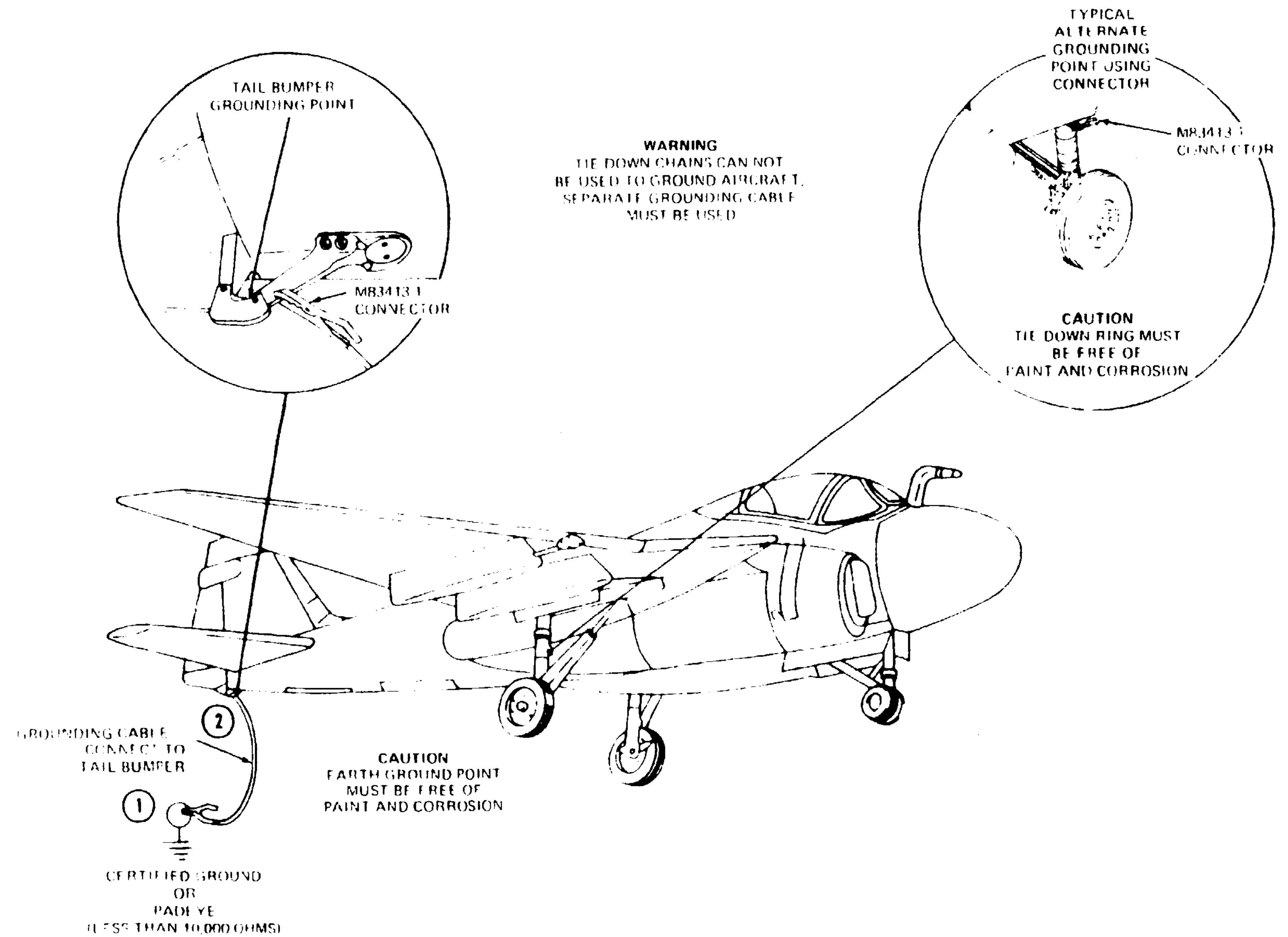

FIGURE 2-14. A-6 aircraft grounding, stores loading/unloading evolution.

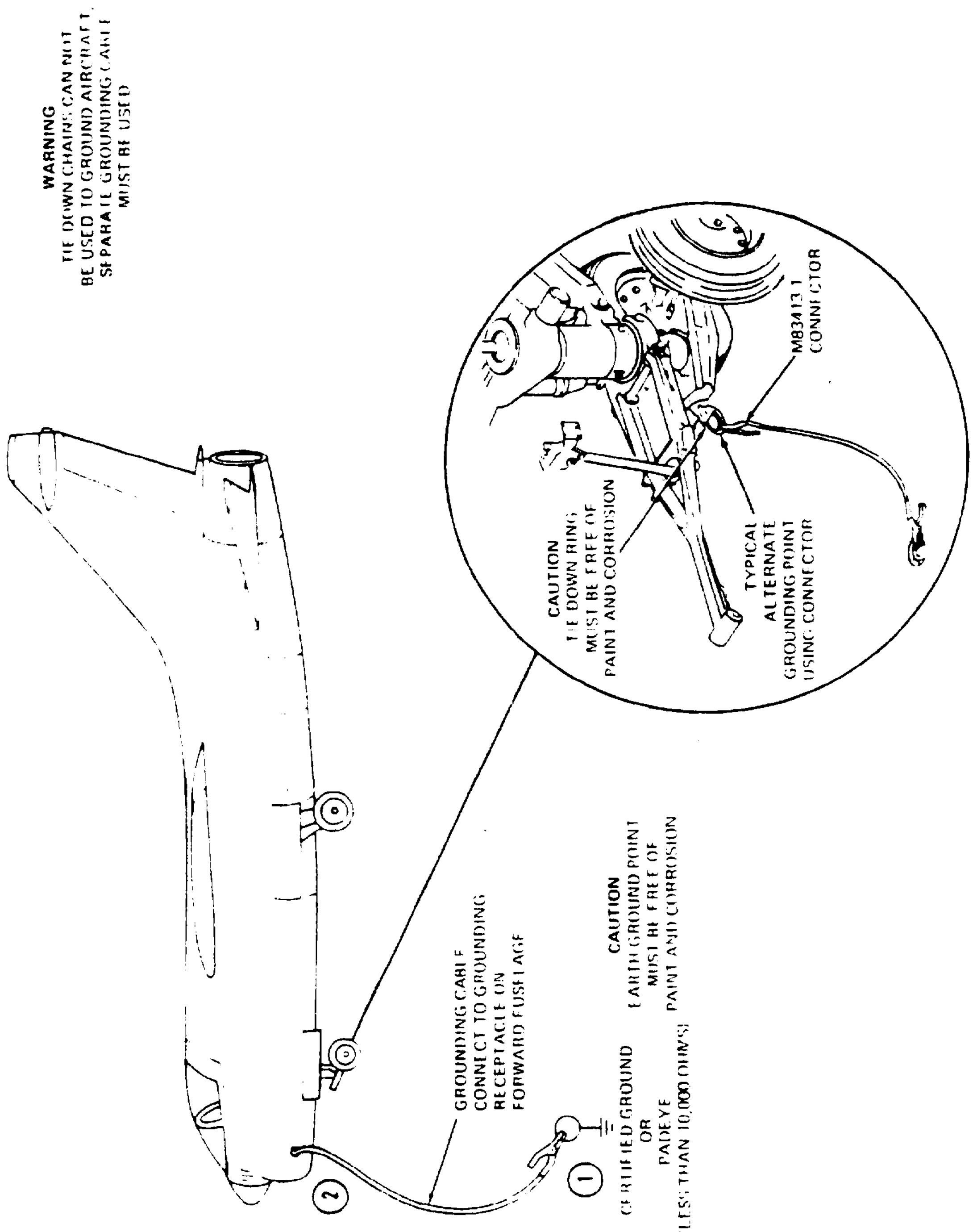

FIGURE 2-15. A-7 aircraft grounding, parked evolution.

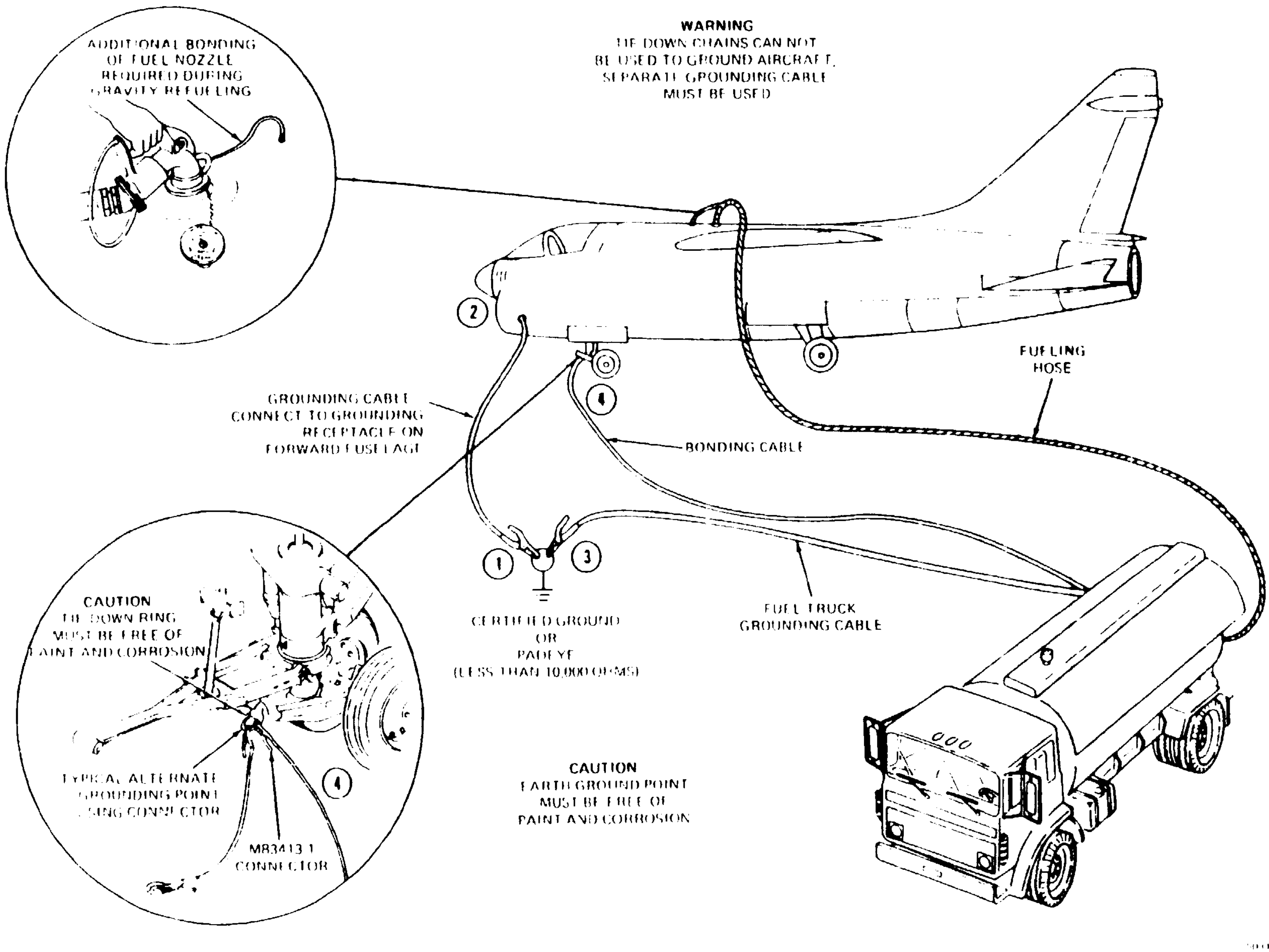

FIGURE 2-16. A-7 aircraft grounding, fueling/defueling evolution.

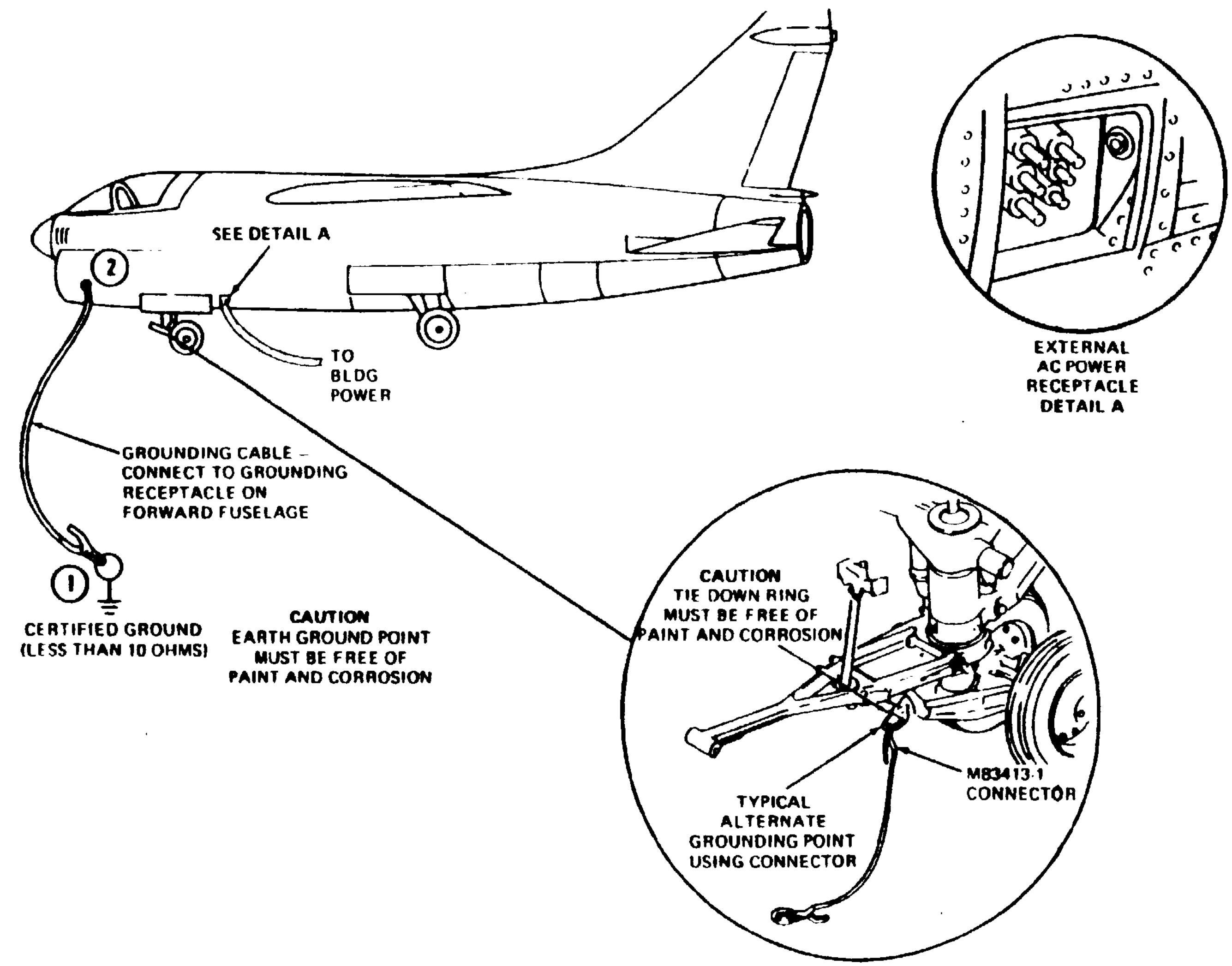

FIGURE 2-17. Hangar-based A-7 aircraft grounding, maintenance evolution.

c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.21 A-7 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground A-7 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-18):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.22 A-7 apron-based maintenance evolution (using FLEDS). To ground A-7 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-18):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

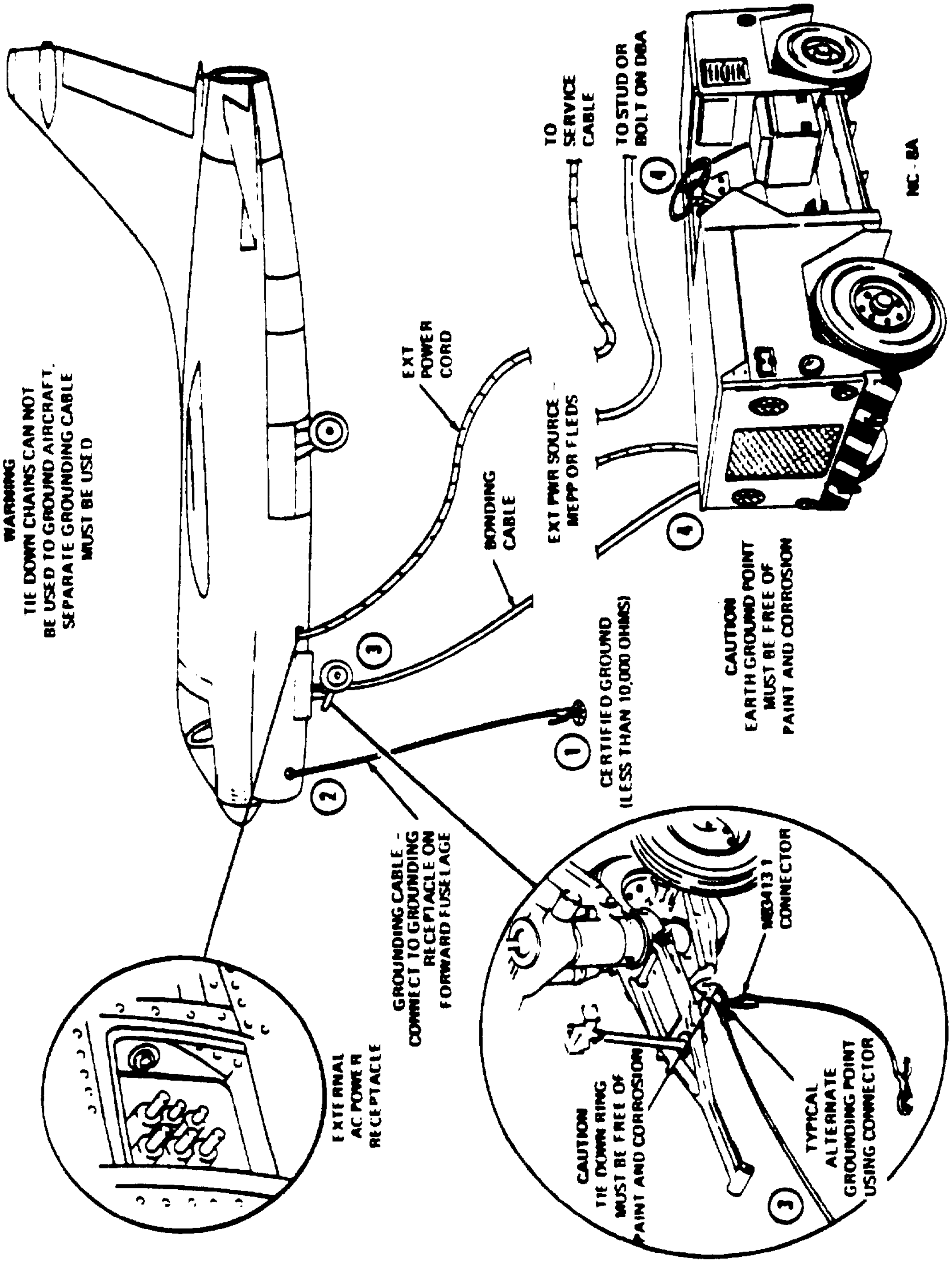

FIGURE 2-18. Apron-based A-7 aircraft grounding, maintenance evolution.

2.1.23 A-7 stores loading/unloading evolution. To ground A-7 aircraft during stores loading or unloading, proceed as follows (see figure 2-19):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.24. AH-1 parked evolution. To ground AH-1 aircraft when in the parked evolution, proceed as follows (see figure 2-20):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.25 AH-1 fueling/defueling evolution. To ground AH-1 aircraft when fueling or defueling, proceed as follows (see figure 2-21):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to front right towing ring (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.26 AH-1 hangar-based maintenance evolution. To ground AH-1 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-22):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

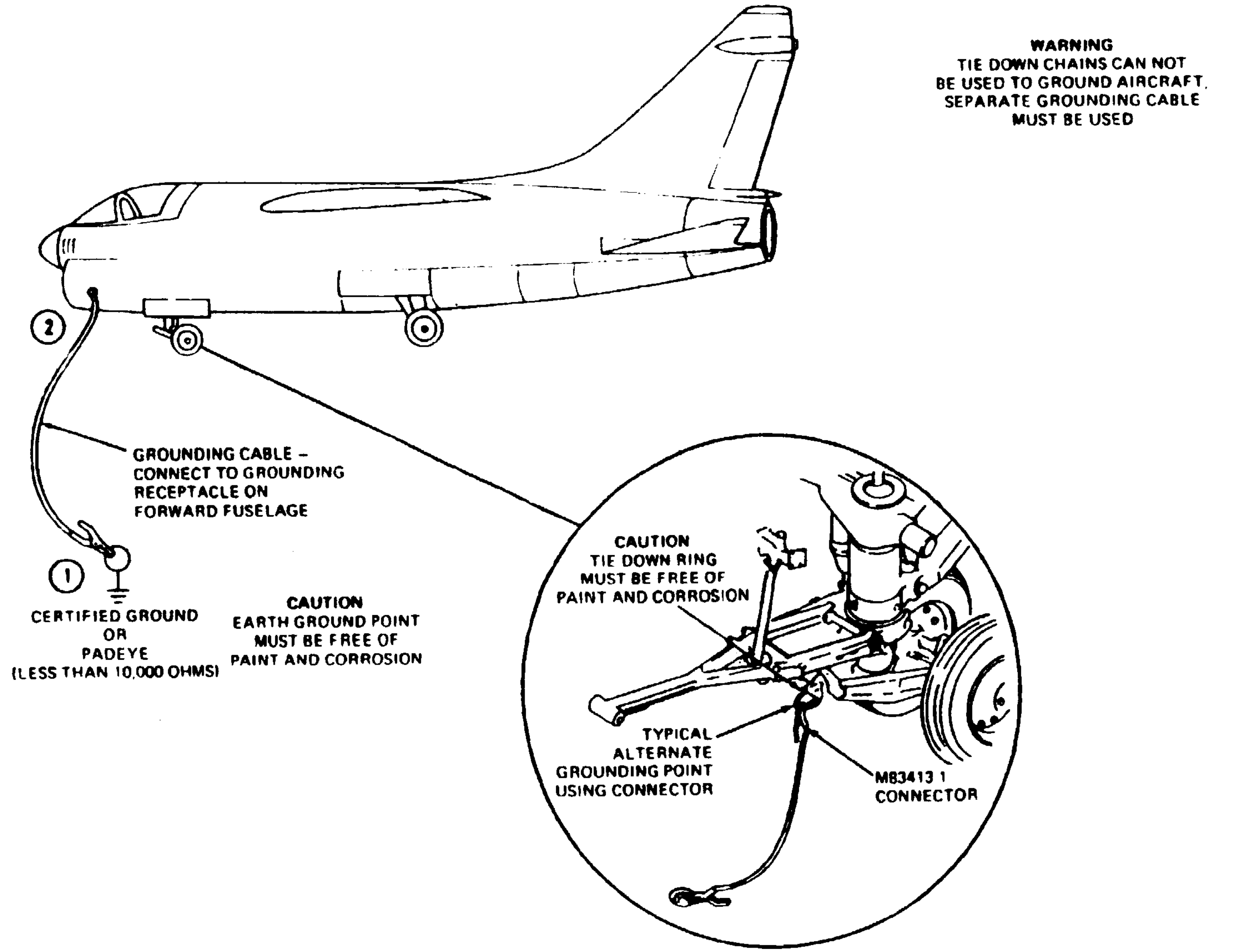

FIGURE 2-19. A-7 aircraft grounding, stores loading/unloading evolution.

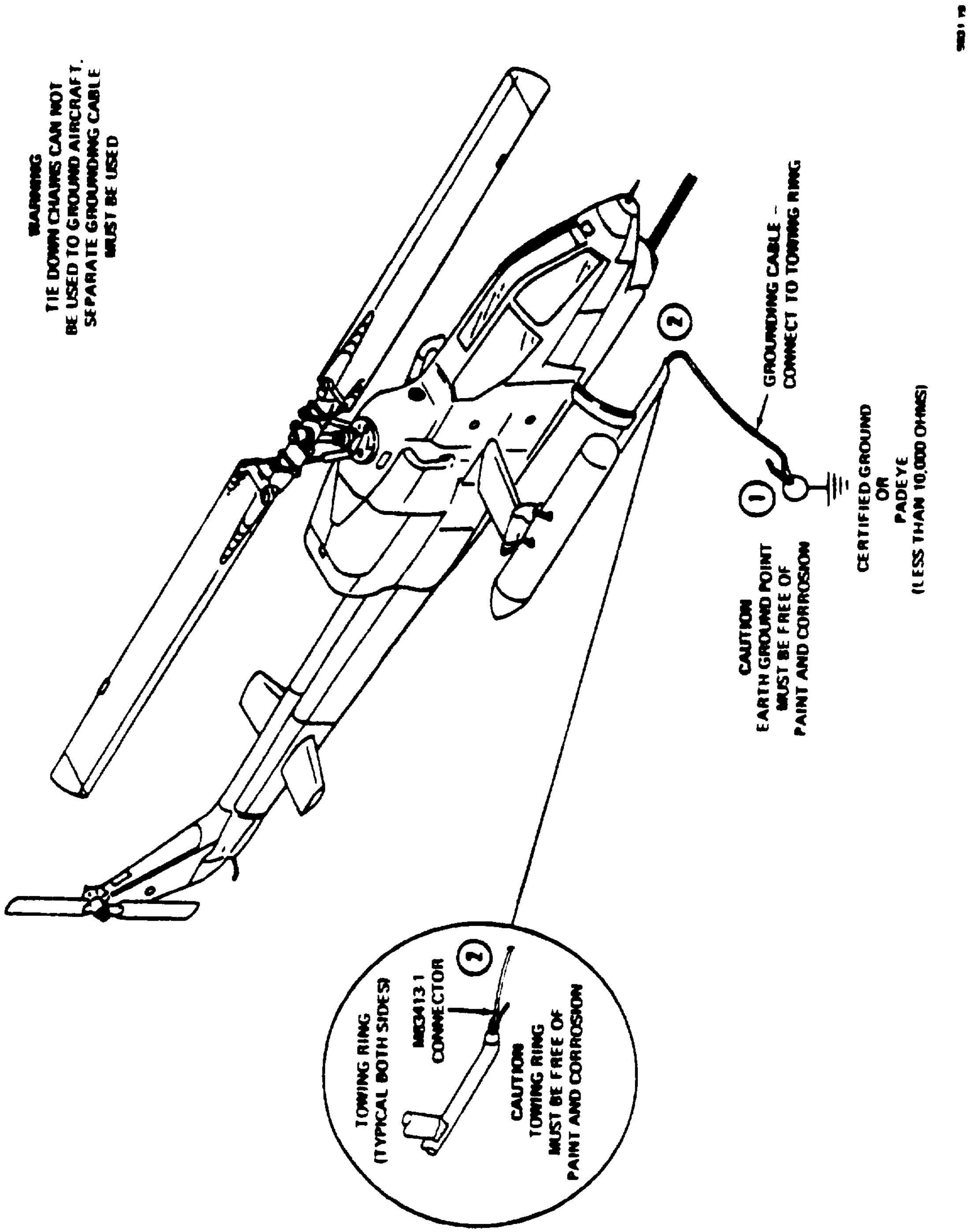

FIGURE 2-20. AH-1 aircraft grounding, parked evolution.

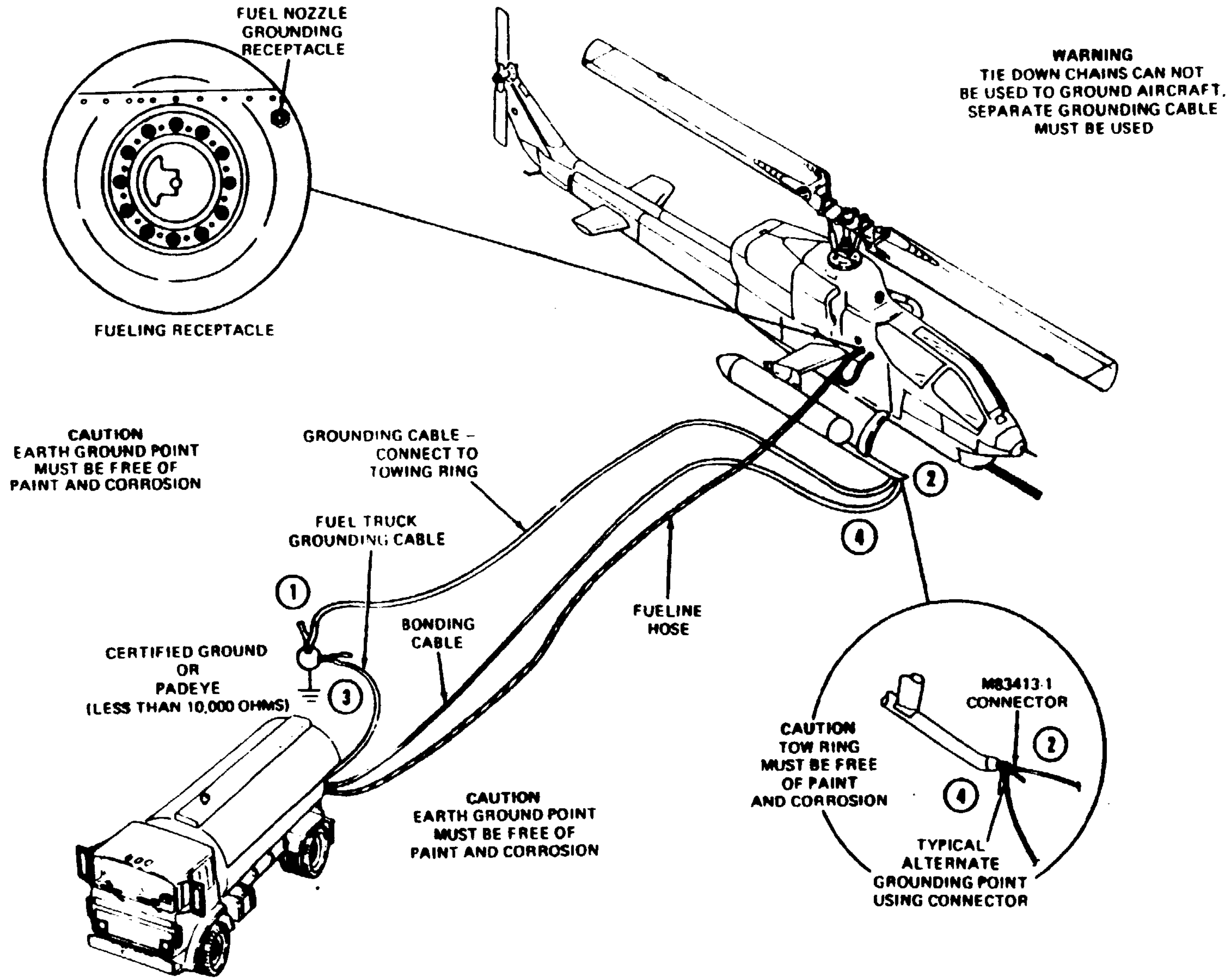

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FIGURE 2-21. AH-1 aircraft grounding, fueling/defueling evolution.

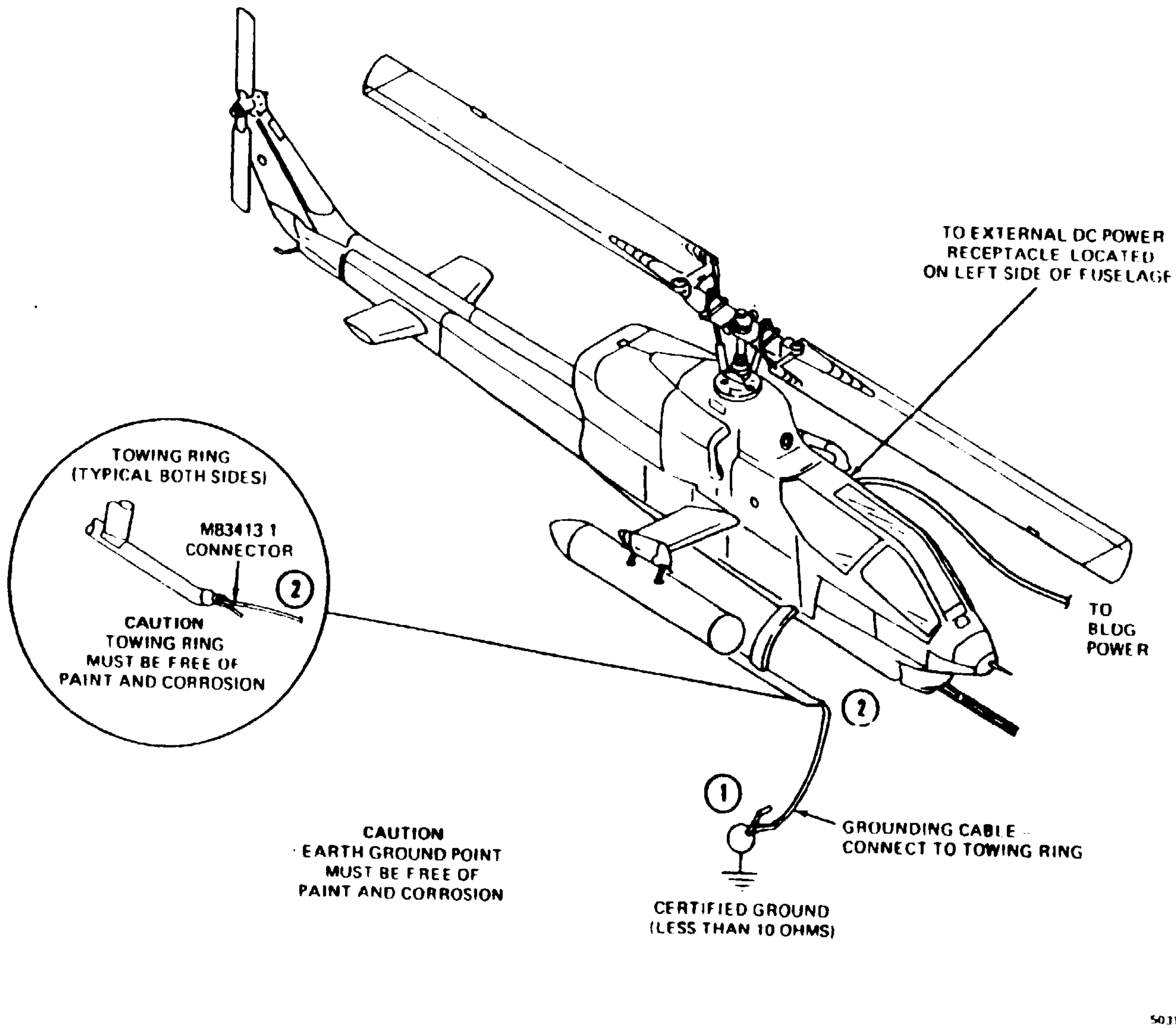

FIGURE 2-22. Hangar-based AH-1 aircraft grounding, maintenance evolution.

2.1.27 AH-1 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground AH-1 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-23):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

c. Attach bonding cable with M83413-1 electrical ground connector to front right towing ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.28 AH-1 stores loading/unloading evolution. To ground AV-8 aircraft during stores loading or unloading, proceed as follows (see figure 2-24):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.29 AV-8 parked evolution. To ground AV-8 aircraft when in the parked evolution, proceed as follows (see figure 2-25):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.30 AV-8 fueling/defueling evolution. To ground AV-8 aircraft when fueling or defueling, proceed as follows (see figure 2-26):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding

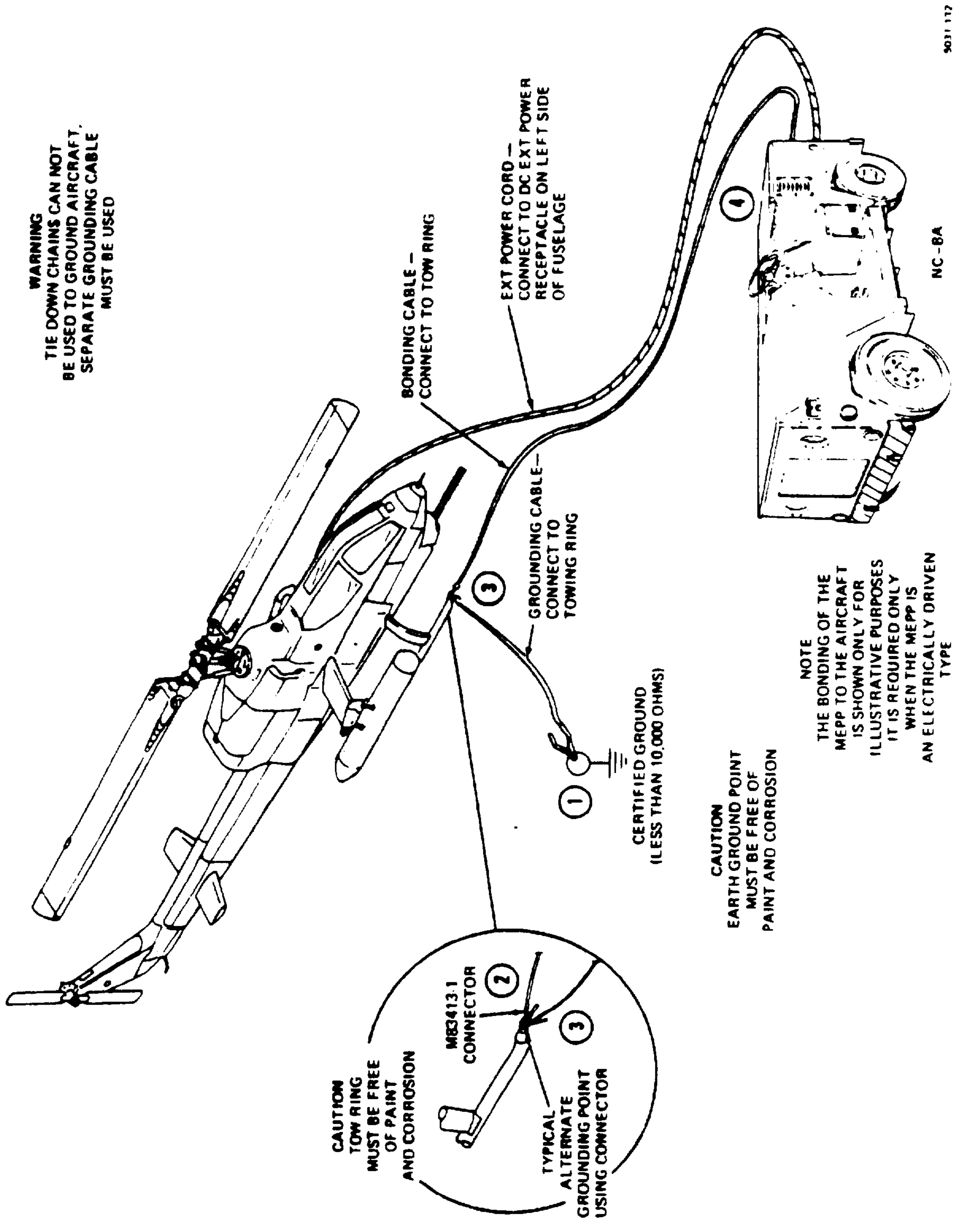

FIGURE 2-23. Apron-based AH-1 aircraft grounding, maintenance evolution.

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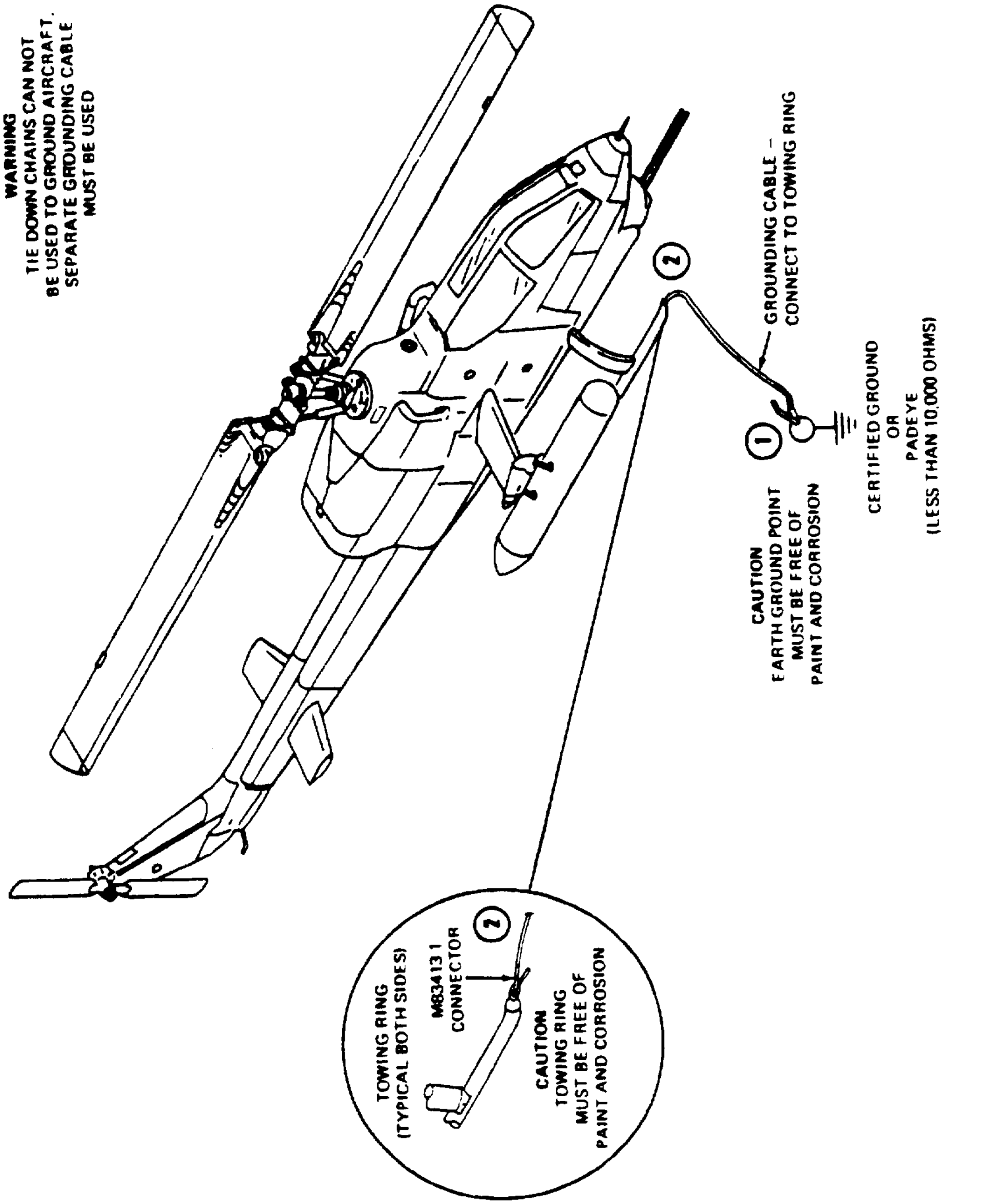


FIGURE 2-24. AH-1 aircraft grounding, stores loading/unloading evolution.

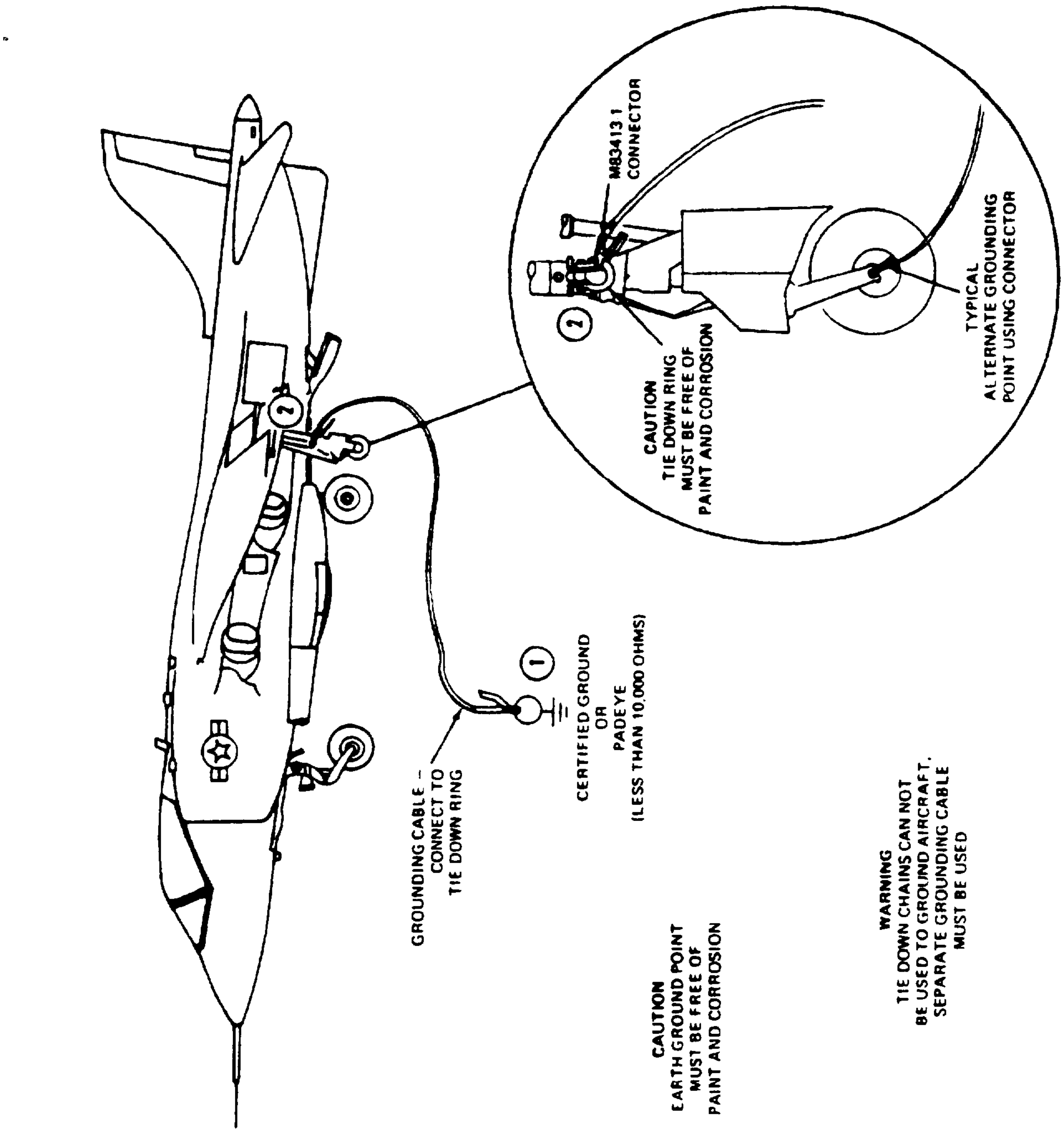


FIGURE 2-25. AV-8 aircraft grounding, parked evolution.

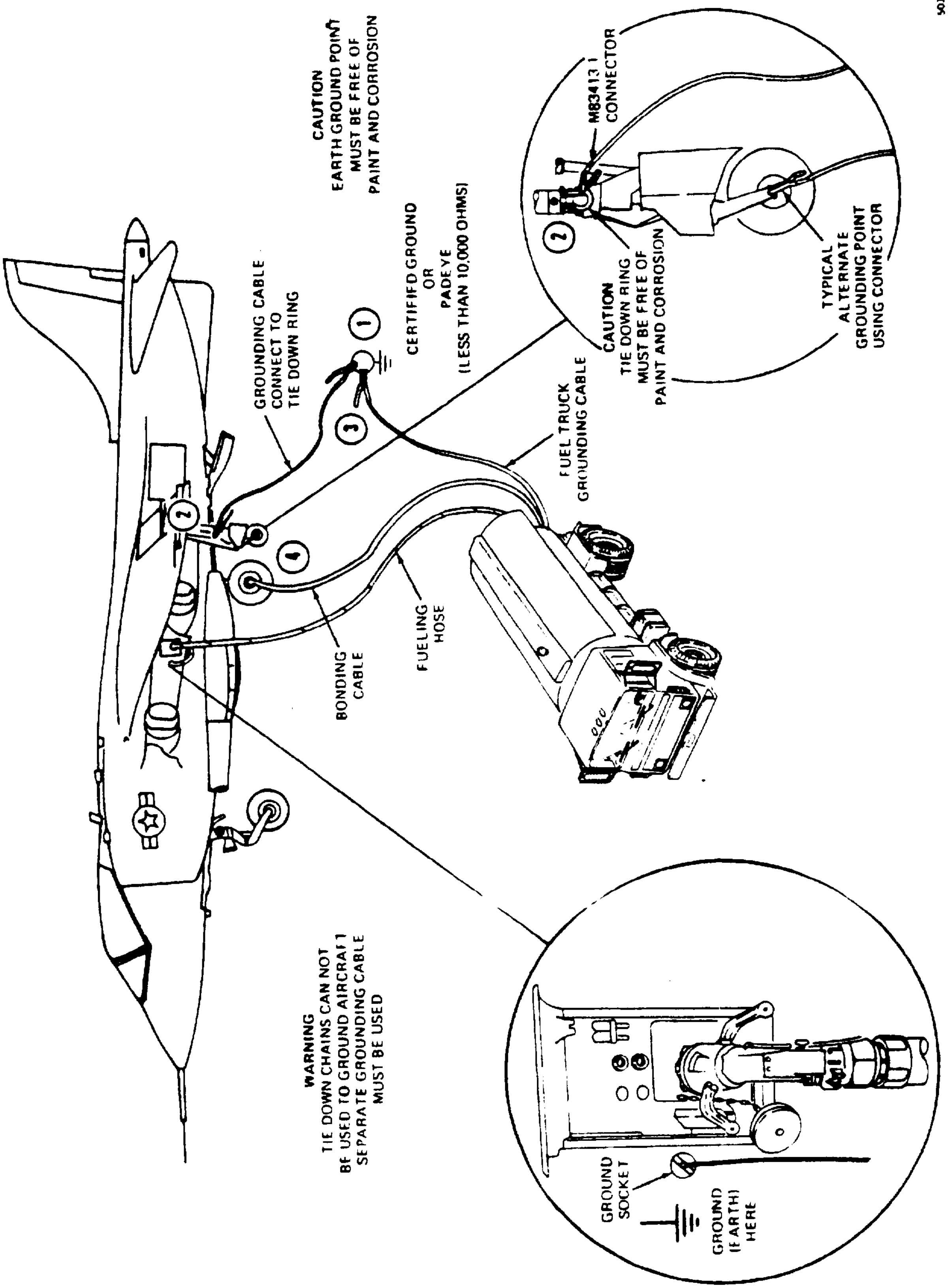


FIGURE 2-26. AV-8 aircraft grounding, fueling/defueling evolution.

cable to bottom part of outrigger gear leg (typical alternate grounding point).

c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to main wheel axle (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.31 AV-8 hangar-based maintenance evolution. To ground AV-8 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-27):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.32 AV-8 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground AV-8 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-28):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse the above procedures.

2.1.33 AV-8 apron-based maintenance evolution (using FLEDS). To ground AV-8 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-28):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).

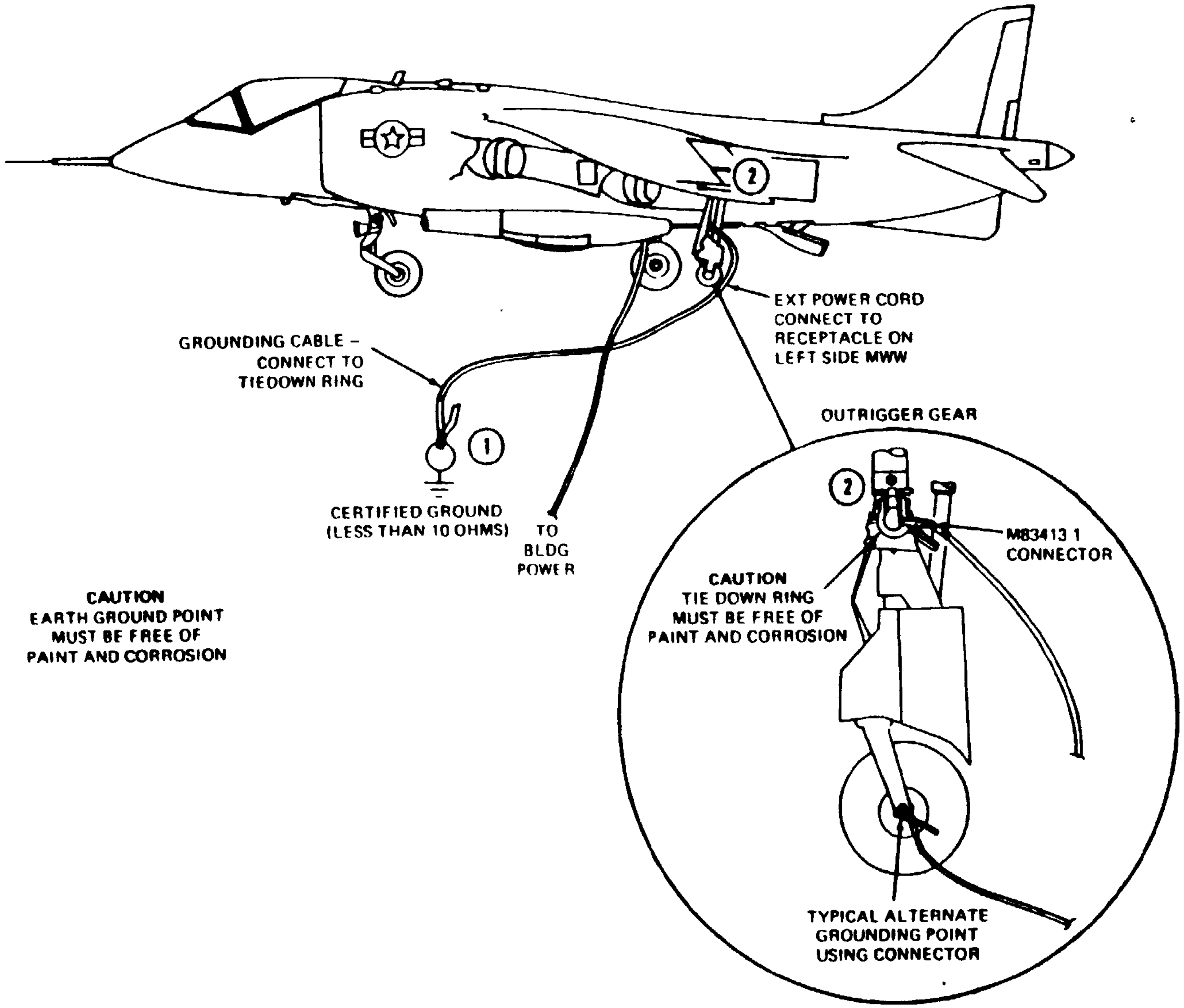


FIGURE 2-27. Hangar-based AV-8 aircraft grounding, maintenance evolution.

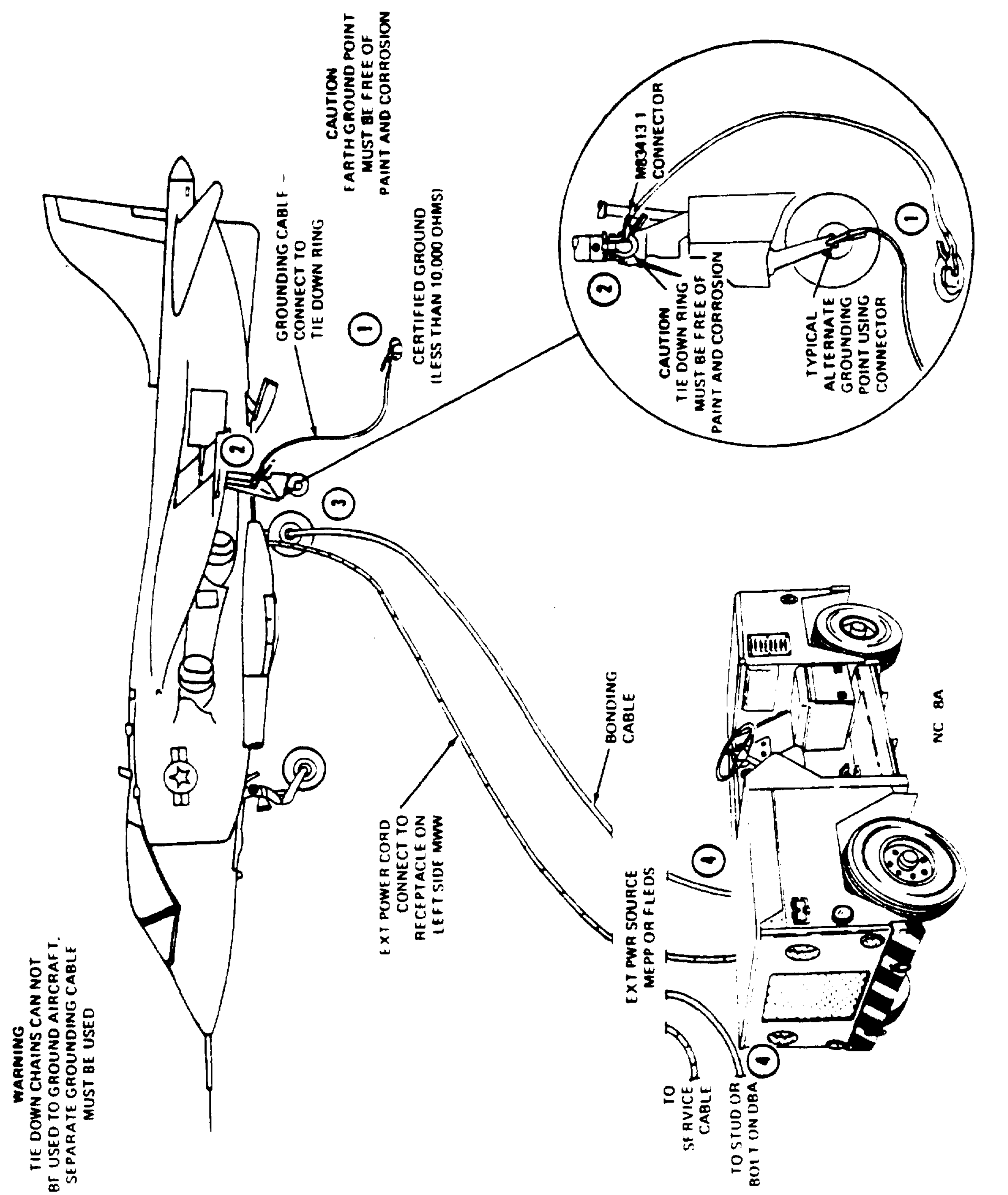


FIGURE 2-28. Apron-based AV-8 aircraft grounding, maintenance evolution.

c. Attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.34 AV-8 stores loading/unloading evolution. To ground AV-8 aircraft during stores loading or unloading, proceed as follows (see figure 2-29):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.35 C-1 parked evolution. To ground C-1 aircraft when in the parked evolution, proceed as follows (see figure 2-30):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.36 C-1 Fueling/defueling evolution. To ground C-1 aircraft when fueling or defueling, proceed as follows (see figure 2-31):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of ground cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to nose gear towing ring (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.37 C-1 hangar-based maintenance evolution. To ground C-1 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-32):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

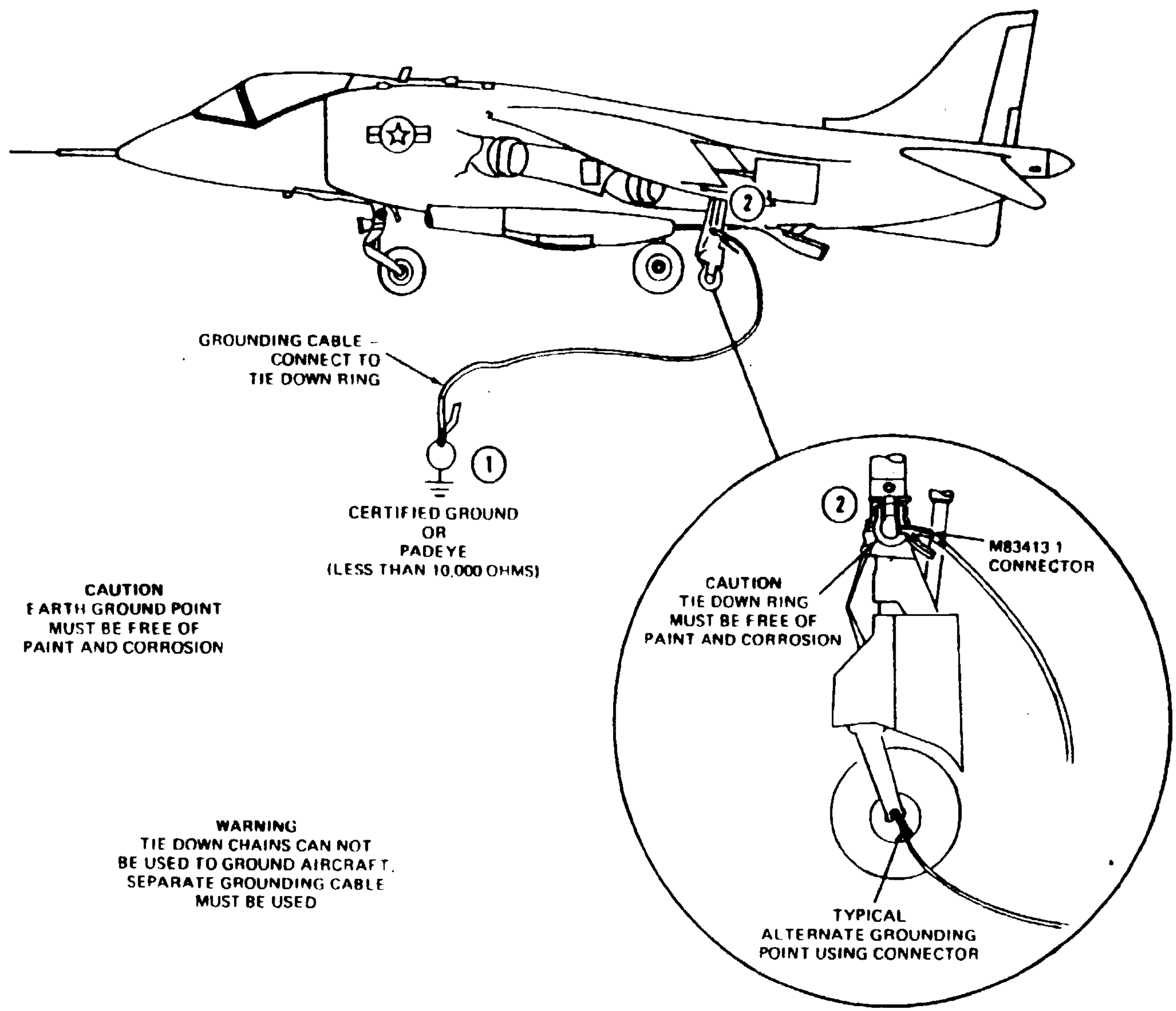


FIGURE 2-29. AV-8 aircraft grounding, stores loading/unloading evolution.

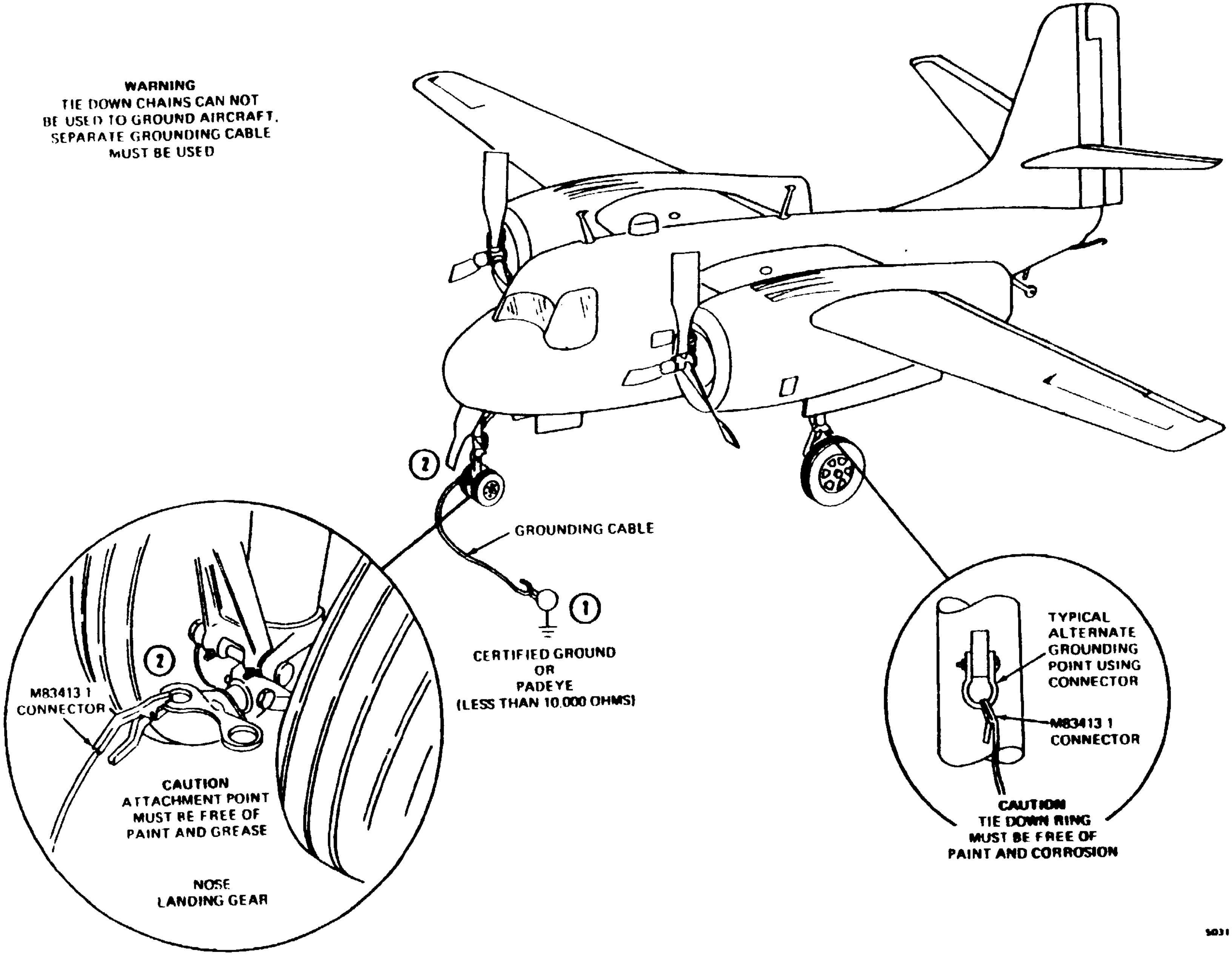


FIGURE 2-30. C-1 aircraft grounding, parked evolution.

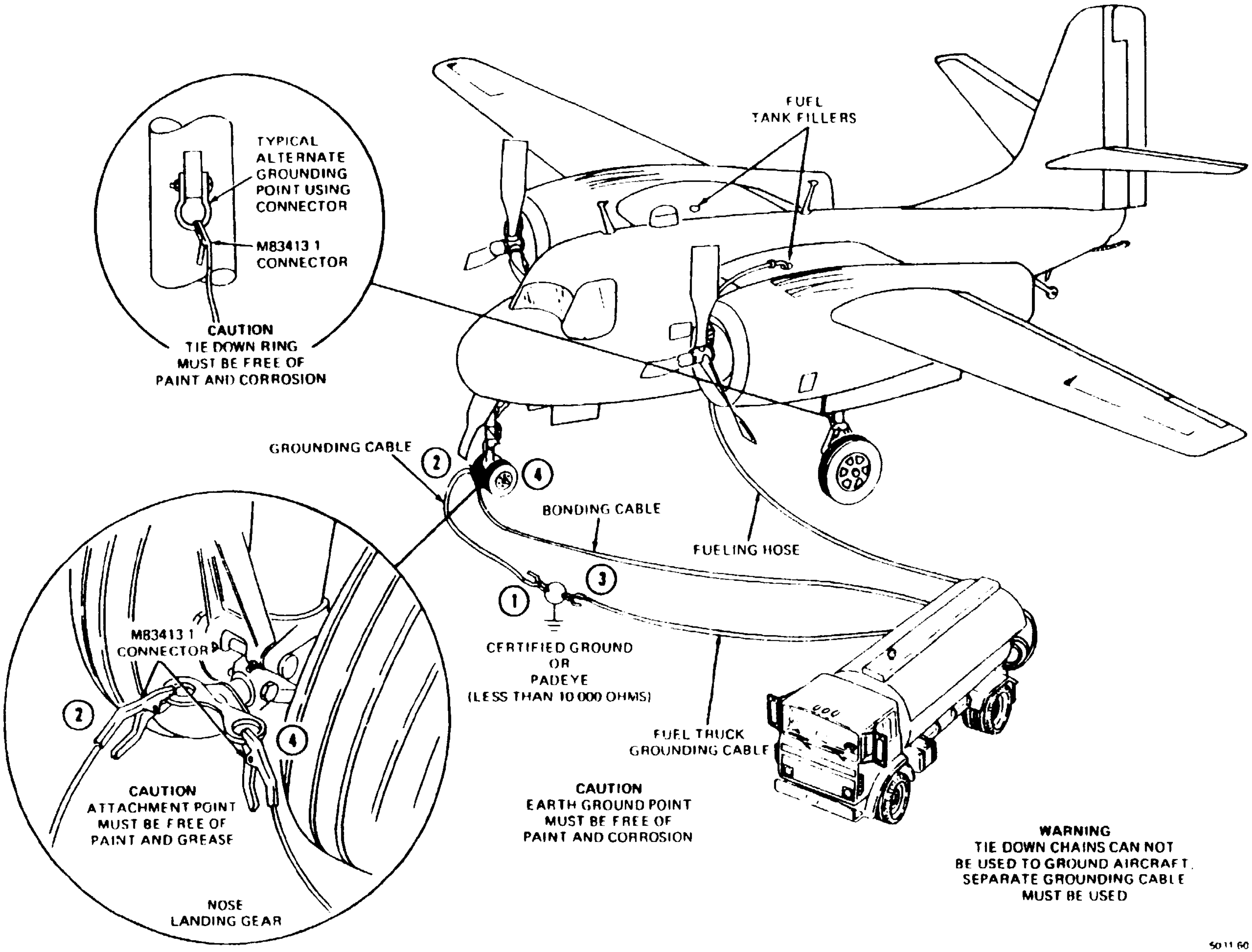


FIGURE 2-31. C-1 aircraft grounding, fueling/defueling evolution.

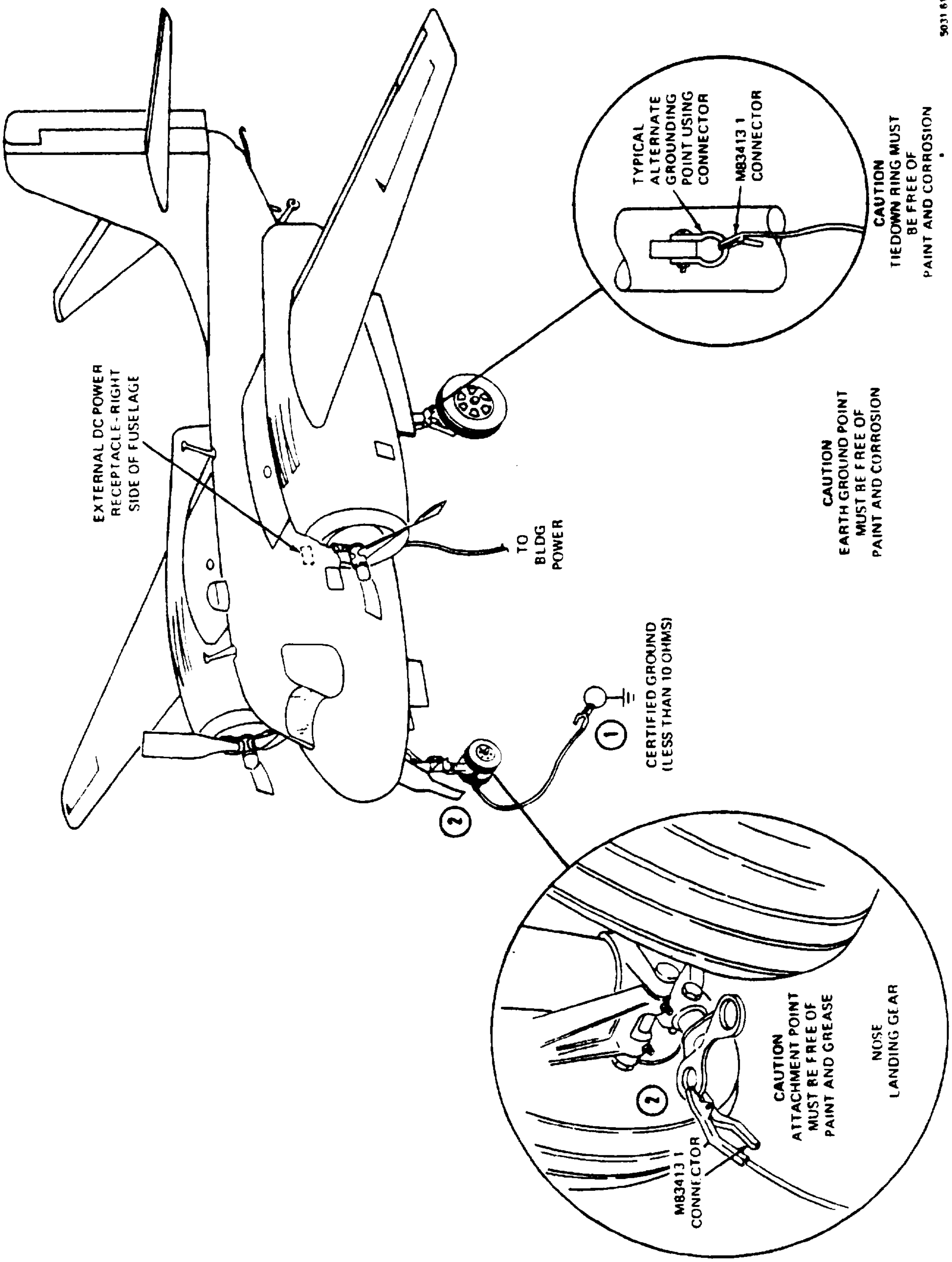


FIGURE 2-32. Hangar-based C-1 aircraft grounding, maintenance evolution.

2.1.38 C-1 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground C-1 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-33):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to the nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

c. Attach bonding cable with M83413-1 electrical ground connector to nose gear towing ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.39 C-130 parked evolution. To ground C-130 aircraft when in the parked evolution, proceed as follows (see figure 2-34):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main wheel well door (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.40 C-130 fueling/defueling evolution. To ground C-130 aircraft when fueling or defueling, proceed as follows (see figure 2-35):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main wheel well door (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to main wheel well door (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove bonding or grounding cable, reverse above procedures.

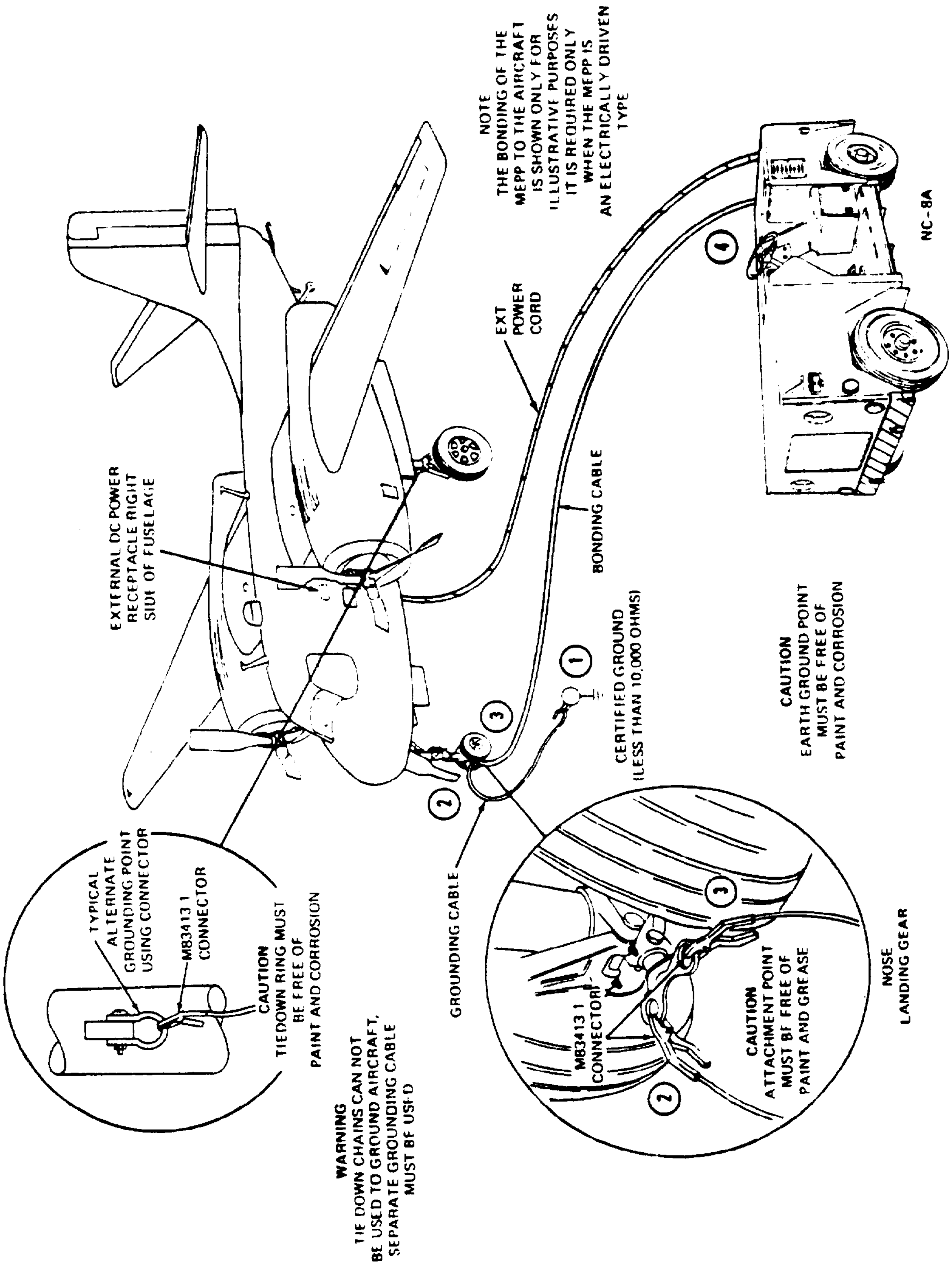


FIGURE 2-33. Apron-based C-1 aircraft grounding, maintenance evolution.

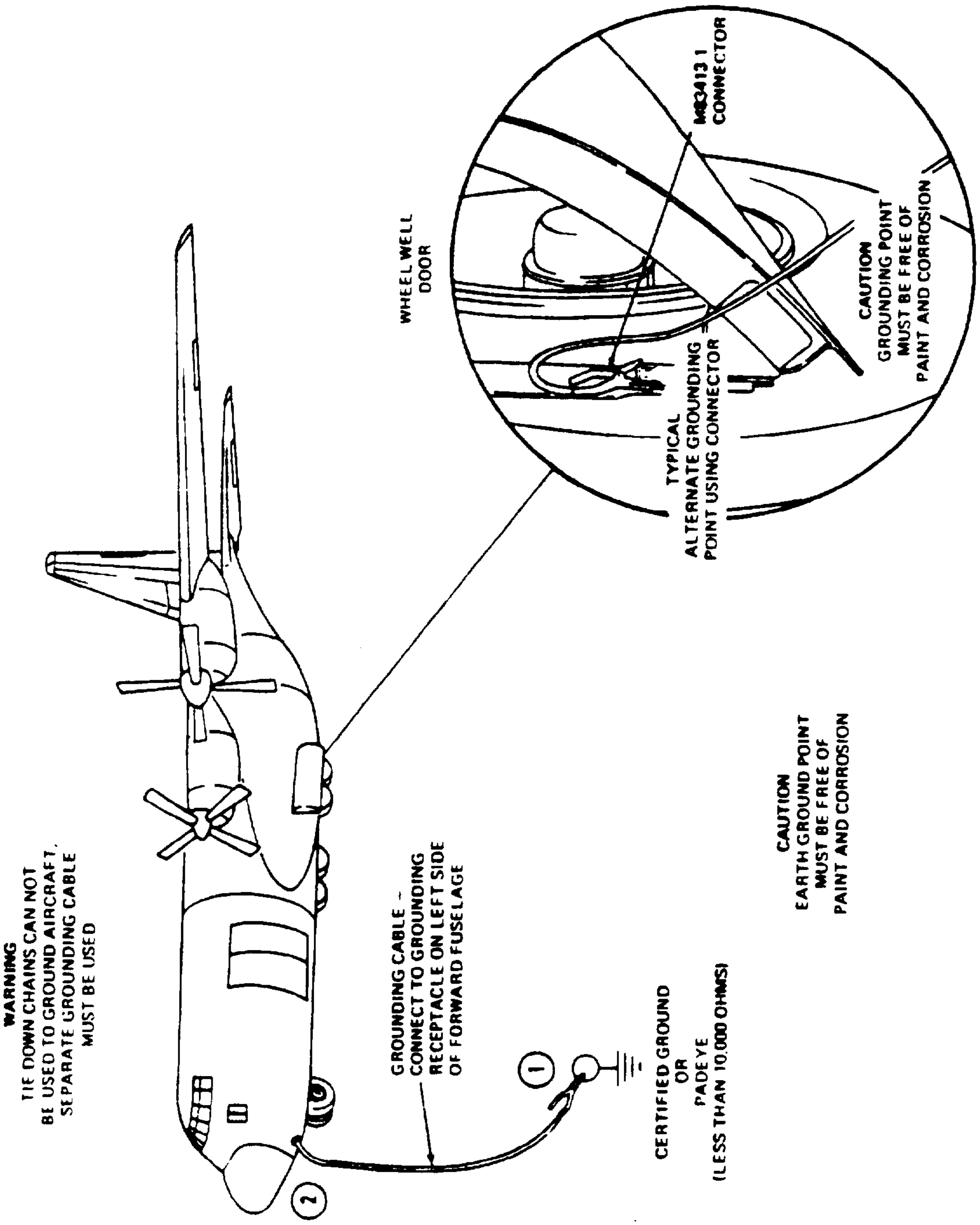


FIGURE 2-34. C-130 aircraft grounding, parked evolution.

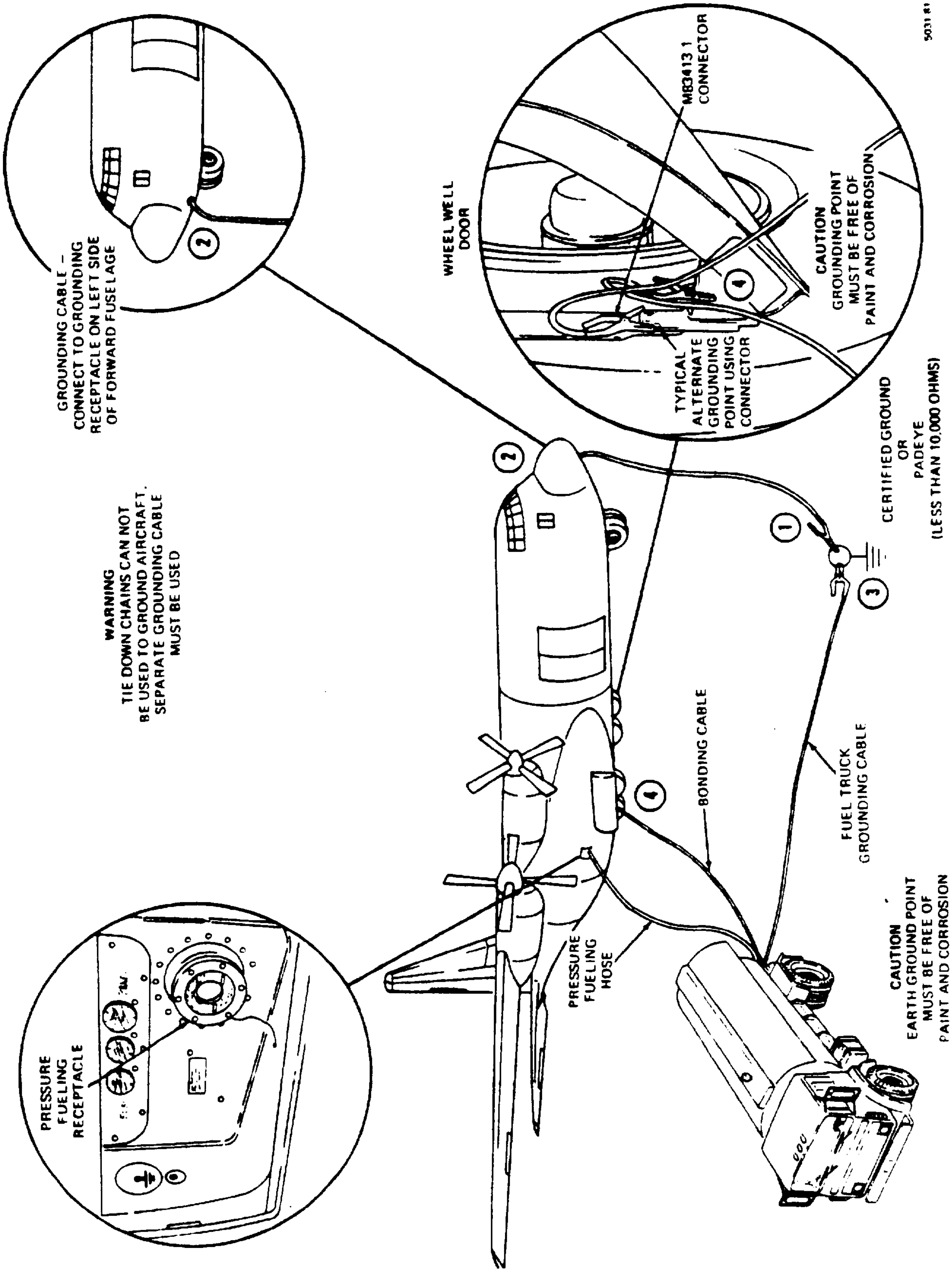


FIGURE 2-35. C-130 aircraft grounding, fueling/defueling evolution.

2.1.41 C-130 hangar-based maintenance evolution. To ground C-130 aircraft during maintenance in the hangar, proceed as follows (see figure 2-36):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to the forward fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main wheel well door (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.42 C-130 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground C-130 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-37):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to forward fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main wheel well door (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main wheel well door (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above proceedures.

2.1.43 C-130 apron-based maintenance evolution (using FLEDS). To ground C-130 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-37):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with a M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main wheel door (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main wheel well door (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

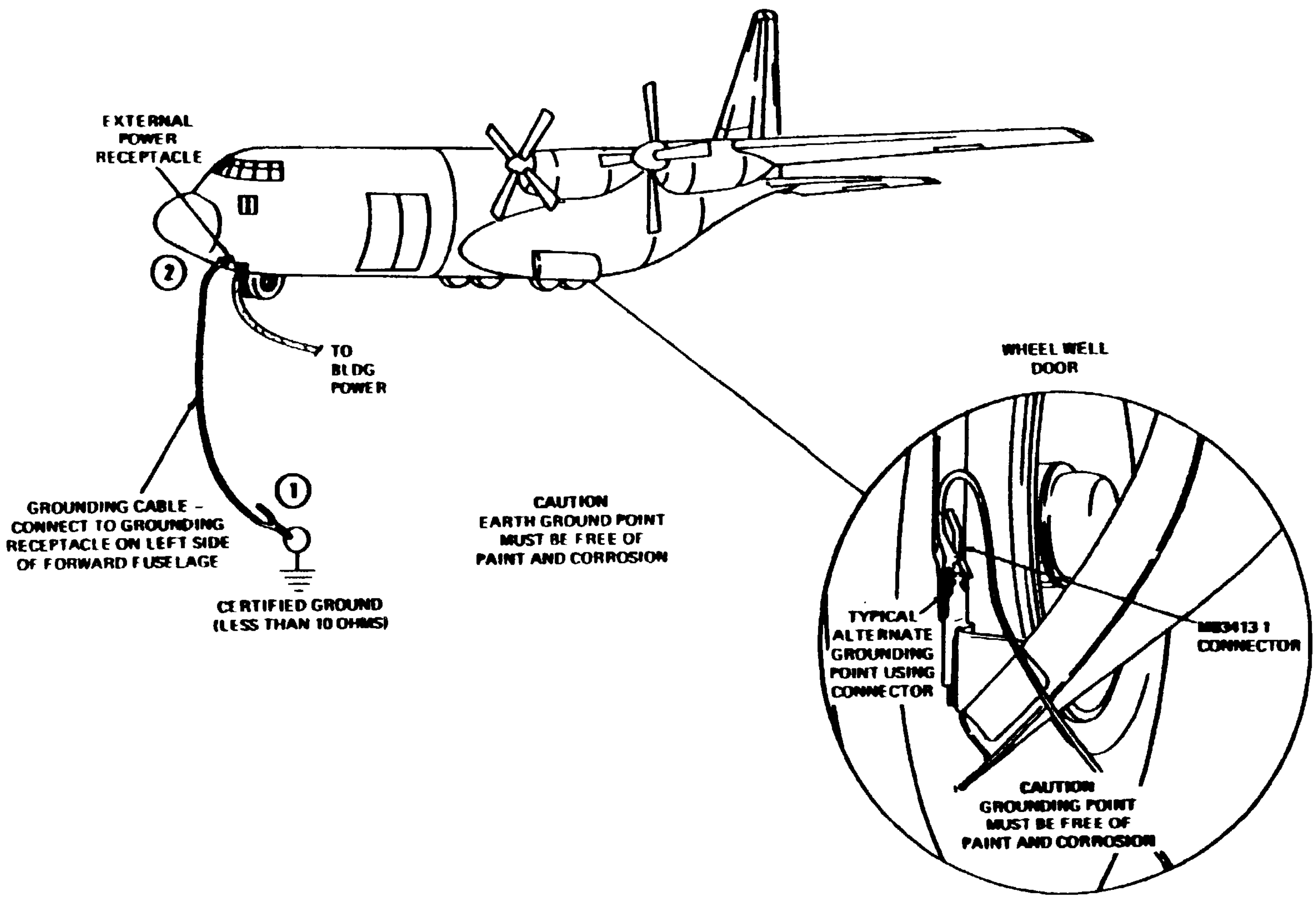


FIGURE 2-36. Hangar-based C-130 aircraft grounding, maintenance evolution.

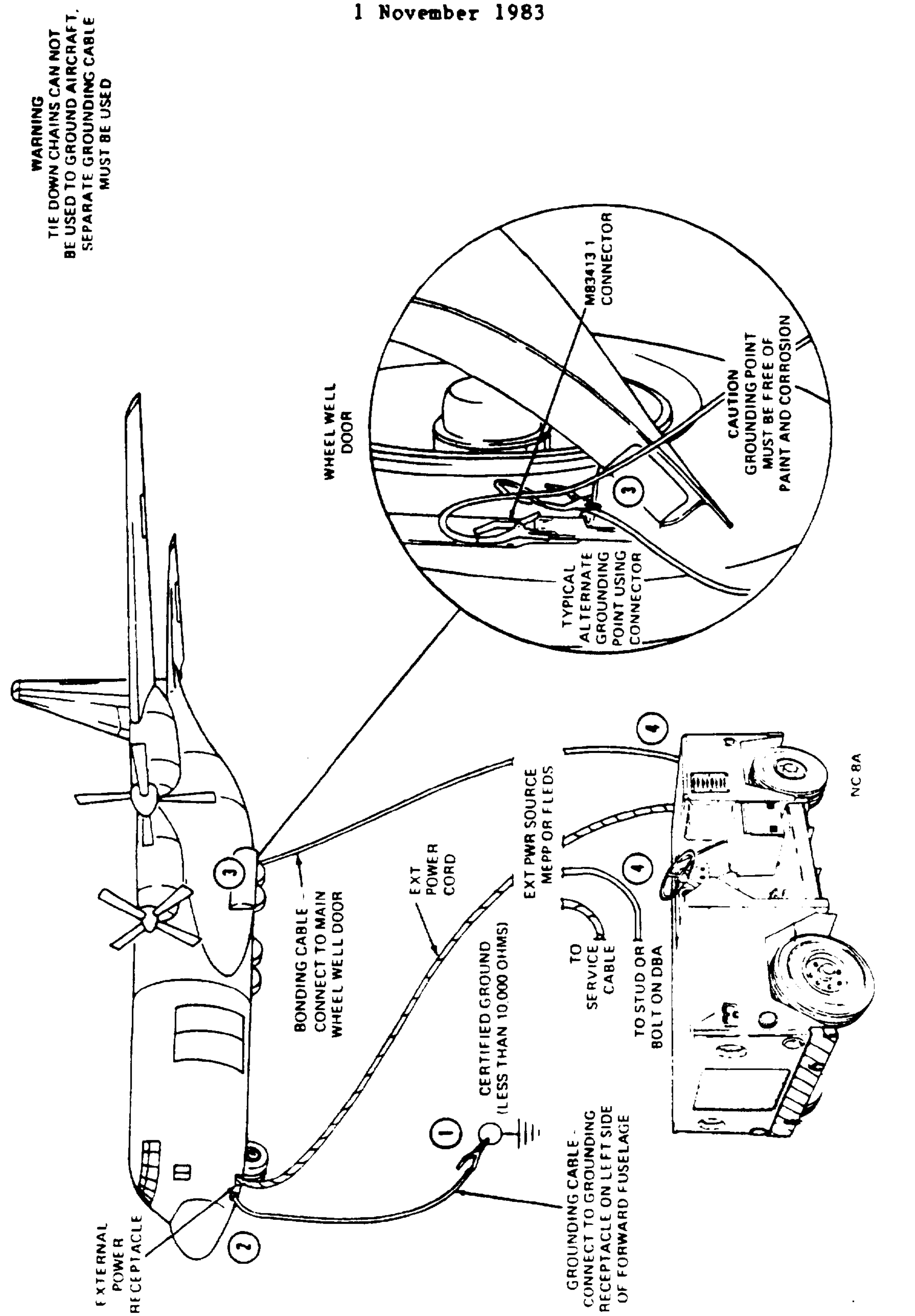


FIGURE 2-37. Apron-based C-130 aircraft grounding, maintenance evolution.

2.1.44 CH-53 parked evolution. To ground CH-53 aircraft when in the parked evolution, proceed as follows (see figure 2-38):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.45 CH-53 fueling/defueling evolution. To ground CH-53 aircraft when fueling or defueling, proceed as follows (see figure 2-39):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to static drag wire (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove bonding or grounding cable, reverse above procedures.

2.1.46 CH-53 hangar-based maintenance evolution. To ground CH-53 aircraft during maintenance in the hangar, proceed as follows (see figure 2-40):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.47 CH-53 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground CH-53 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-41):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

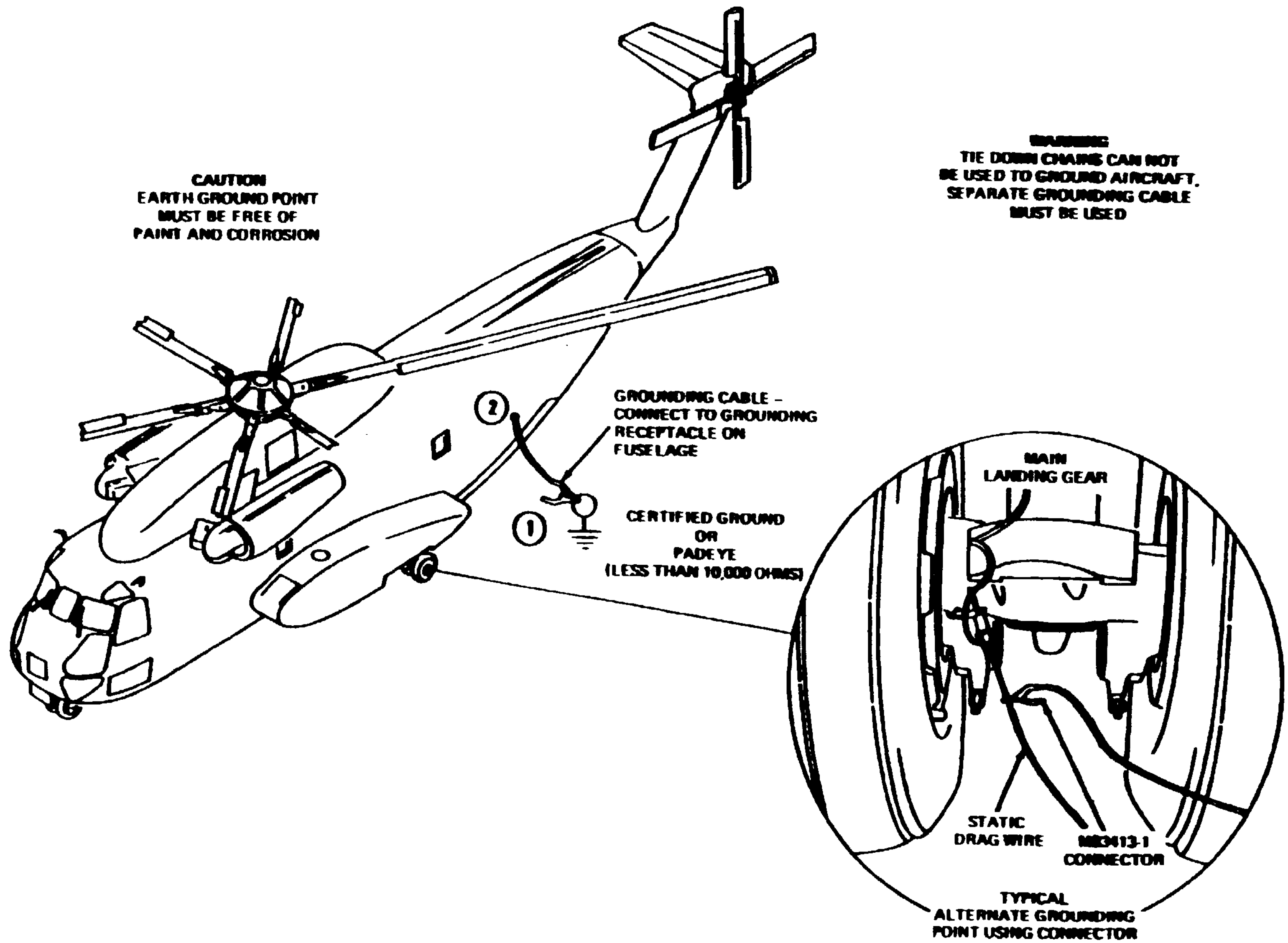


FIGURE 2-38. CH-53 aircraft grounding, parked evolution.

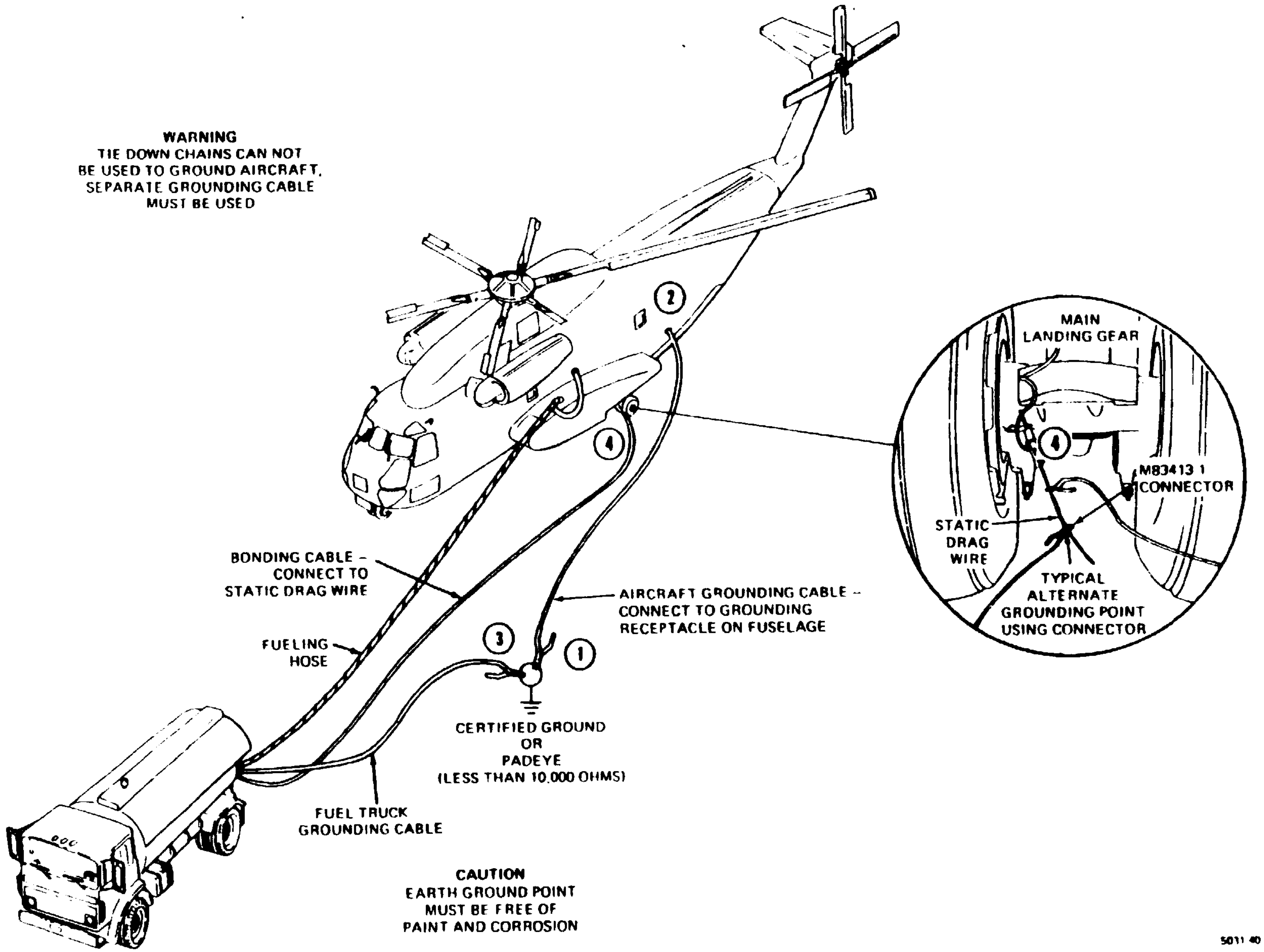


FIGURE 2-39. CH-53 aircraft grounding, fueling/defueling evolution.

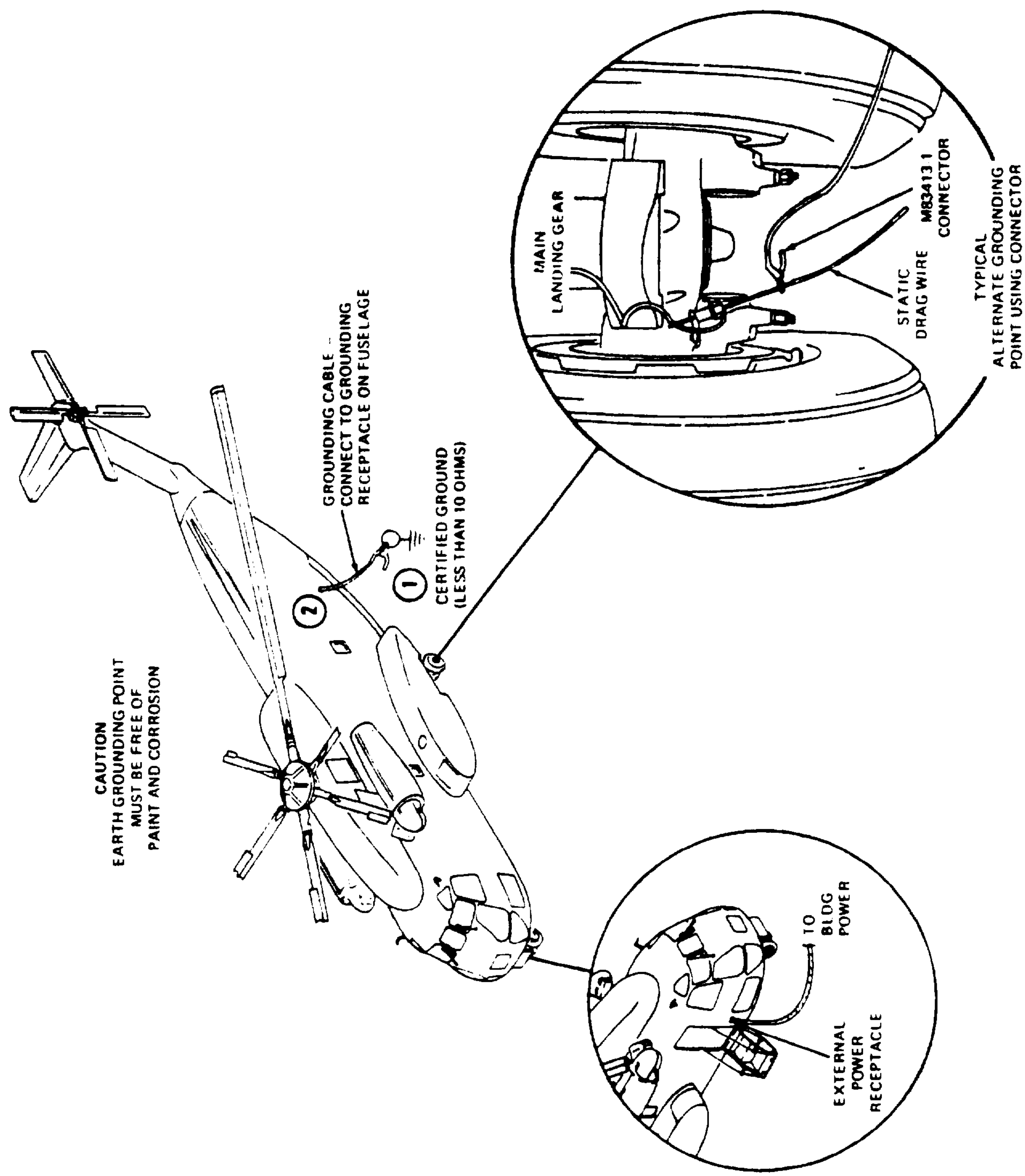


FIGURE 2-40. Hangar-based CH-53 aircraft grounding, maintenance evolution.

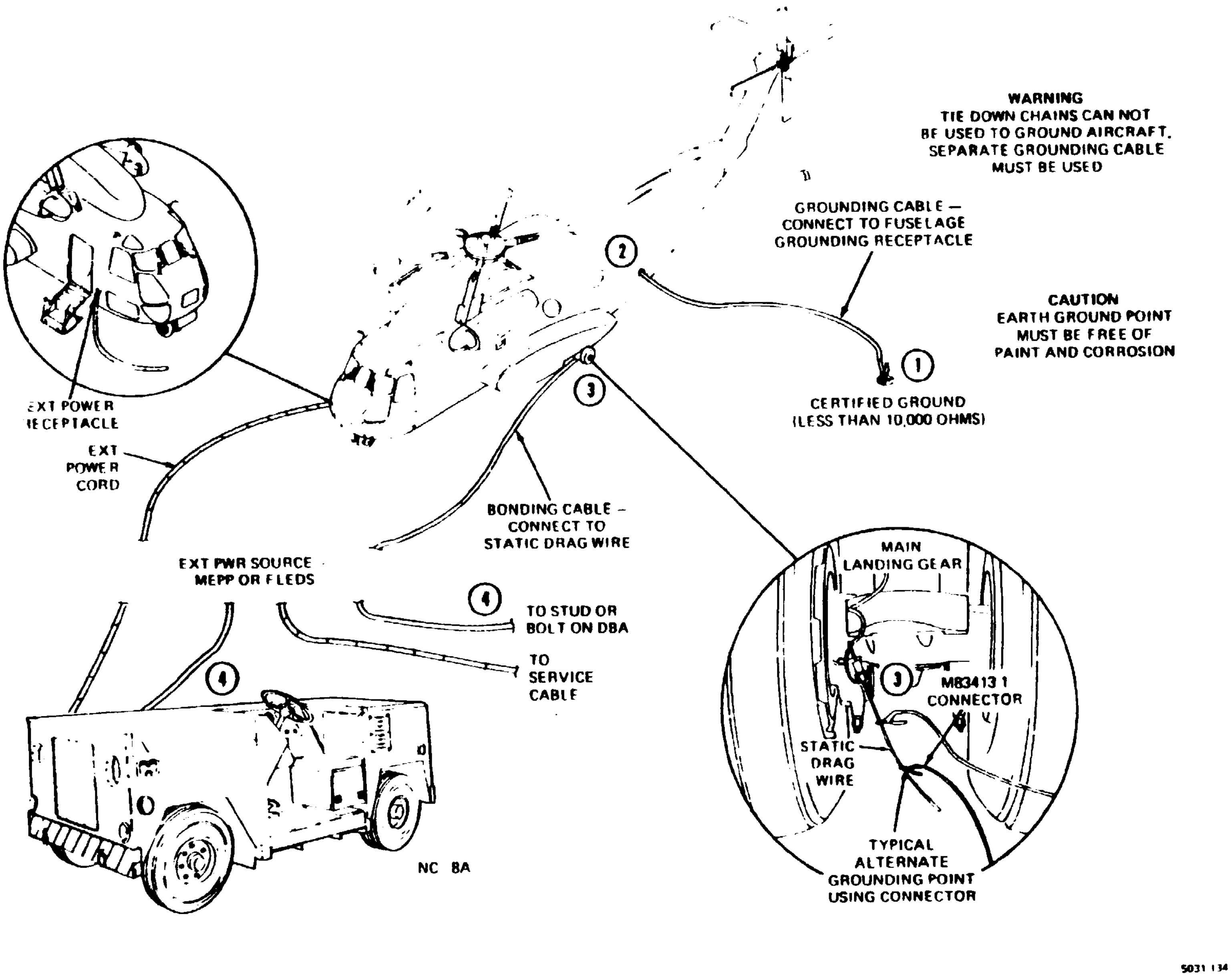


FIGURE 2-41. Apron-based CH-53 aircraft grounding, maintenance evolution.

b. Connect free end of grounding cable to left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.48 CH-53 apron-based maintenance evolution (using FLEDS). To ground CH-53 aircraft when in the maintenance evolution on the apron using FLEDS, proceeed as follows (see figure 2-41):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to the left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.49 CH-53 stores loading/unloading evolution. To ground CH-53 aircraft during stores loading or unloading, proceed as follows (see figure 2-42):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to the left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.50 E-2 parked evolution. To ground E-2 aircraft when in the parked evolution, proceed as follows (see figure 2-43):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on the nose gear (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

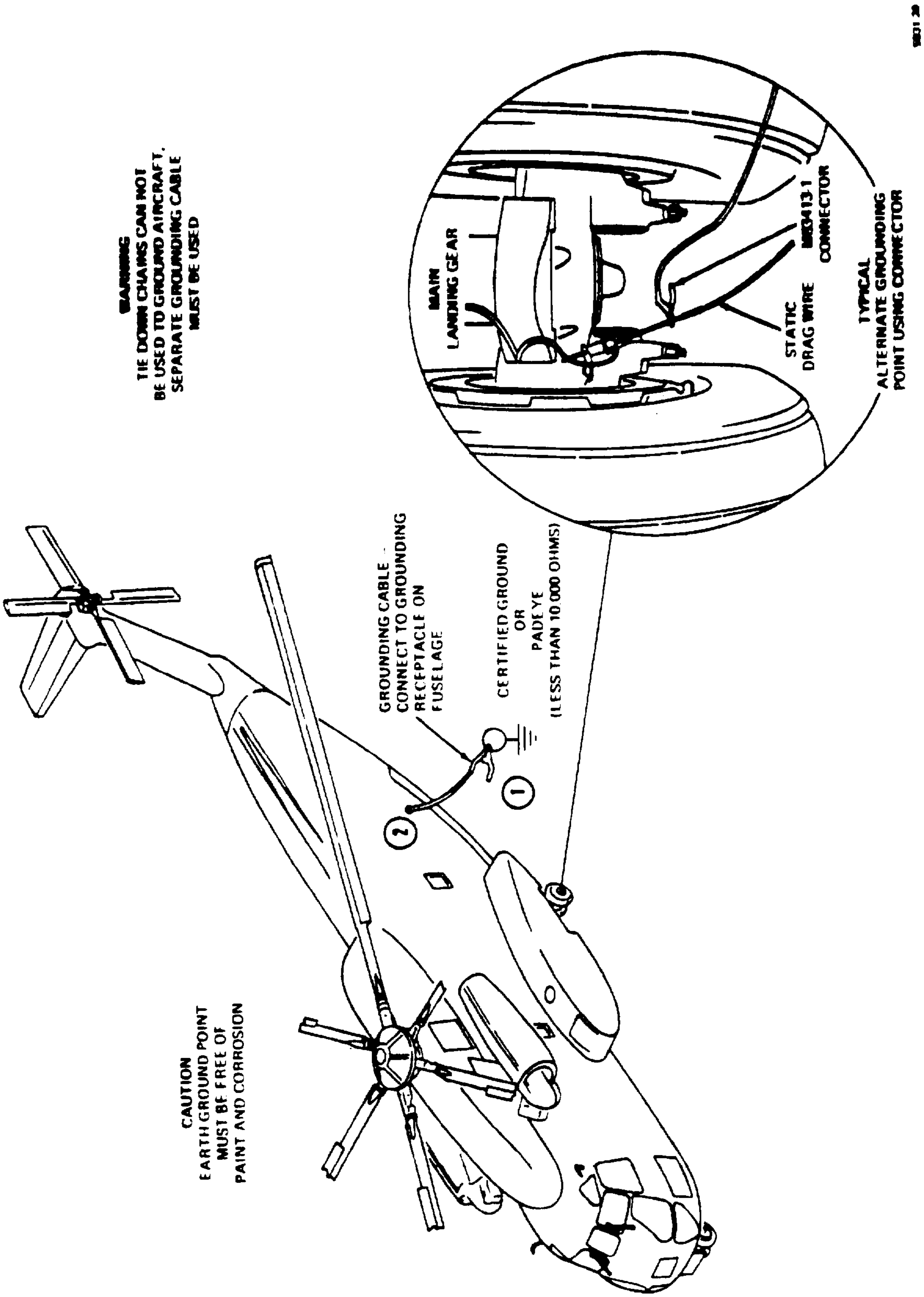


FIGURE 2-42. CH-53 aircraft grounding, stores loading/unloading evolution.

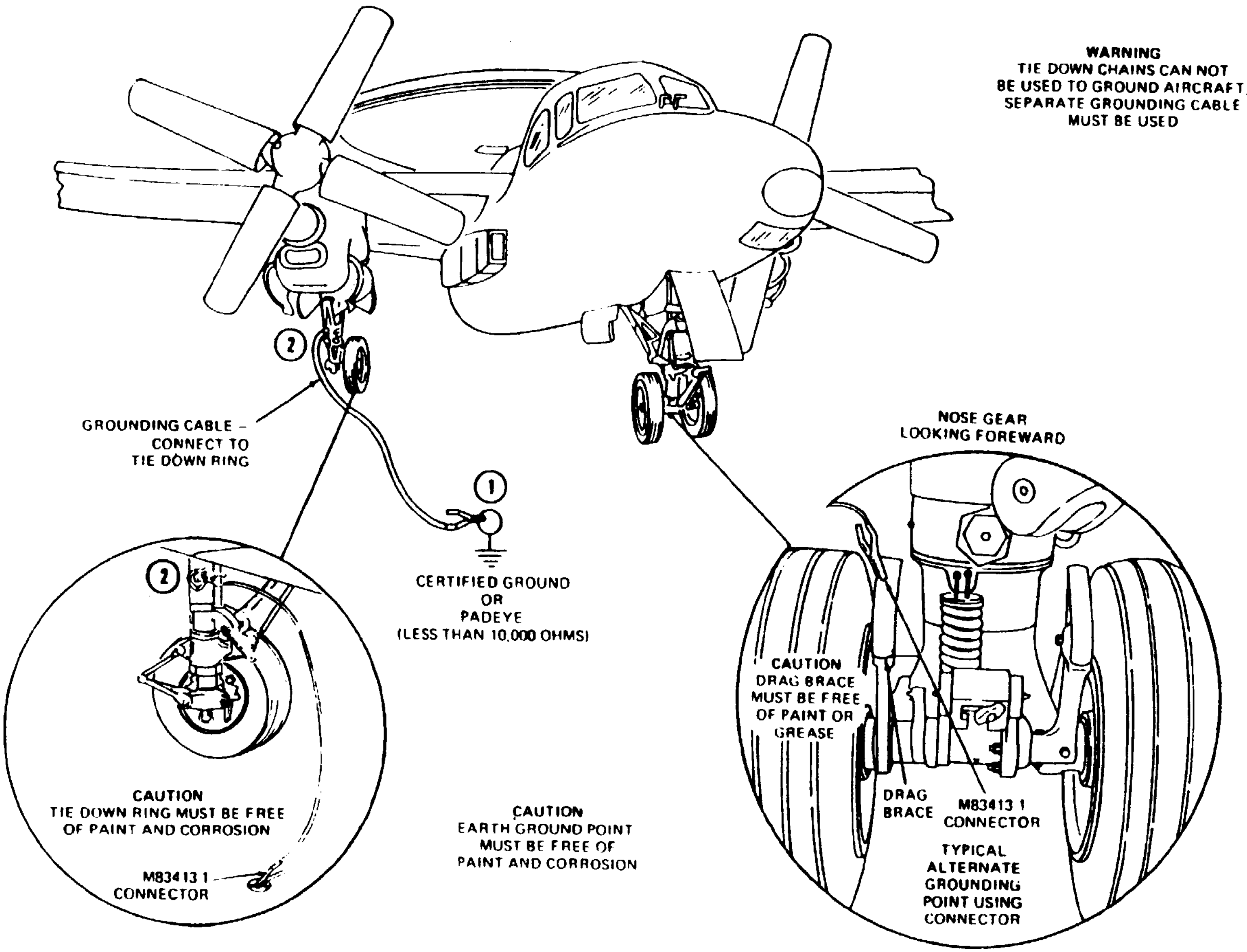


FIGURE 2-43. E-2 aircraft grounding, parked evolution.

2.1.51 E-2 fueling/defueling evolution. To ground E-2 aircraft when fueling or defueling, proceed as follows (see figure 2-44):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on the nose gear (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to main gear tiedown ring (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.52 E-2 hangar-based maintenance evolution. To ground E-2 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-45):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on the nose gear (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.53 E-2 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground E-2 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-46):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on the nose gear (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.54 E-2 apron-based maintenance evolution (using FLEDS) To ground E-2 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-46):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on the nose gear (typical alternate grounding point).

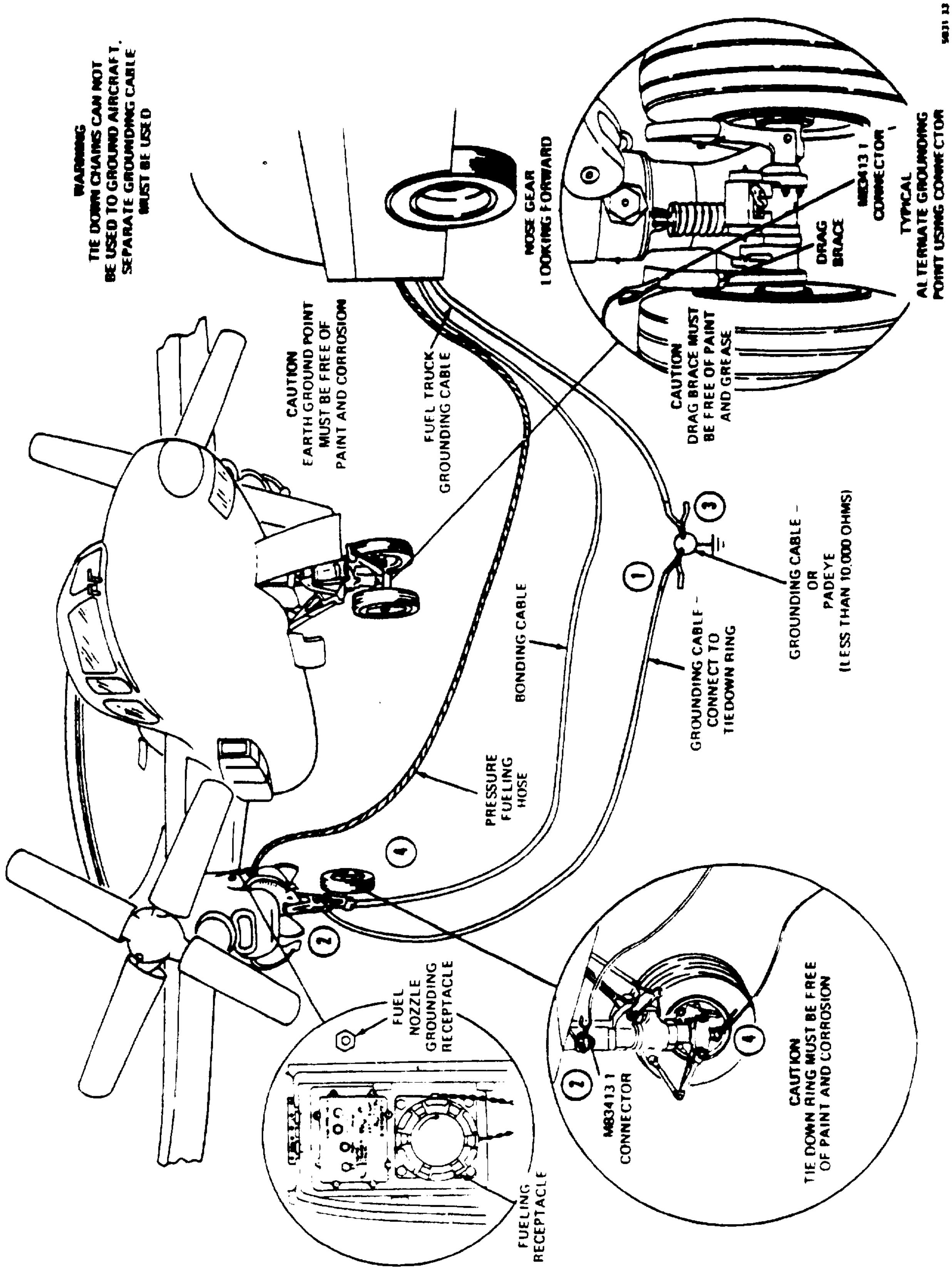


FIGURE 2-44. E-2 aircraft grounding, fueling/defueling evolution.

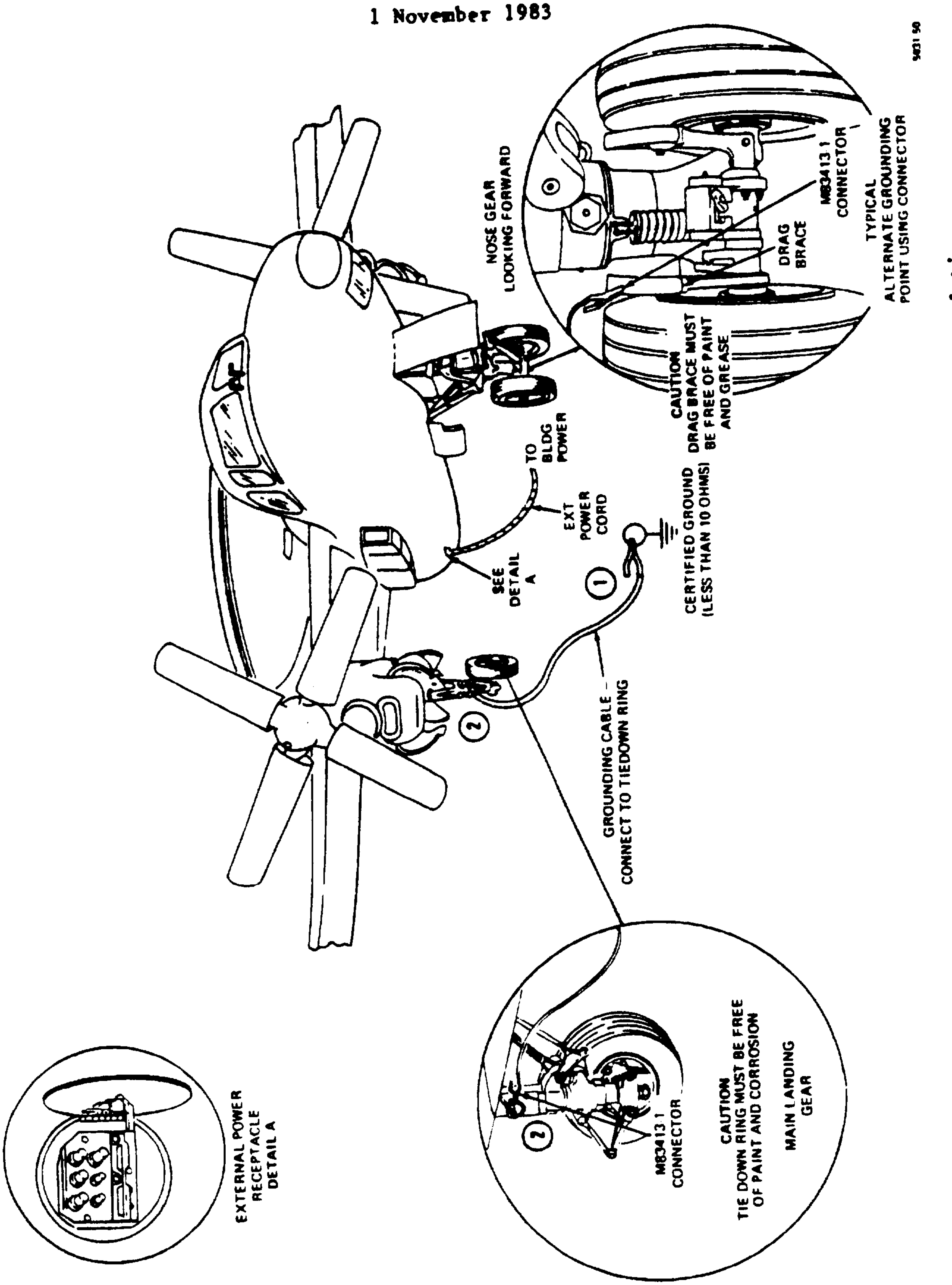


FIGURE 2-45. Hangar-based E-2 aircraft grounding, maintenance evolution.

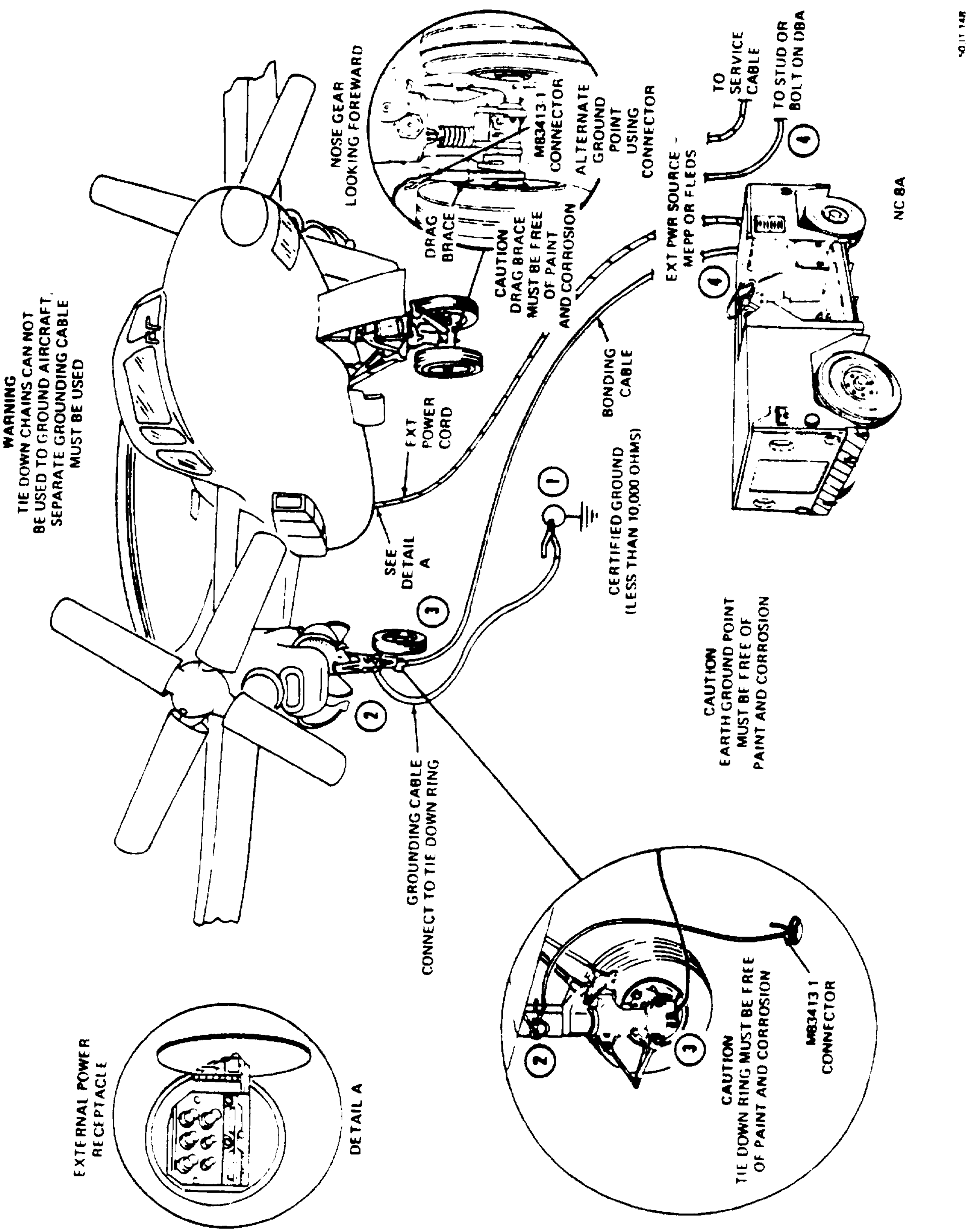


FIGURE 2-46. Apron-based E-2 aircraft grounding, maintenance evolution.

c. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.55 EA-6 parked evolution. To ground EA-6 aircraft when in the parked evolution, proceed as follows (see figure 2-47):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.56 EA-6 fueling/defueling evolution. To ground EA-6 aircraft when fueling or defueling, proceed as follows (see figure 2-48):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to bracket inside nose wheel well (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.57 EA-6 hangar-based maintenance evolution. To ground EA-6 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-49):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.58 EA-6 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground EA-6 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-50):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).

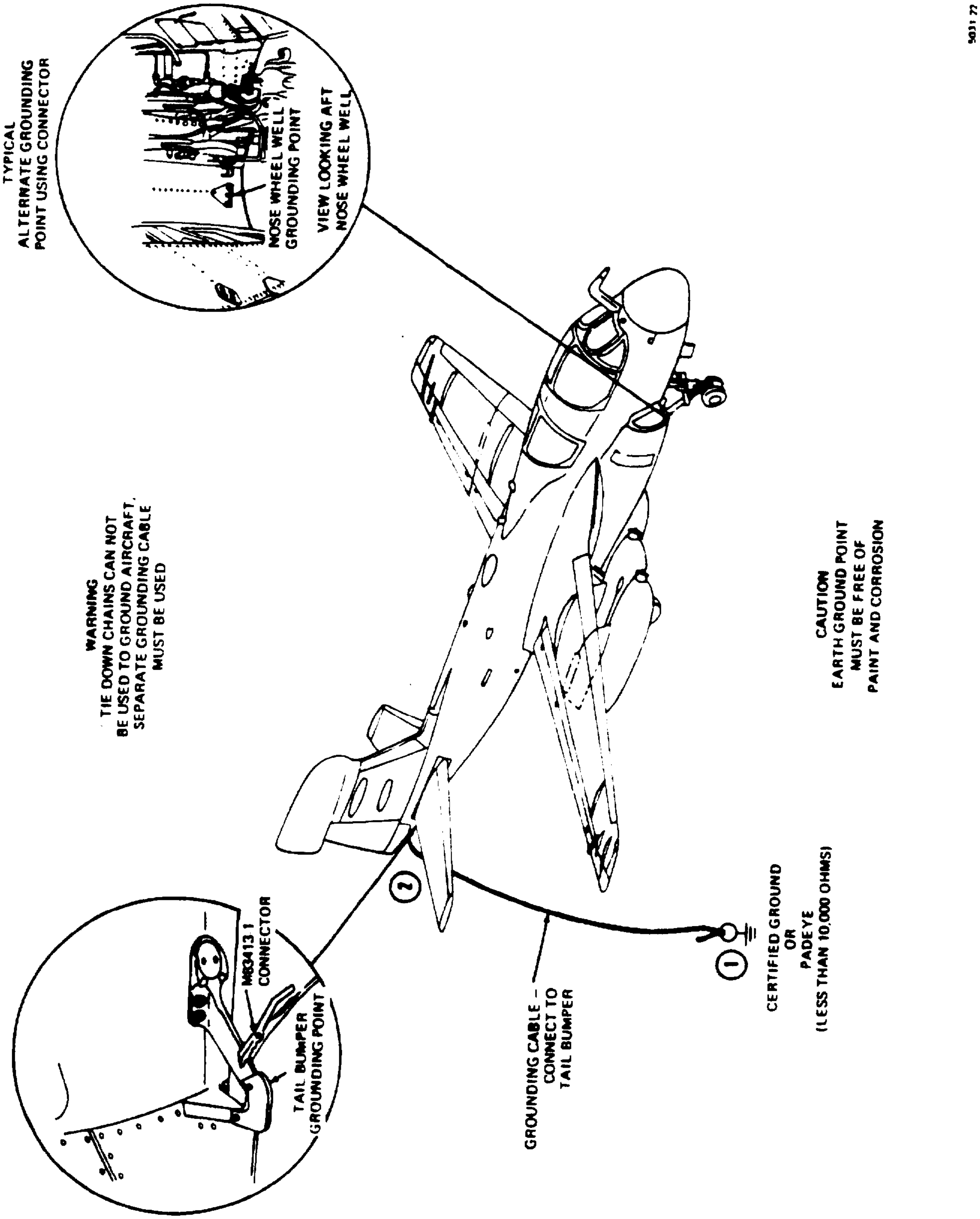


FIGURE 2-47. EA-6 aircraft grounding, parked evolution.

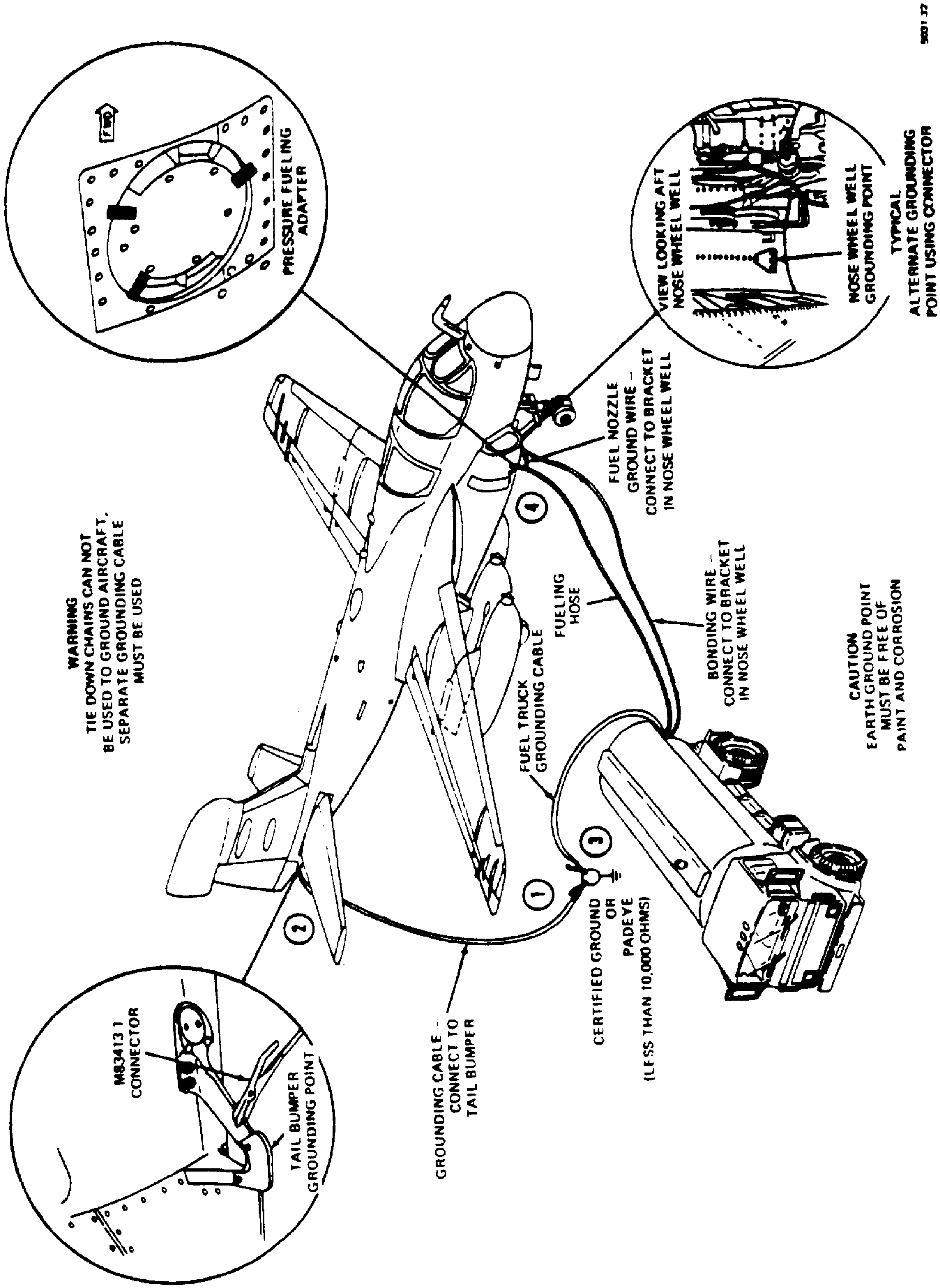


FIGURE 2-48. EA-6 aircraft grounding, fueling/defueling evolution.

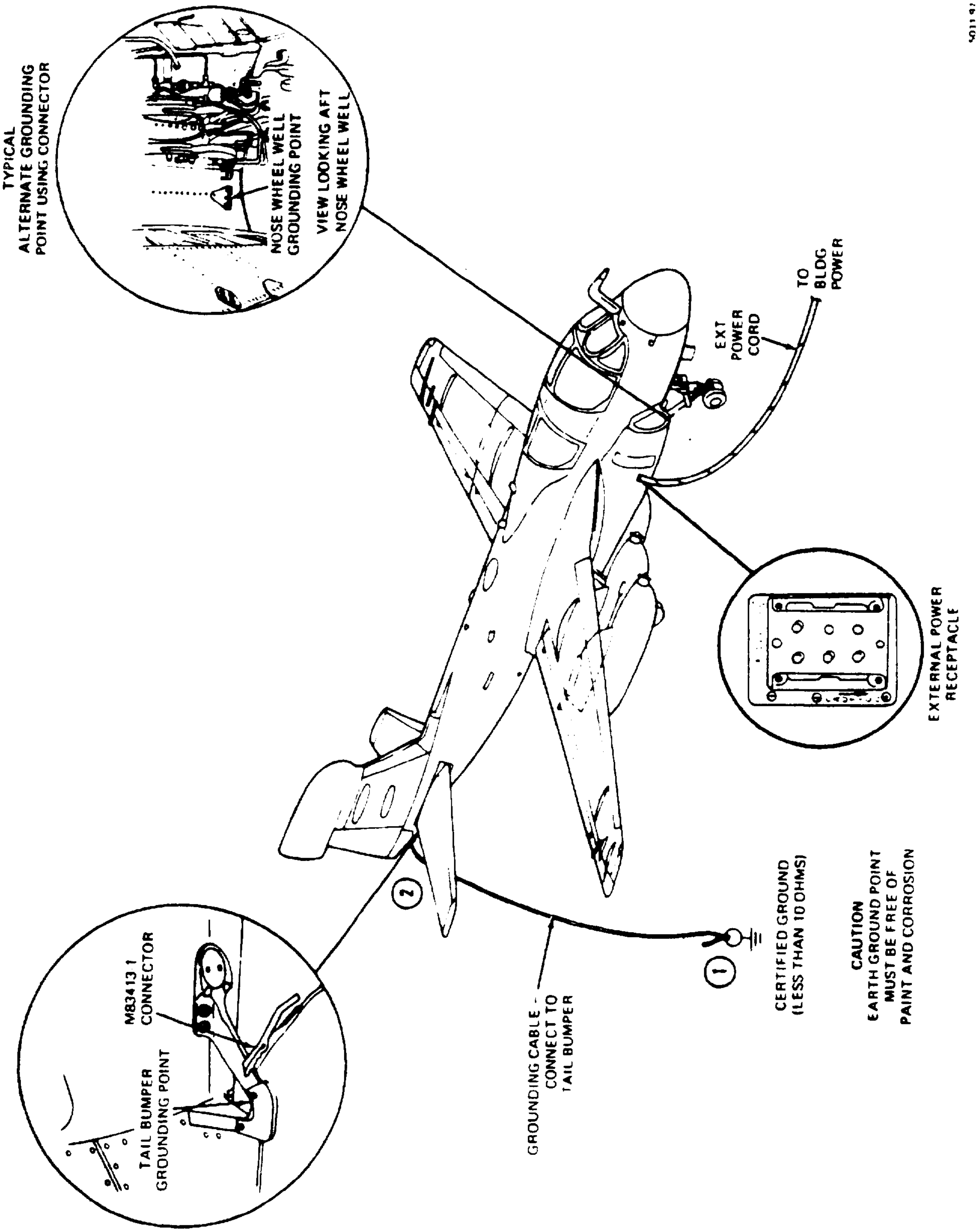


FIGURE 2-49. Hangar-based EA-6 aircraft grounding, maintenance evolution.

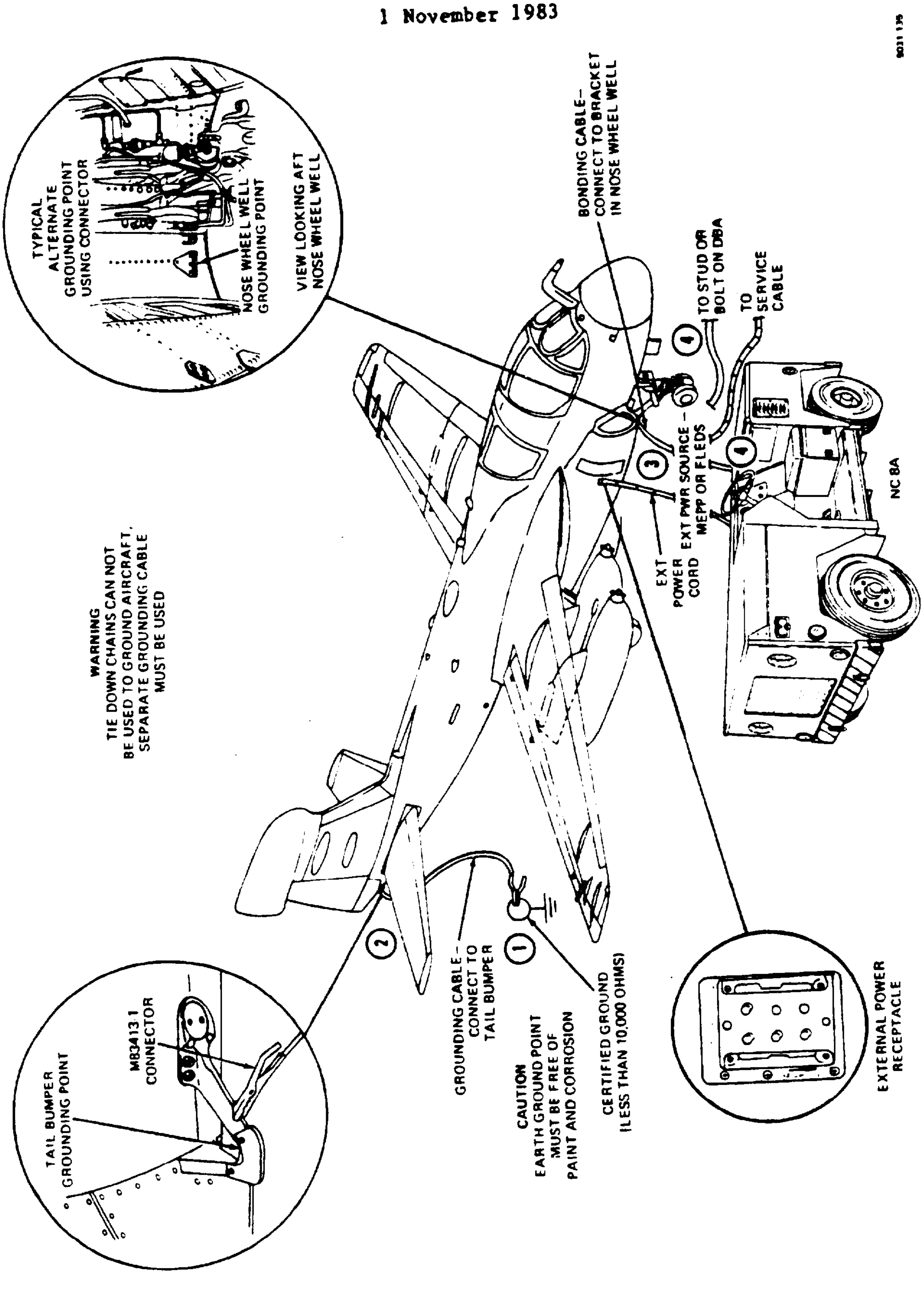


FIGURE 2-50. Apron-based EA-6 aircraft grounding, maintenance evolution.

c. Attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.59 EA-6 apron-based maintenance evolution (using FLEDS) To ground EA-6 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-50):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.60 EA-6 stores loading/unloading evolution. To ground EA-6 aircraft during stores loading or unloading, proceed as follows (see figure 2-51):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.61 F-4 parked evolution. To ground F-4 aircraft when in the parked evolution, proceed as follows (see figure 2-52):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.62 F-4 fueling/defueling evolution. To ground F-4 aircraft when fueling or defueling, proceed as follows (see figure 2-53):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).

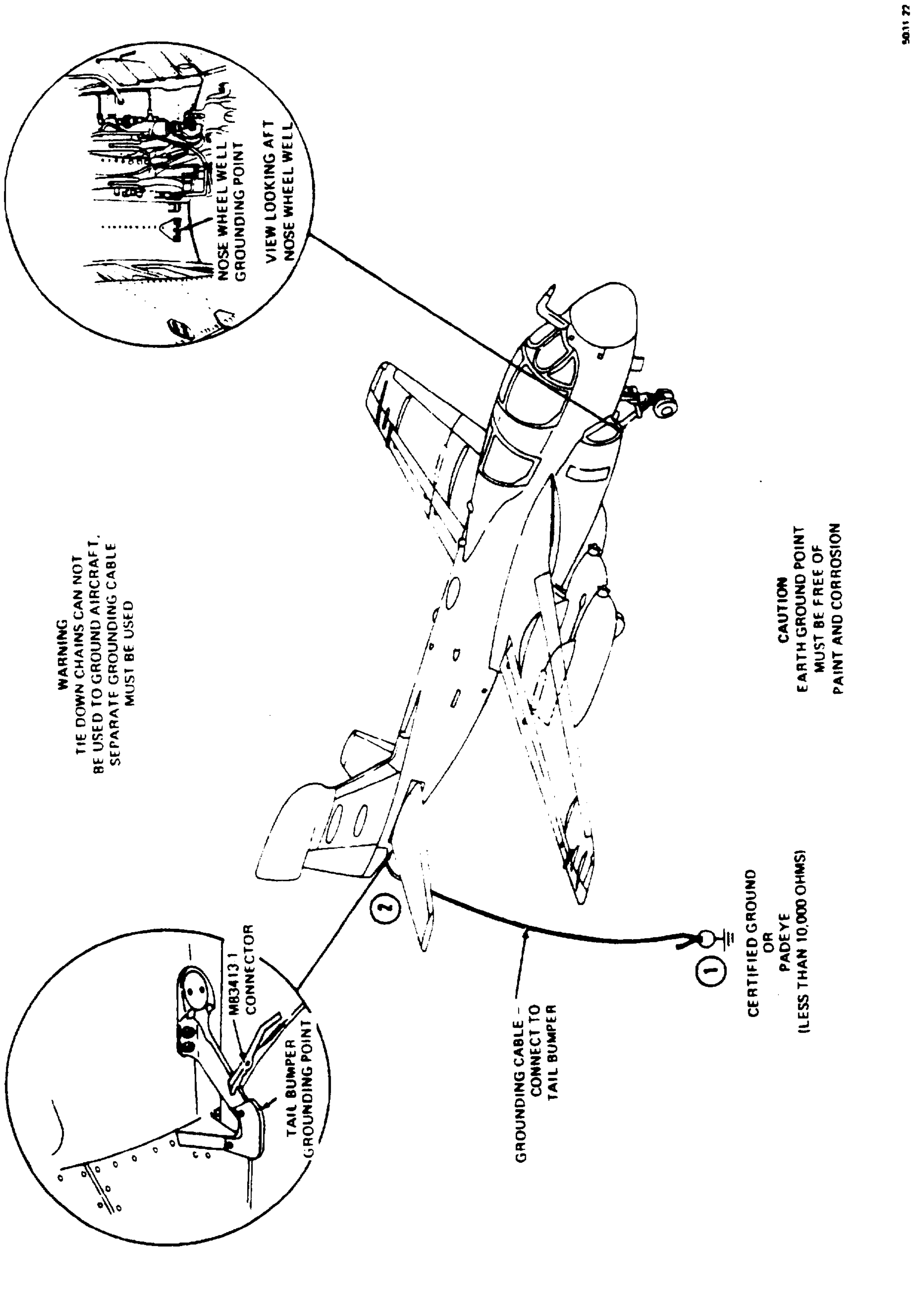


FIGURE 2-51. EA-6 aircraft grounding, stores loading/unloading evolution.

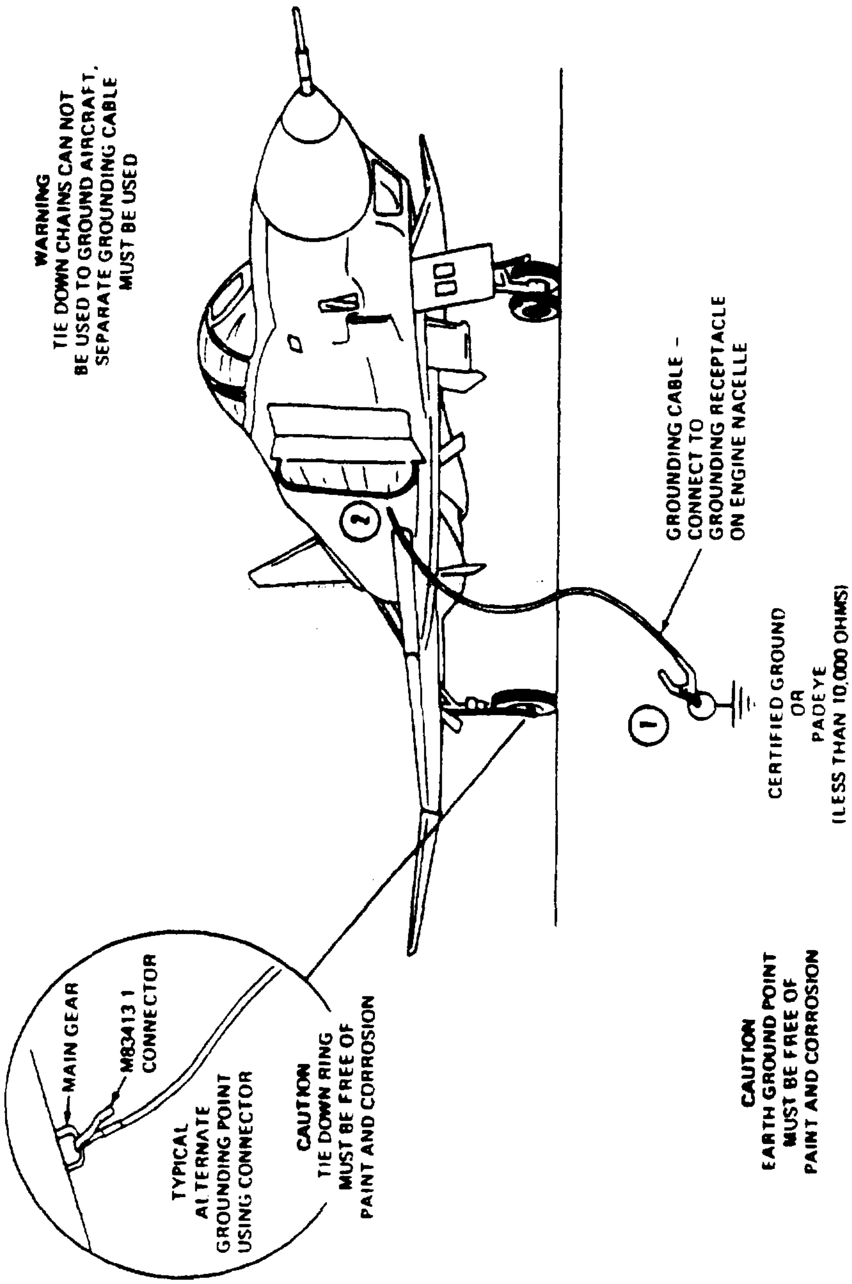


FIGURE 2-52. E-4 aircraft grounding, parked evolution.

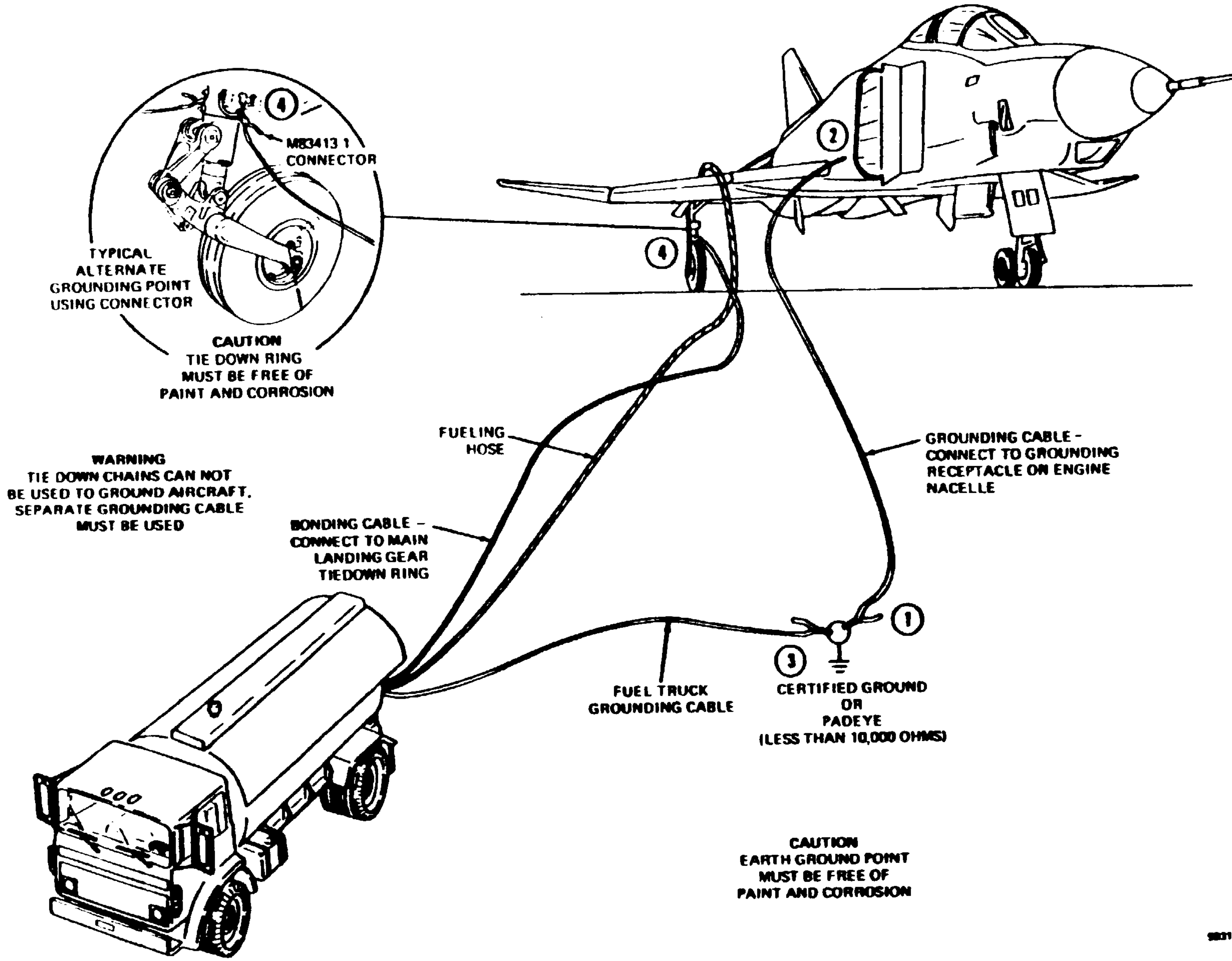


FIGURE 2-53. F-4 aircraft grounding, fueling/defueling evolution.

c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to main gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

2.1.63 F-4 hanger-based maintenance evolution. To ground F-4 aircraft during maintenance in the hangar, proceed as follows (see figure 2-54):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.64 F-4 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground F-4 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-55):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

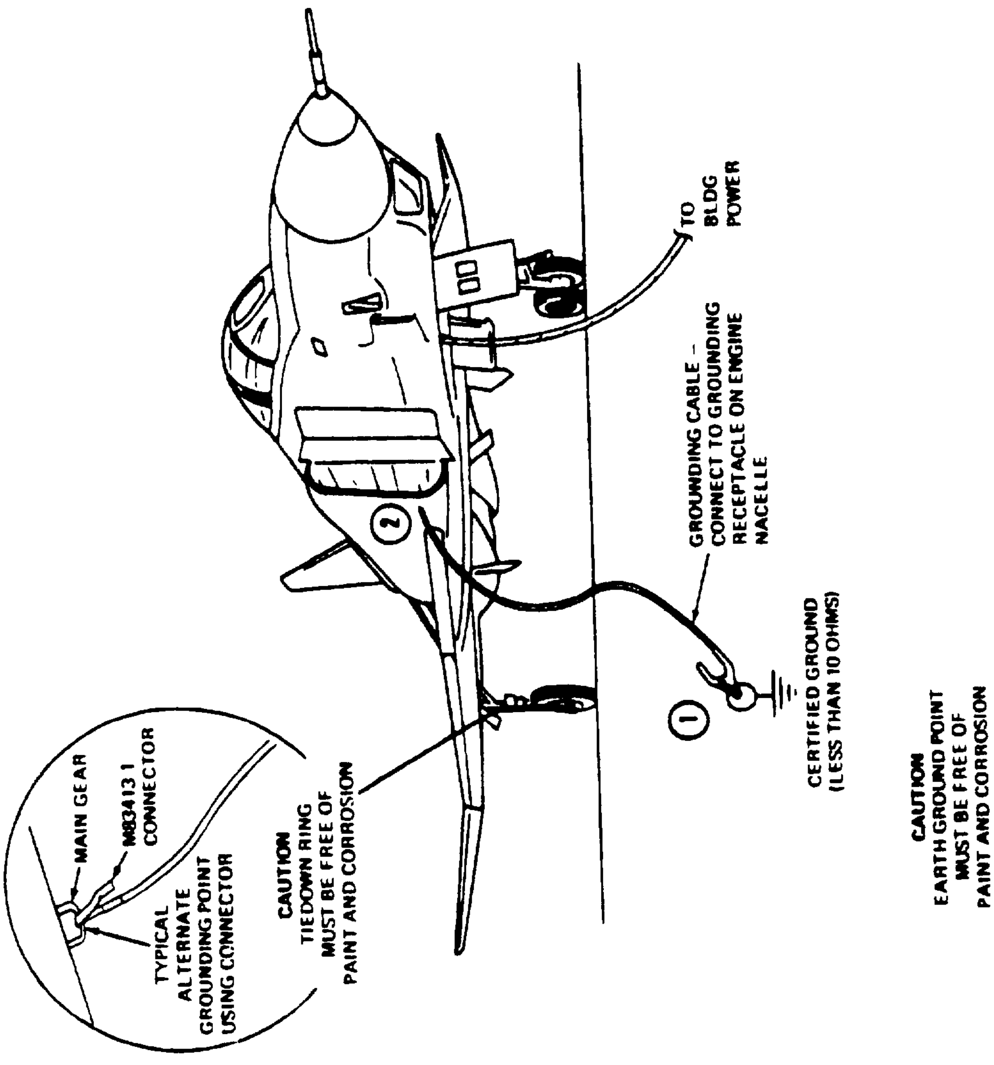


FIGURE 2-54. Hangar-based F-4 aircraft grounding, maintenance evolution.

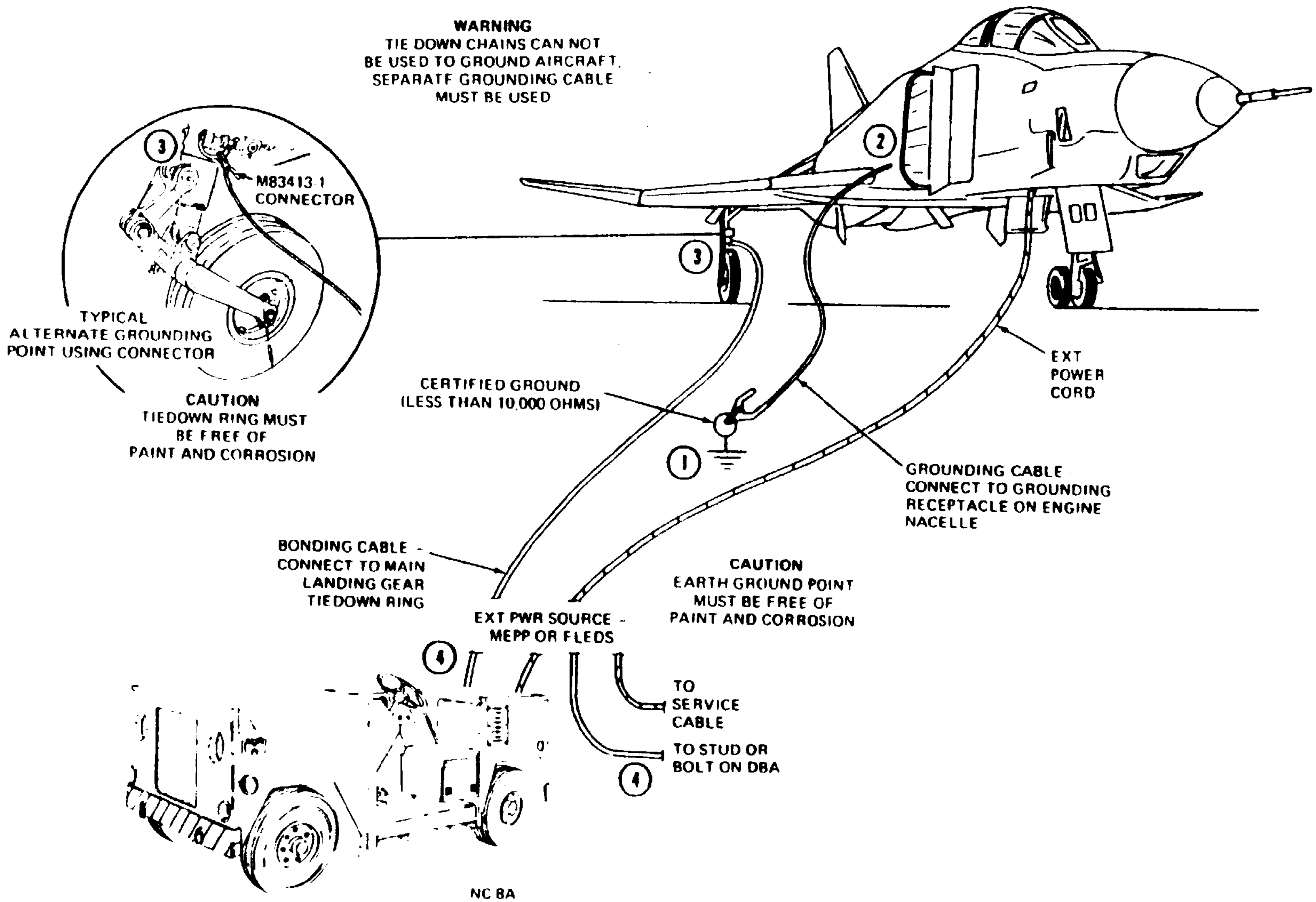


FIGURE 2-55. Apron-based F-4 aircraft grounding, maintenance evolution.

2.1.65 F-4 apron-based maintenance evolution (using FLEDS). To ground F-4 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-55):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.66 F-4 stores loading/unloading evolution. To ground F-4 aircraft during stores loading or unloading, proceed as follows (see figure 2-56):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.67 F-14 parked evolution. To ground F-14 aircraft when in the parked evolution, proceed as follows (see figure 2-57):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.68 F-14 fueling/defueling evolution. To ground F-14 aircraft when fueling or defueling, proceed as follows (see figure 2-58):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).

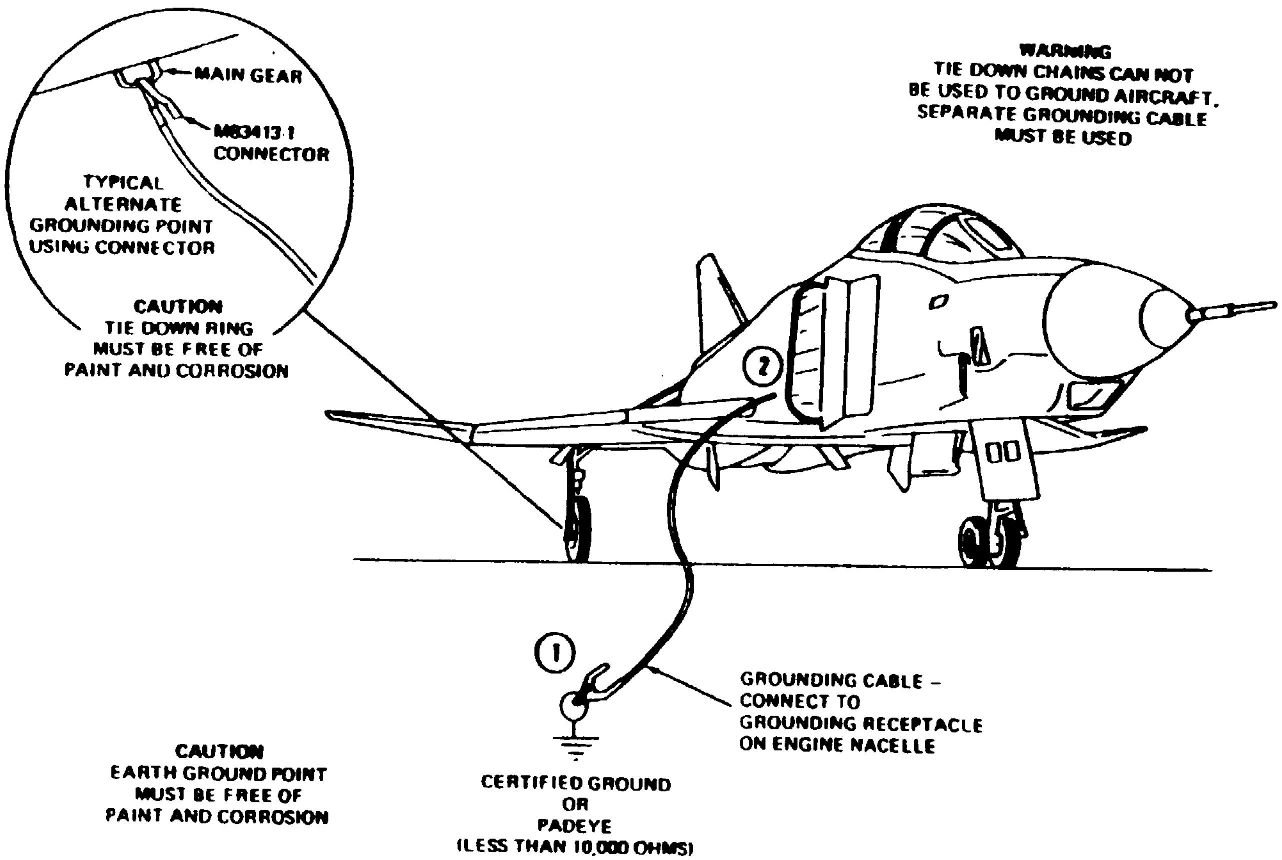


FIGURE 2-56. F-4 aircraft grounding, stores loading/unloading evolution.

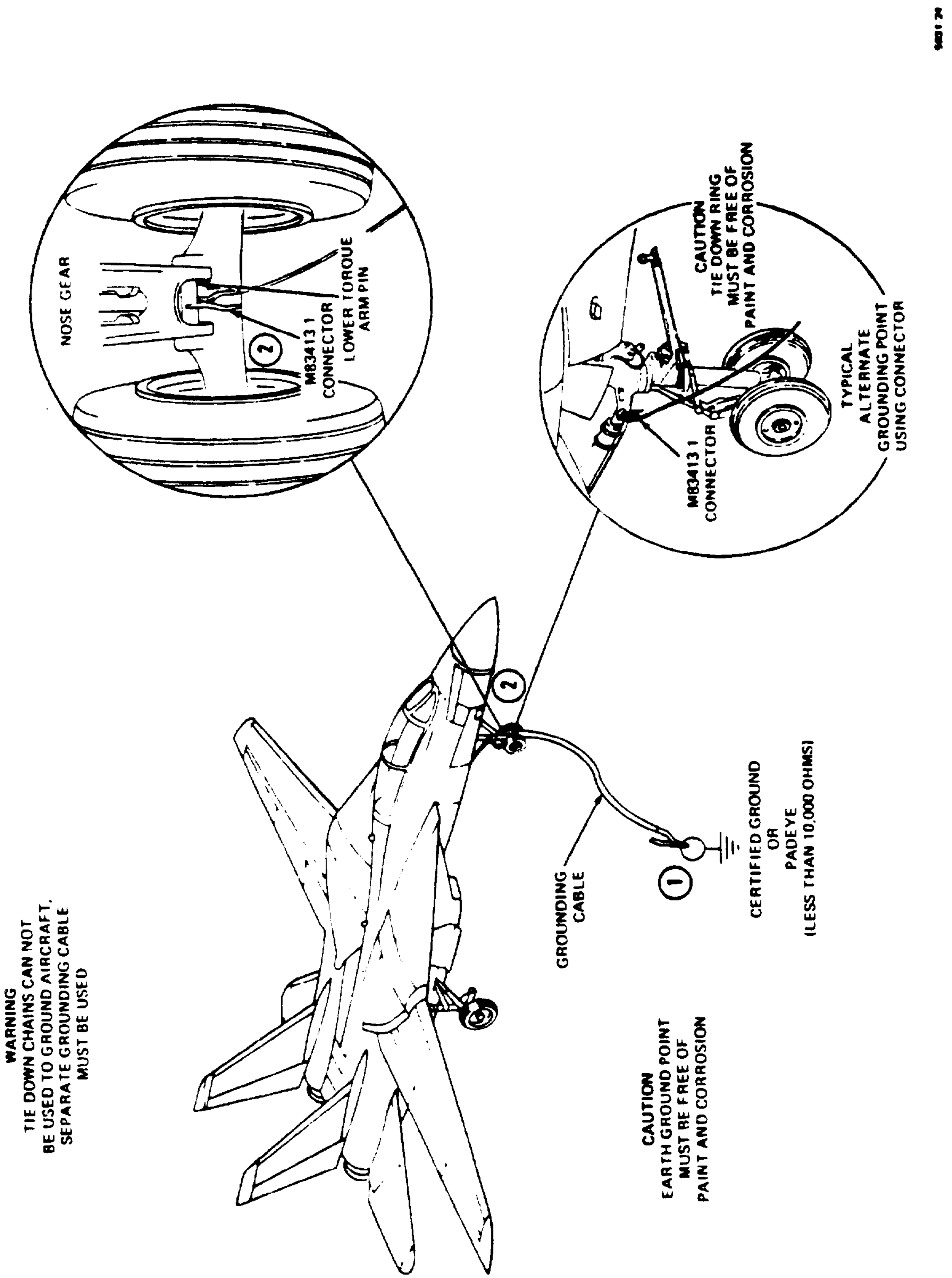


FIGURE 2-57. F-14 aircraft grounding, parked evolution.

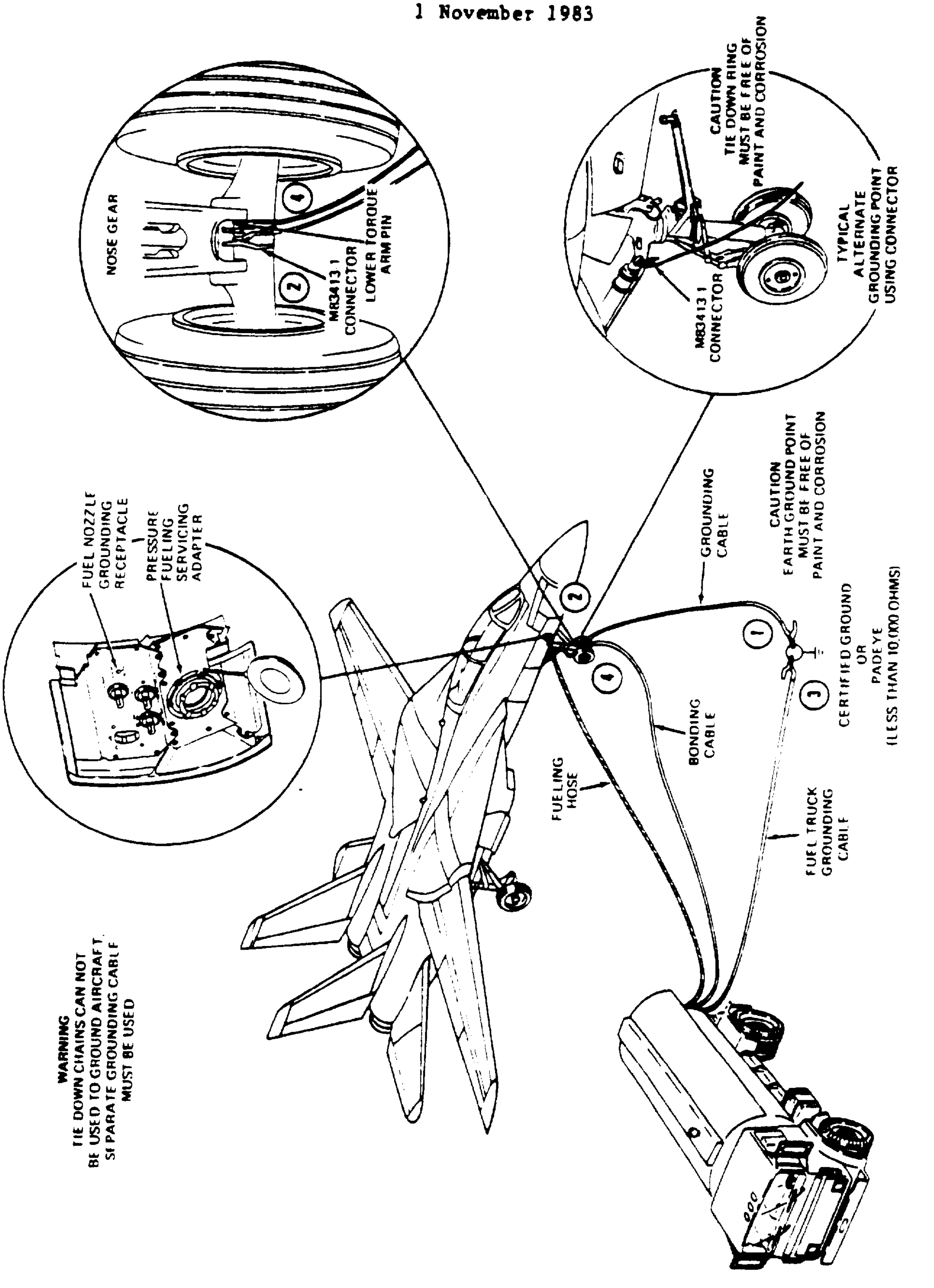


FIGURE 2-58. F-14 aircraft grounding, fueling/defueling evolution.

c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to lower torque arm pin on nose gear (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.69 F-14 hangar-based maintenance evolution. To ground F-14 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-59):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.70 F-14 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground F-14 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-60):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to lower torque arm pin on nose gear (3).

d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.71 F-14 apron-based maintenance evolution (using FLEDS). To ground F-14 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-60):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to lower torque arm pin (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

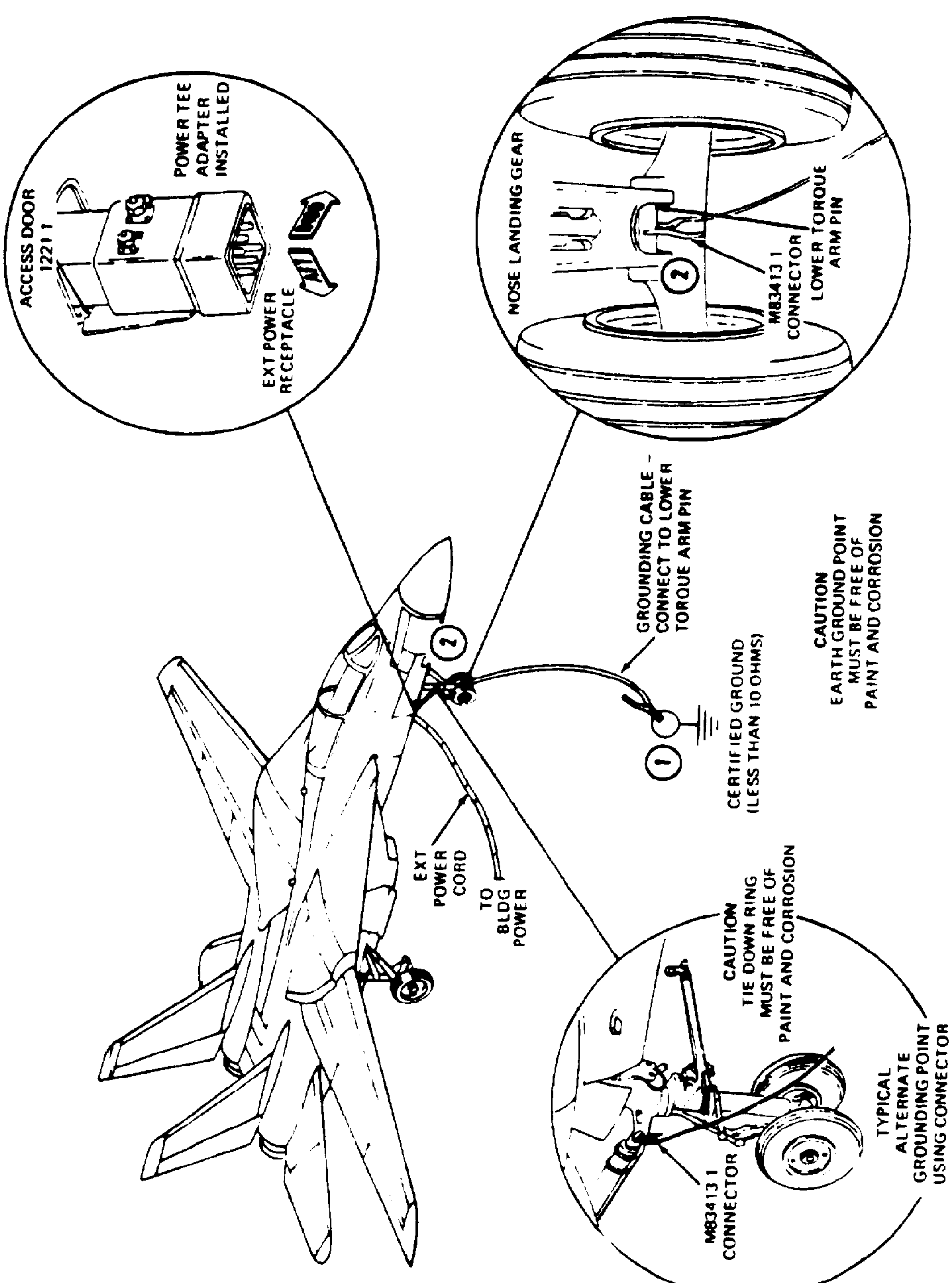


FIGURE 2-59. Hangar-based F-14 aircraft grounding, maintenance evolution.

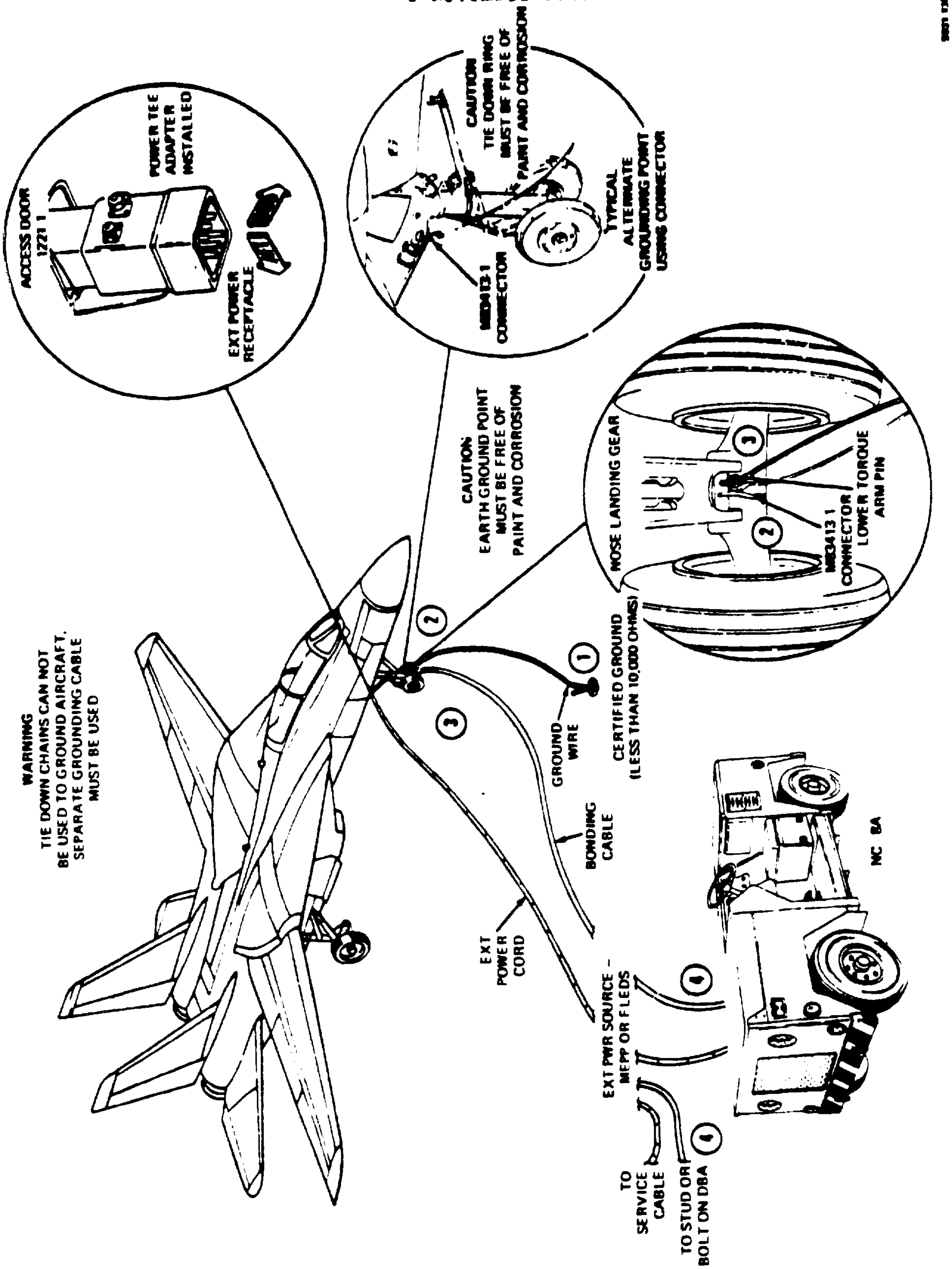


FIGURE 2-60. Apron-based F-14 aircraft grounding, maintenance evolution.

2.1.72 F-14 stores loading/unloading evolution. To ground F-14 aircraft during stores loading or unloading, proceed as follows (see figure 2-61):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.73 F-18 parked evolution. To ground F-18 aircraft when in the parked evolution, proceed as follows (see figure 2-62):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.74 F-18 fueling/defueling evolution. To ground F-18 aircraft when fueling or defueling, proceed as follows (see figure 2-63):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to main gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

2.1.75 F-18 hangar-based maintenance evolution. To ground F-18 aircraft during maintenance in the hangar, proceed as follows (see figure 2-64):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).

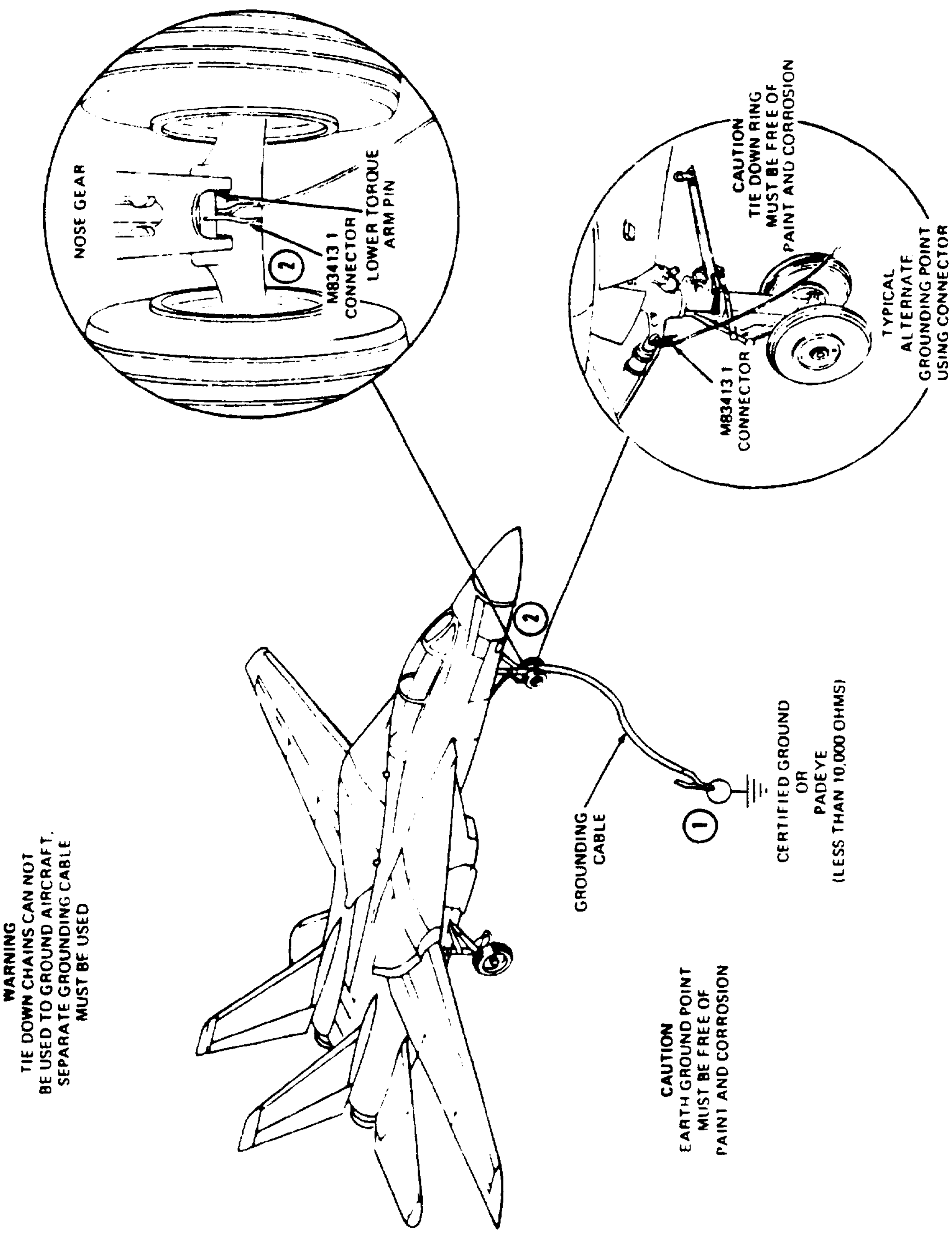


FIGURE 2-61. F-14 aircraft grounding, stores loading/unloading evolution.

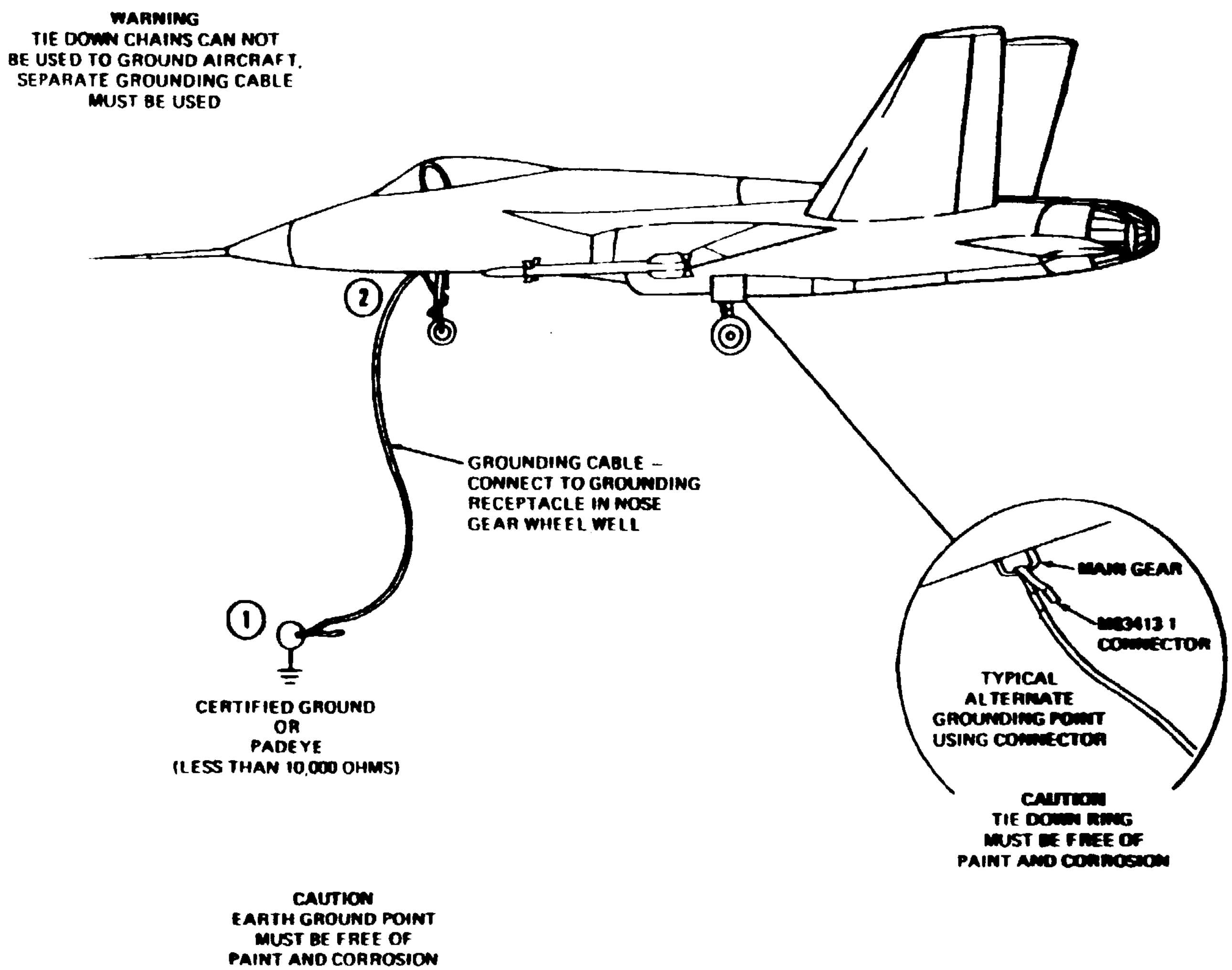


FIGURE 2-62. F-18 aircraft grounding, parked evolution.

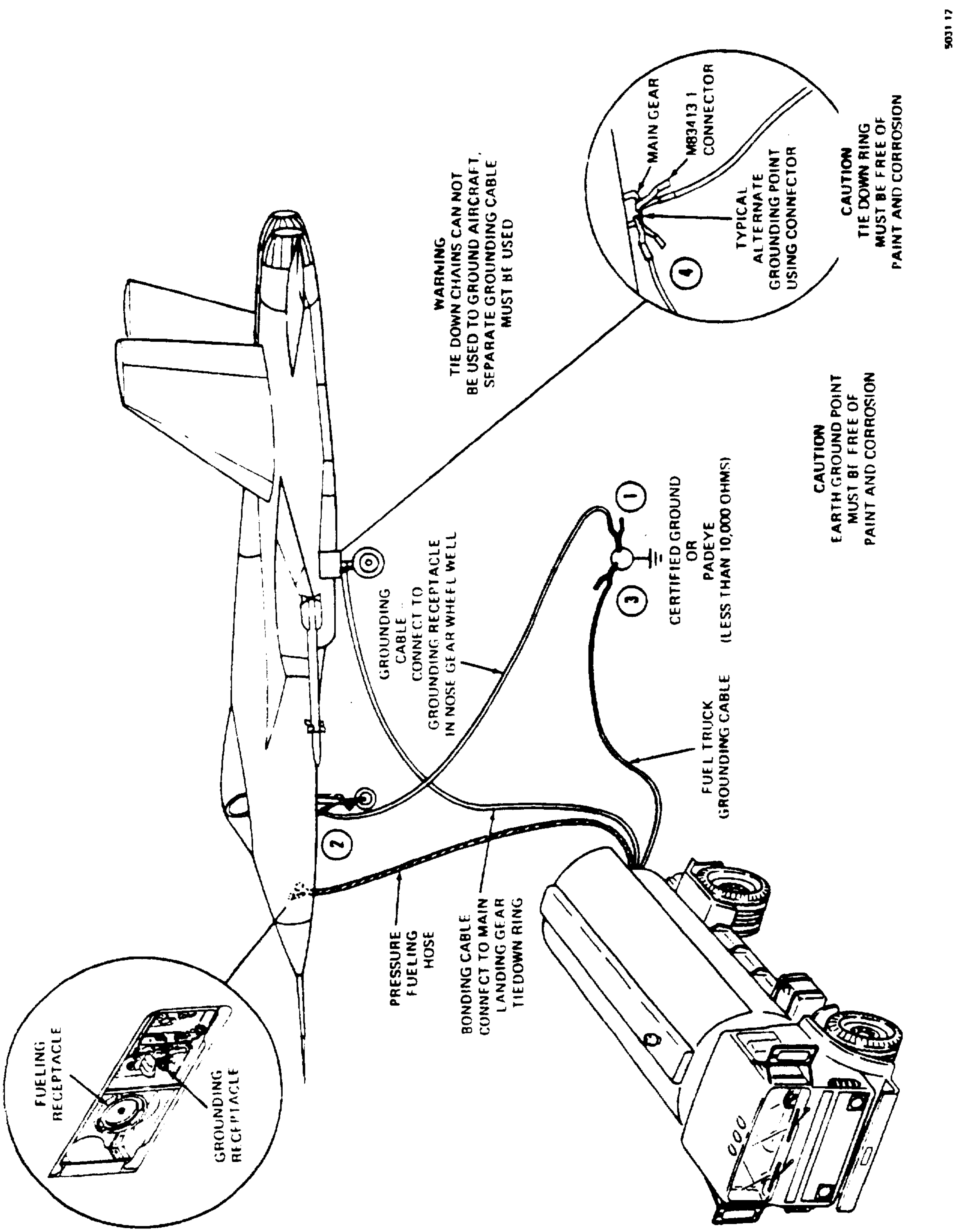


FIGURE 2-63. F-18 aircraft grounding, fueling/defueling evolution.

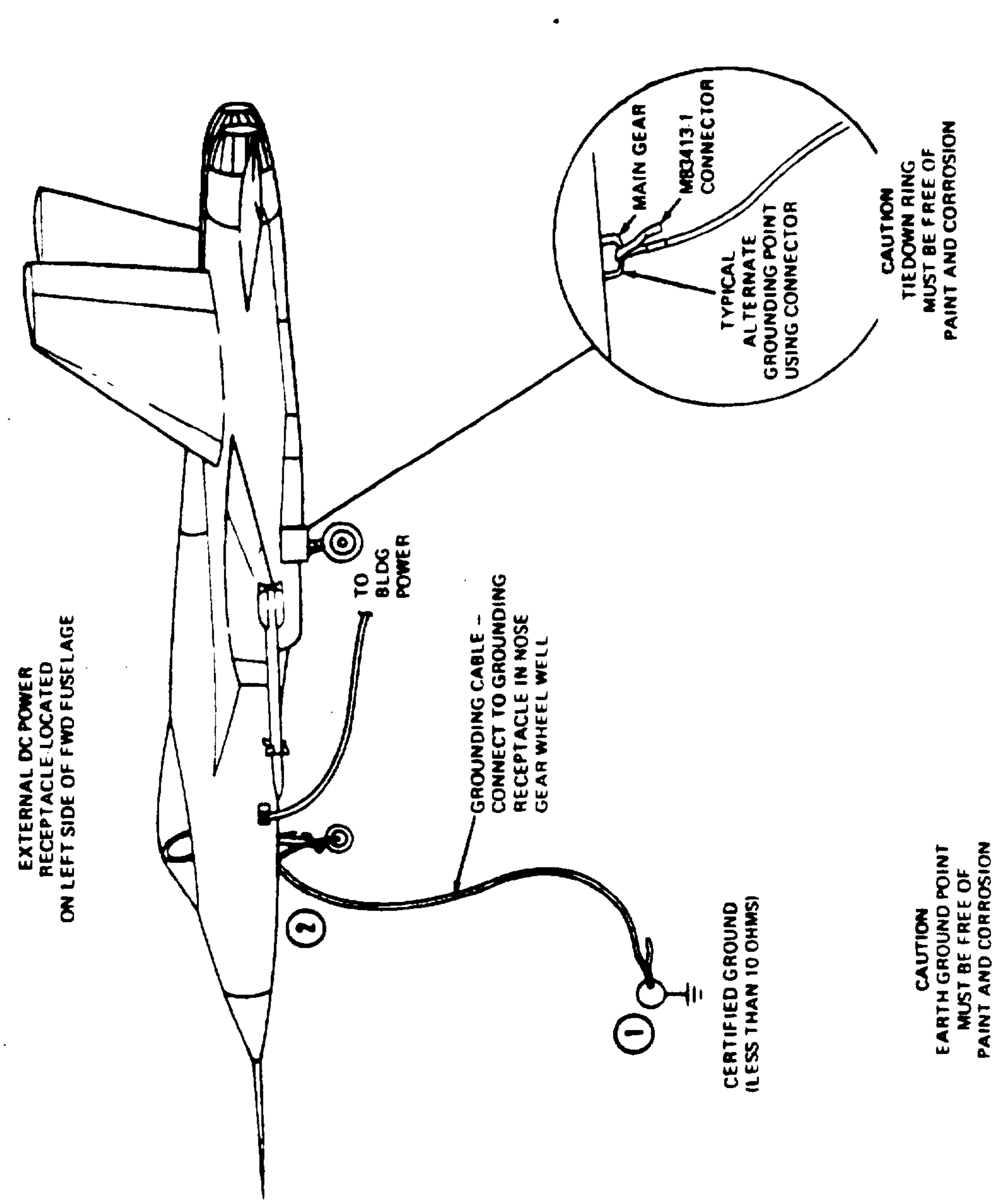


FIGURE 2-64. Hangar-based F-18 aircraft grounding, maintenance evolution.

c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.76 F-18 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground F-18 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-65):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

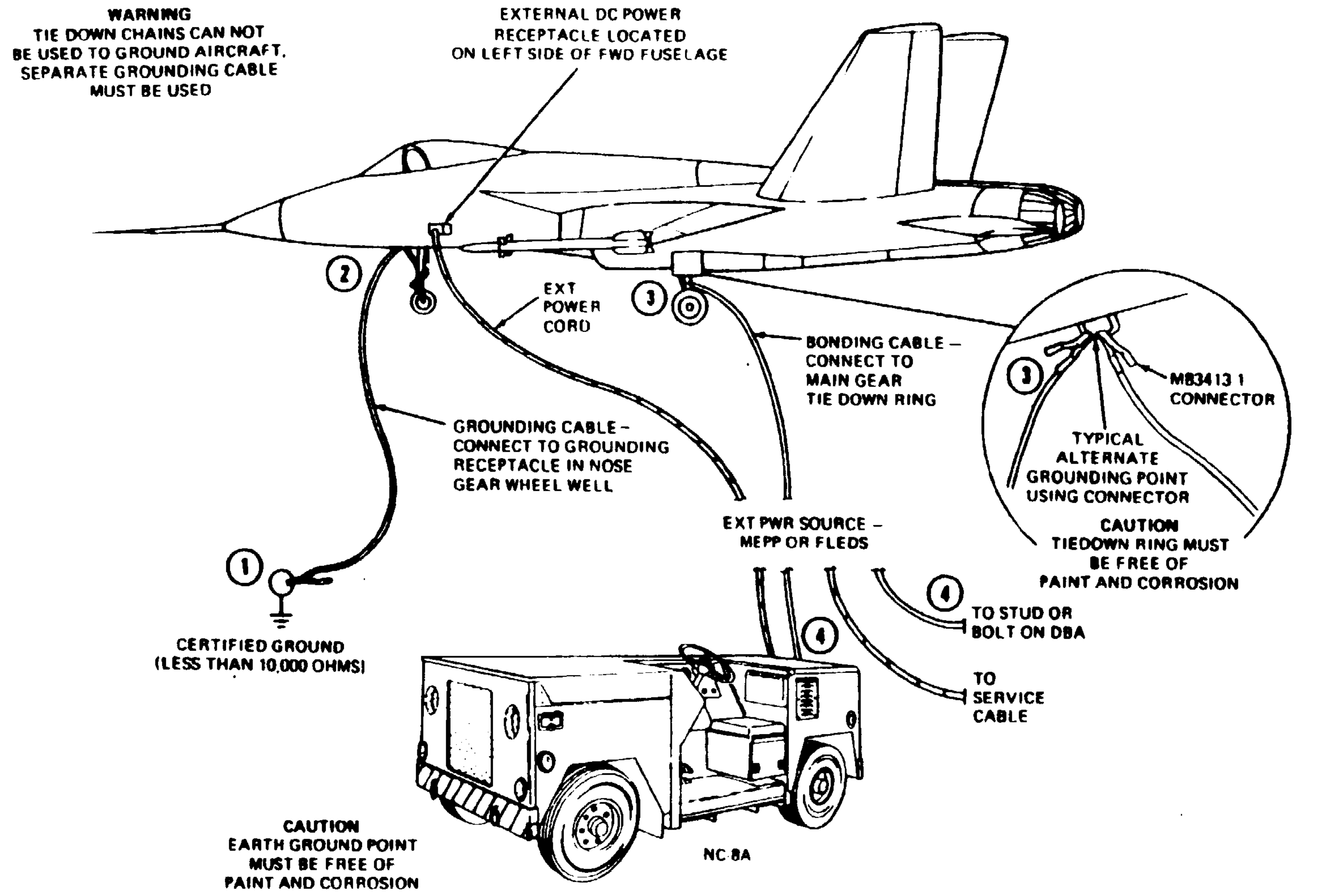
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.77 F-18 apron-based maintenance evolution (using FLEDS). To ground F-18 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-65):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.78 F-18 stores loading/unloading evolution. To ground F-18 aircraft during stores loading or unloading, proceed as follows (see figure 2-66):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).



5031 158

FIGURE 2-65. Apron-based F-18 aircraft grounding, maintenance evolution.

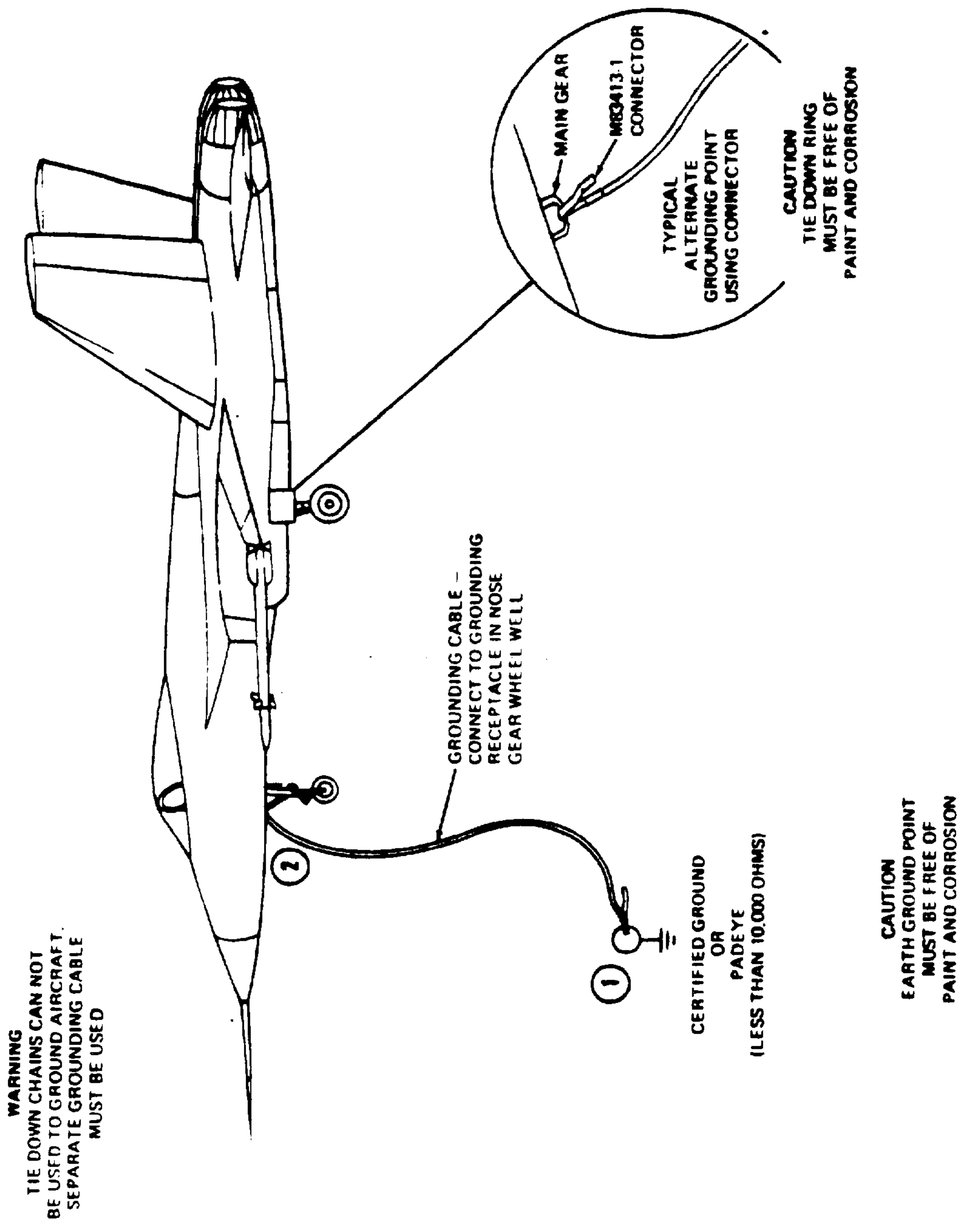


FIGURE 2-66. **F-18 aircraft grounding, stores loading/unloading evolution.**

c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.79 H-46 parked evolution. To ground H-46 aircraft when in the parked evolution, proceed as follows (see figure 2-67):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.80 H-46 fueling/defueling evolution. To ground H-46 aircraft when fueling or defueling, proceed as follows (see figure 2-68):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to left main gear tow fitting point (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

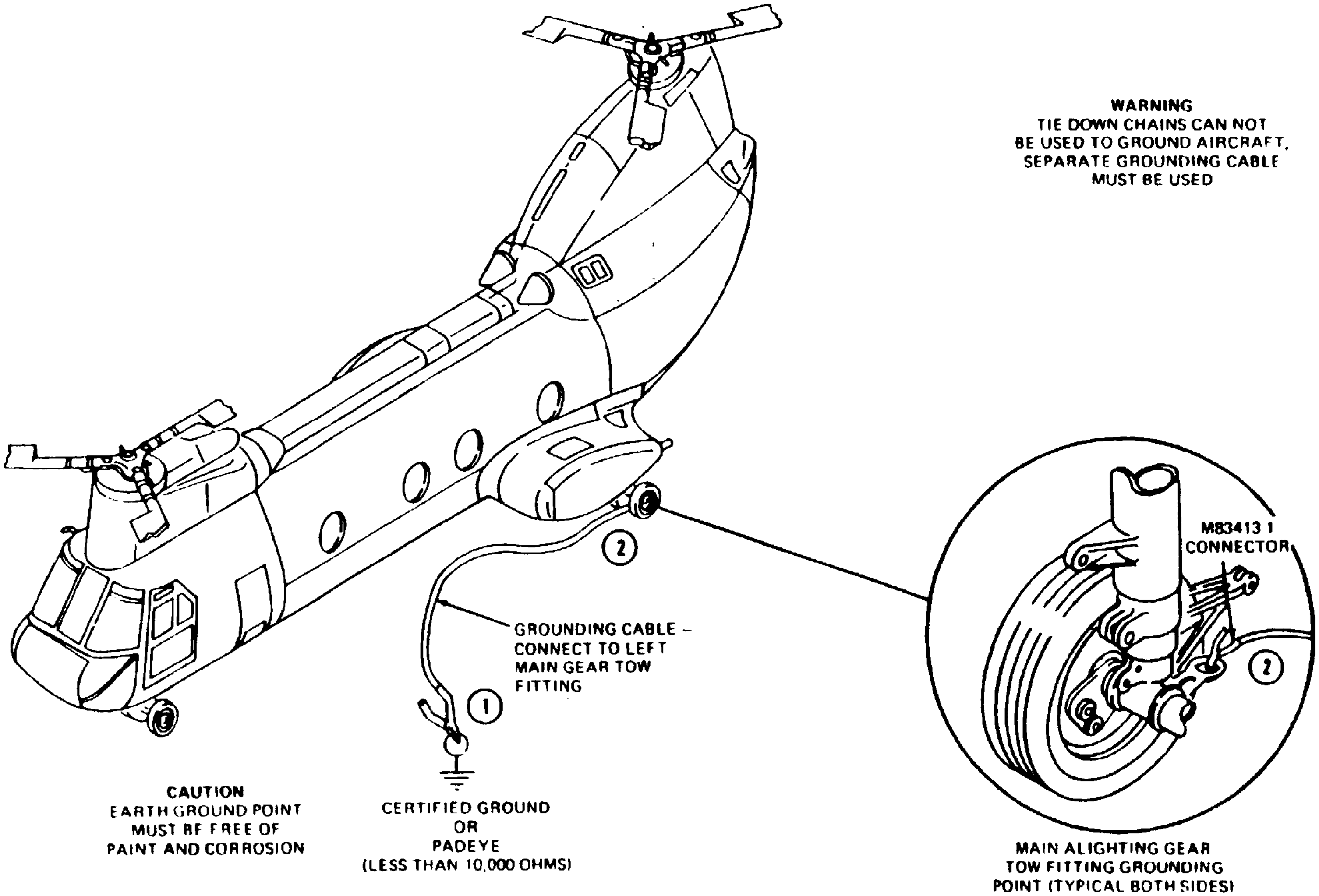
2.1.81 H-46 hangar-based maintenance evolution. To ground H-46 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-69).

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.82 H-46 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground H-46 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-70):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.



5031 21

FIGURE 2-67. H-46 aircraft grounding, parked evolution.

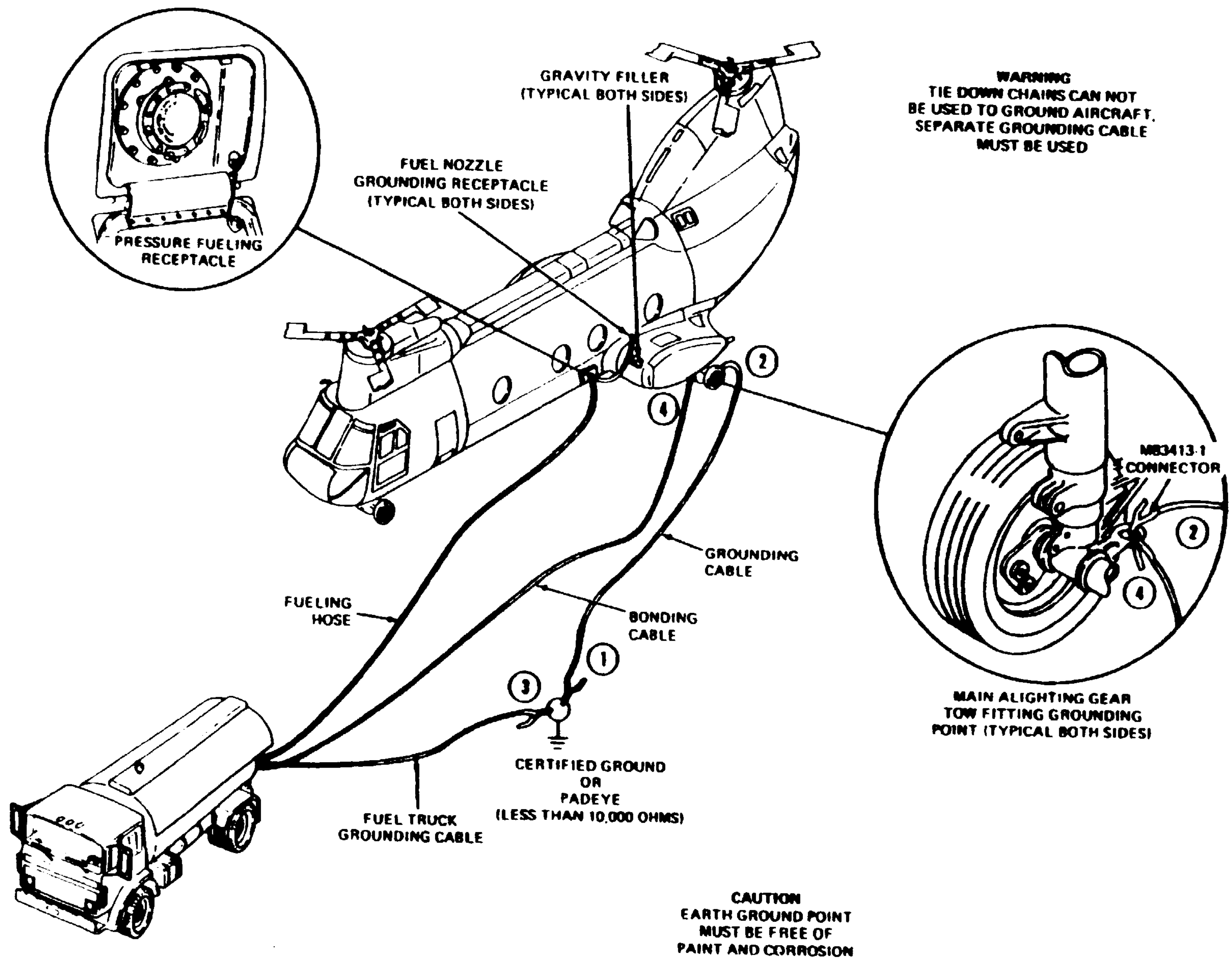


FIGURE 2-68. H-46 aircraft grounding, fueling/defueling evolution.

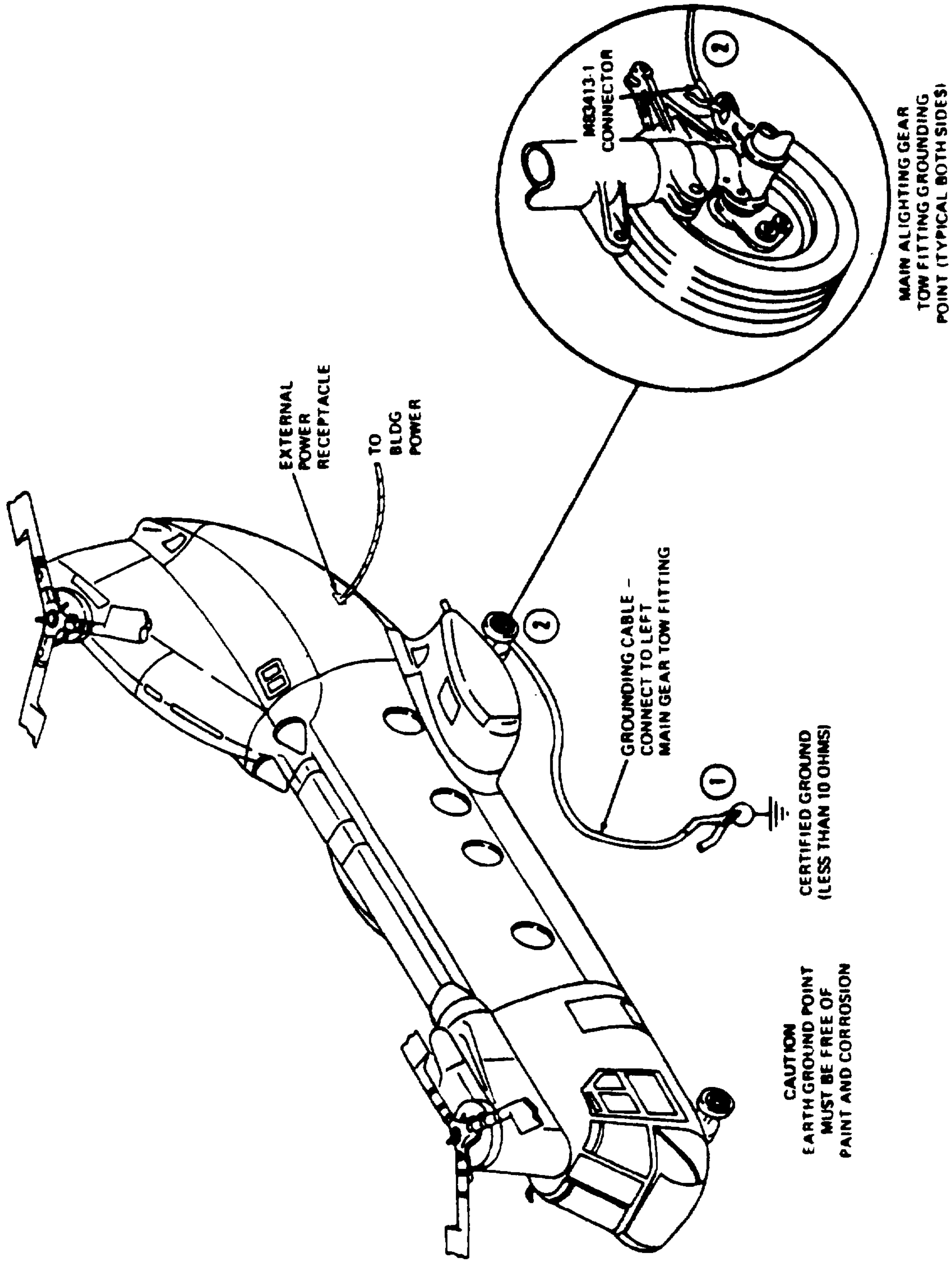


FIGURE 2-69. Hangar-based H-46 aircraft grounding, maintenance evolution.

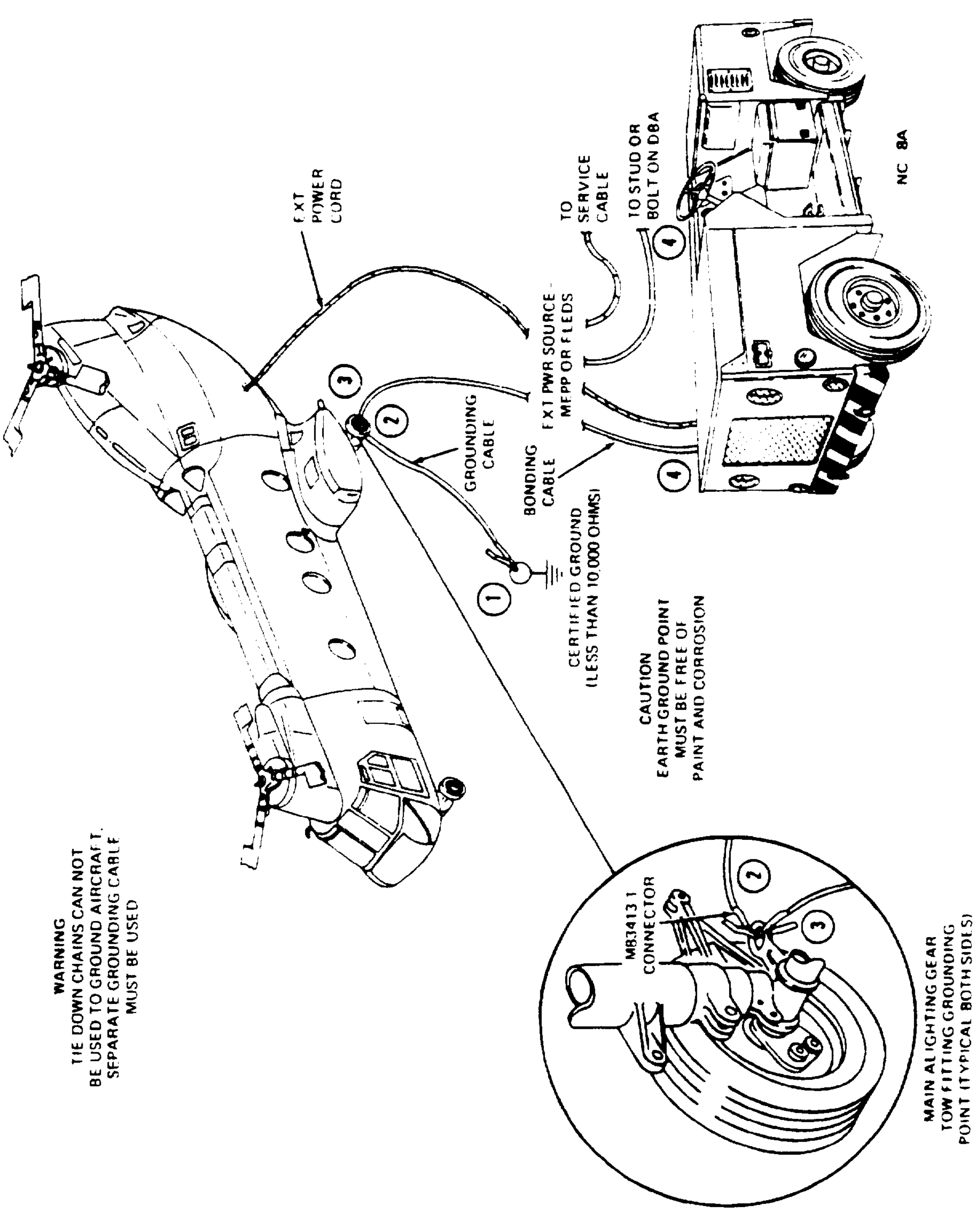


FIGURE 2-70. Apron-based H-46 aircraft grounding, maintenance evolution.

b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to left main gear tow fitting point (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.83 H-46 Apron-based maintenance evolution (using FLEDS). To ground H-46 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-70):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to left main gear tow fitting point (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.84 H-46 stores loading/unloading evolution. To ground H-46 aircraft during stores loading or unloading, proceed as follows (see figure 2-71):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.85 OV-10 parked evolution. To ground OV-10 aircraft when in the parked evolution, proceed as follows (see figure 2-72):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with a M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

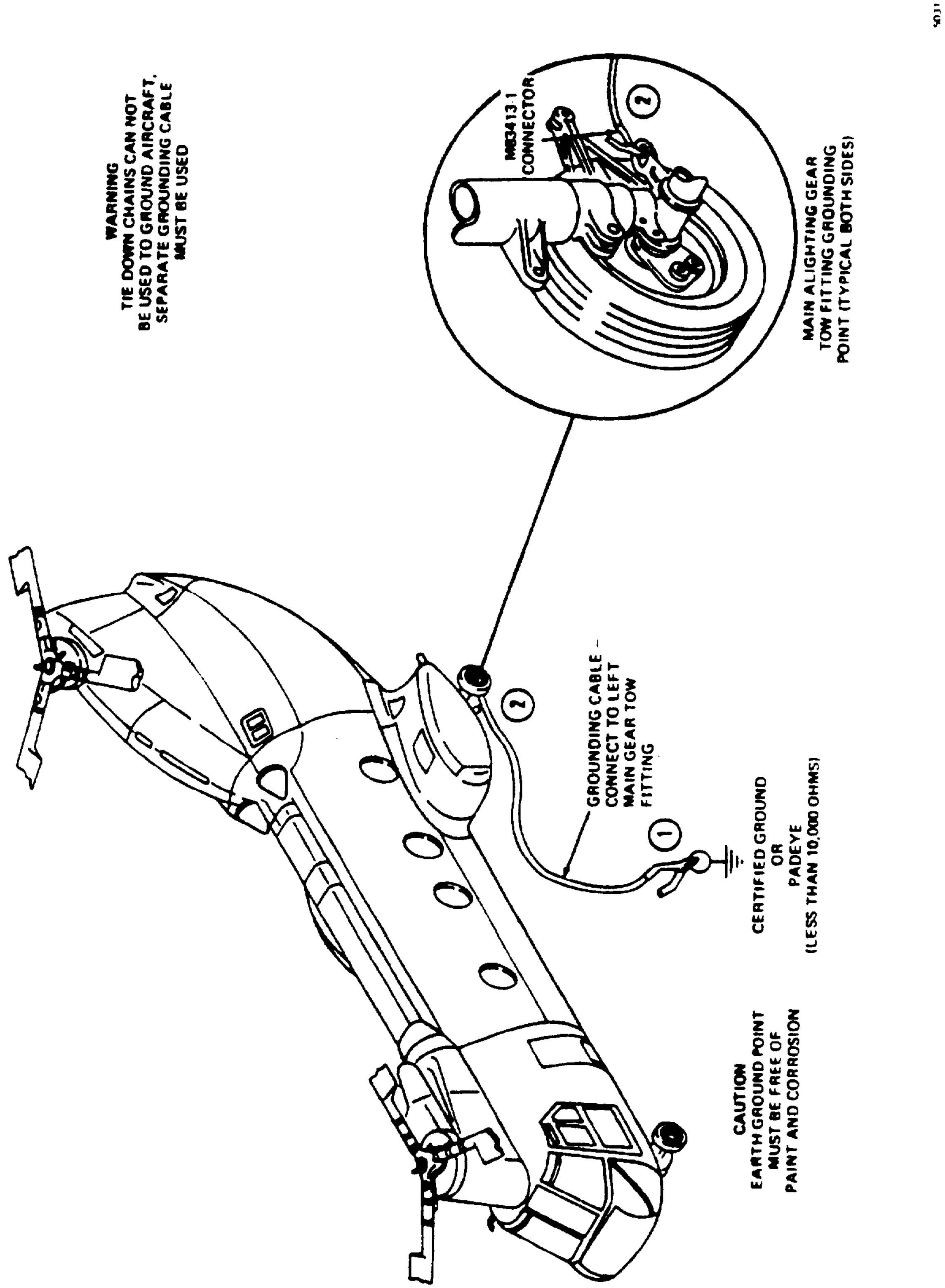


FIGURE 2-71. H-46 aircraft grounding, stores loading/unloading evolution.

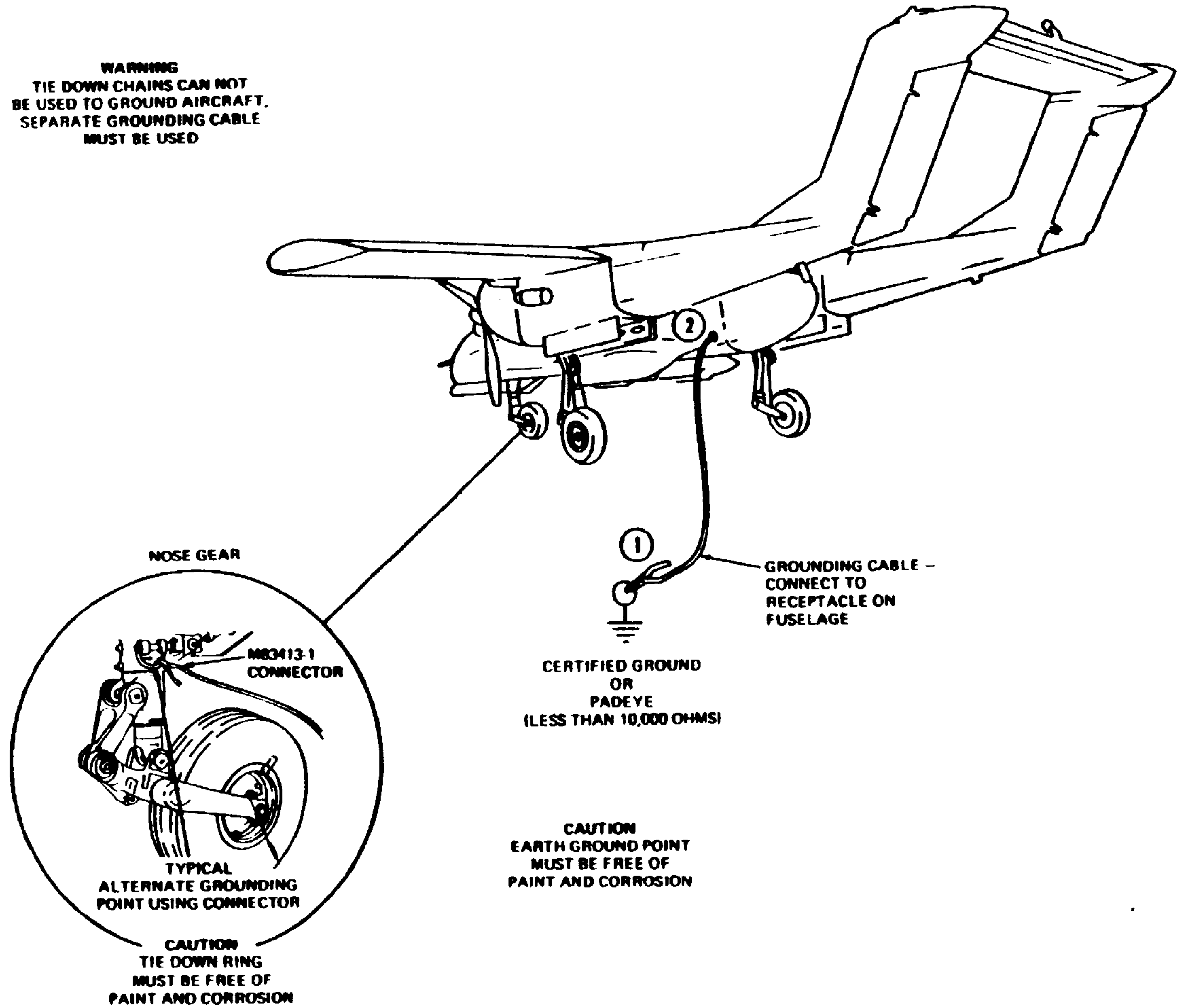


FIGURE 2-72. OV-10 aircraft grounding, parked evolution.

2.1.86 OV-10 fueling/defueling evolution. To ground OV-10 aircraft when fueling or defueling, proceed as follows (see figure 2-73):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with a M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to nose gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

2.1.87 OV-10 hangar-based maintenance evolution. To ground OV-10 aircraft during maintenance in the hangar, proceed as follows (see figure 2-74):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.88 OV-10 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground OV-10 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-75):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).

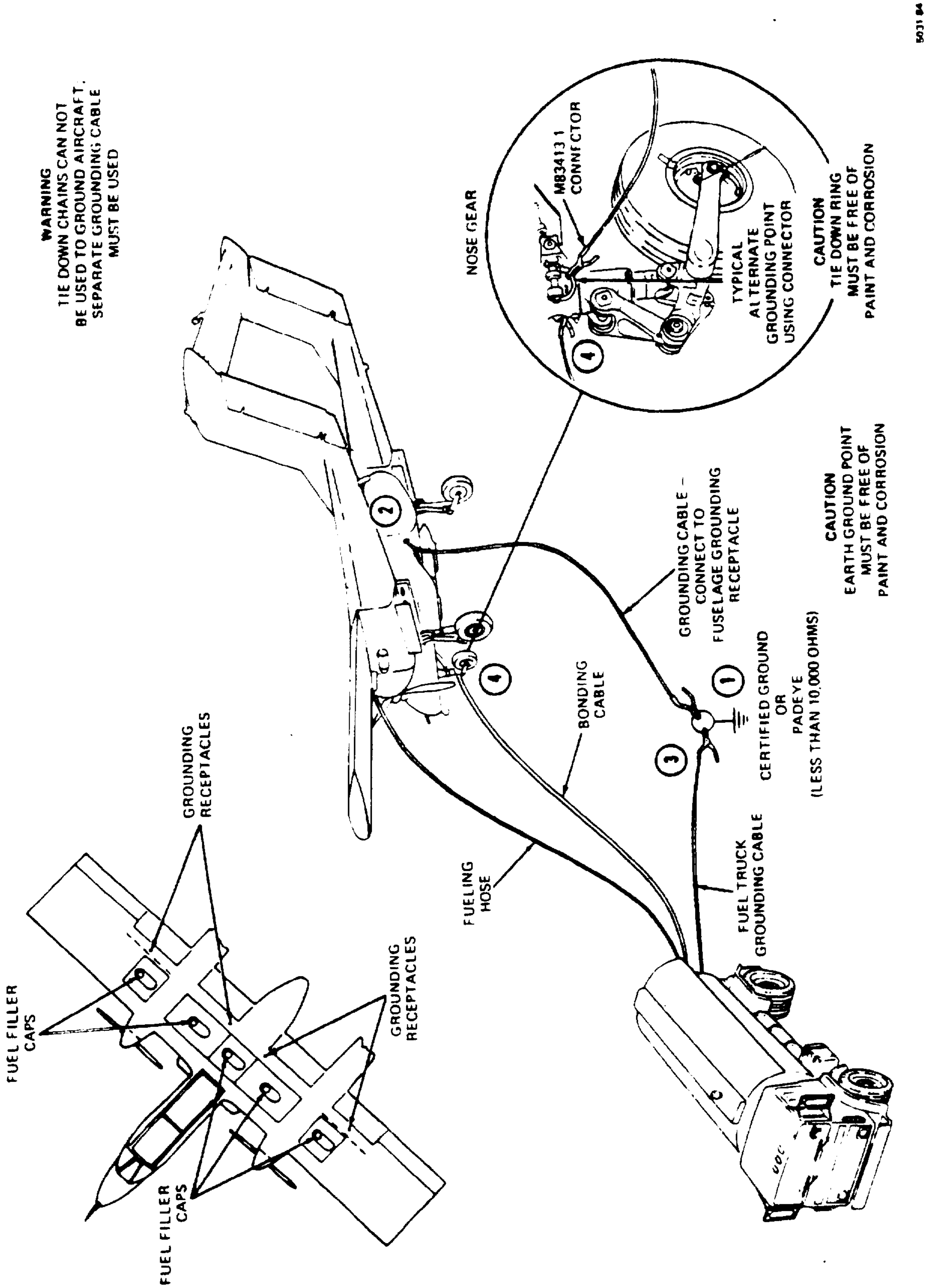


FIGURE 2-73. OV-10 aircraft grounding, fueling/defueling evolution.

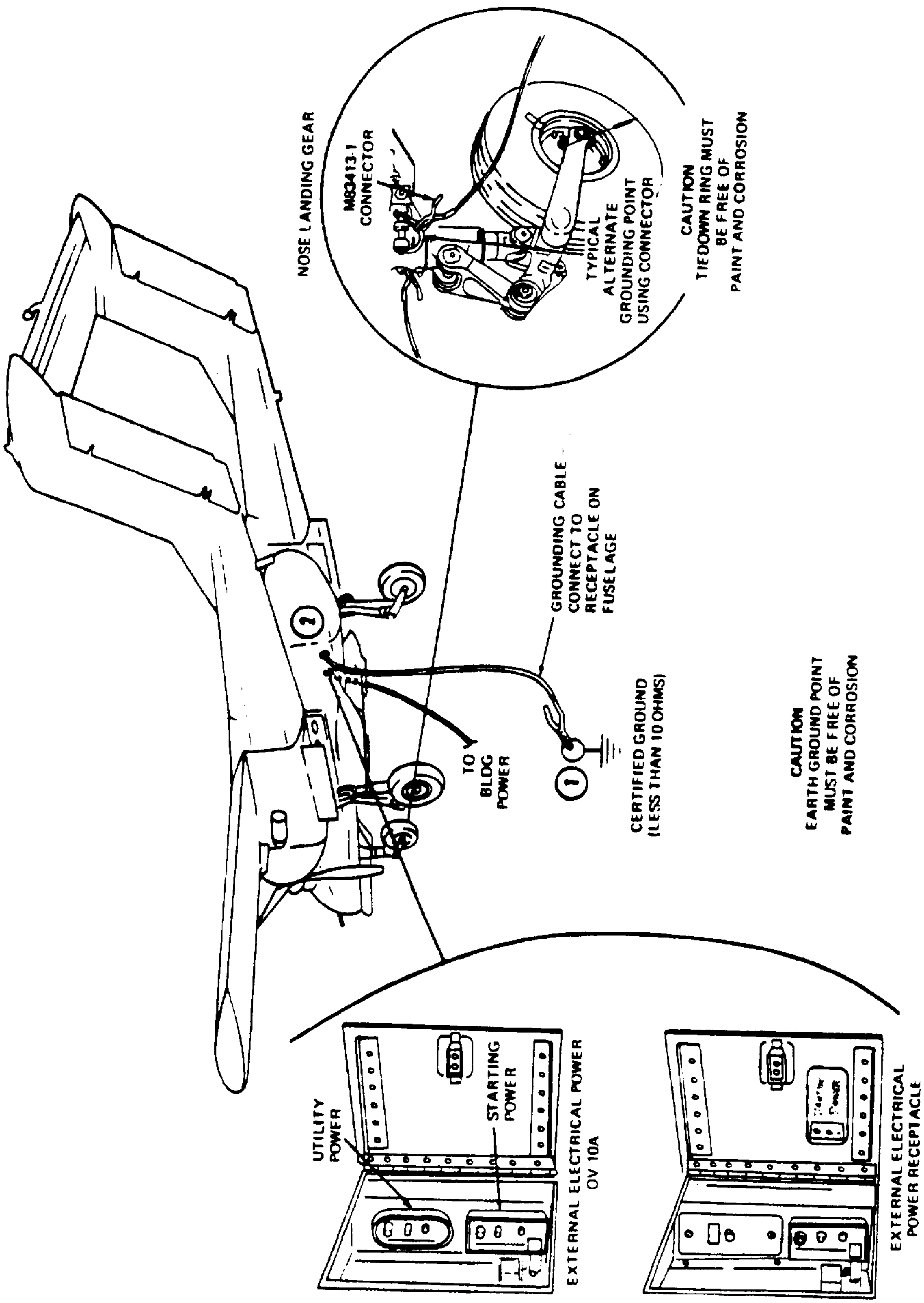


FIGURE 2-74. Hangar-based OV-10 aircraft grounding, maintenance evolution.

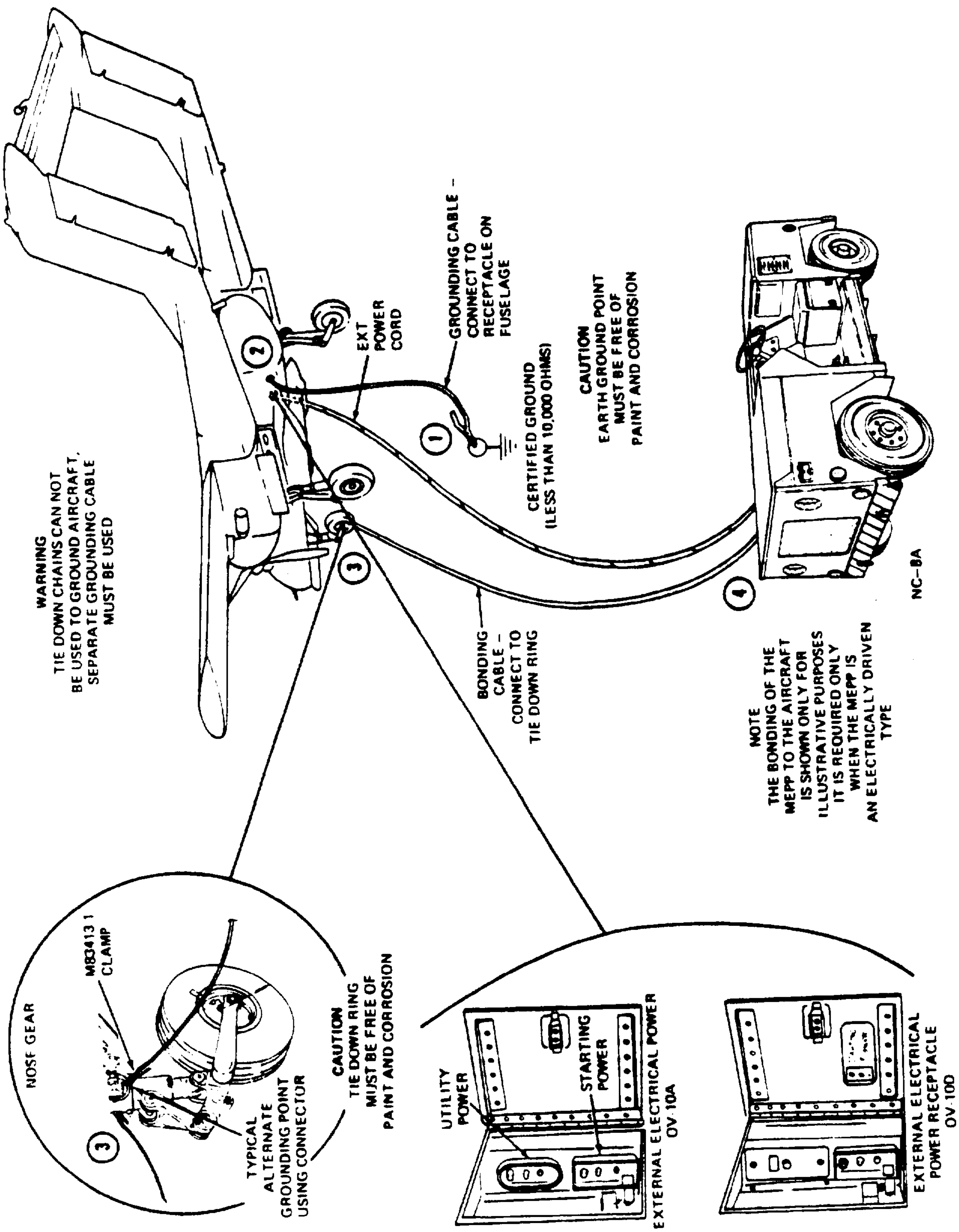


FIGURE 2-75. Apron-based OV-10 aircraft grounding, maintenance evolution.

e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.89 OV-10 stores loading/unloading evolution. To ground OV-10 aircraft during stores loading or unloading, proceed as follows (see figure 2-76):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.90 P-3 parked evolution. To ground P-3 aircraft when in the parked evolution, proceed as follows (see figure 2-77):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding lug on main landing gear (2). If this location is not accessible, then connect grounding cable to upper part of static drag wire (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.91 P-3 fueling/defueling evolution. To ground P-3 aircraft when fueling or defueling, proceed as follows (see figure 2-78):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding lug on main landing gear (2). If this location is not accessible, then connect grounding cable to upper part of static drag wire (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to grounding lug (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

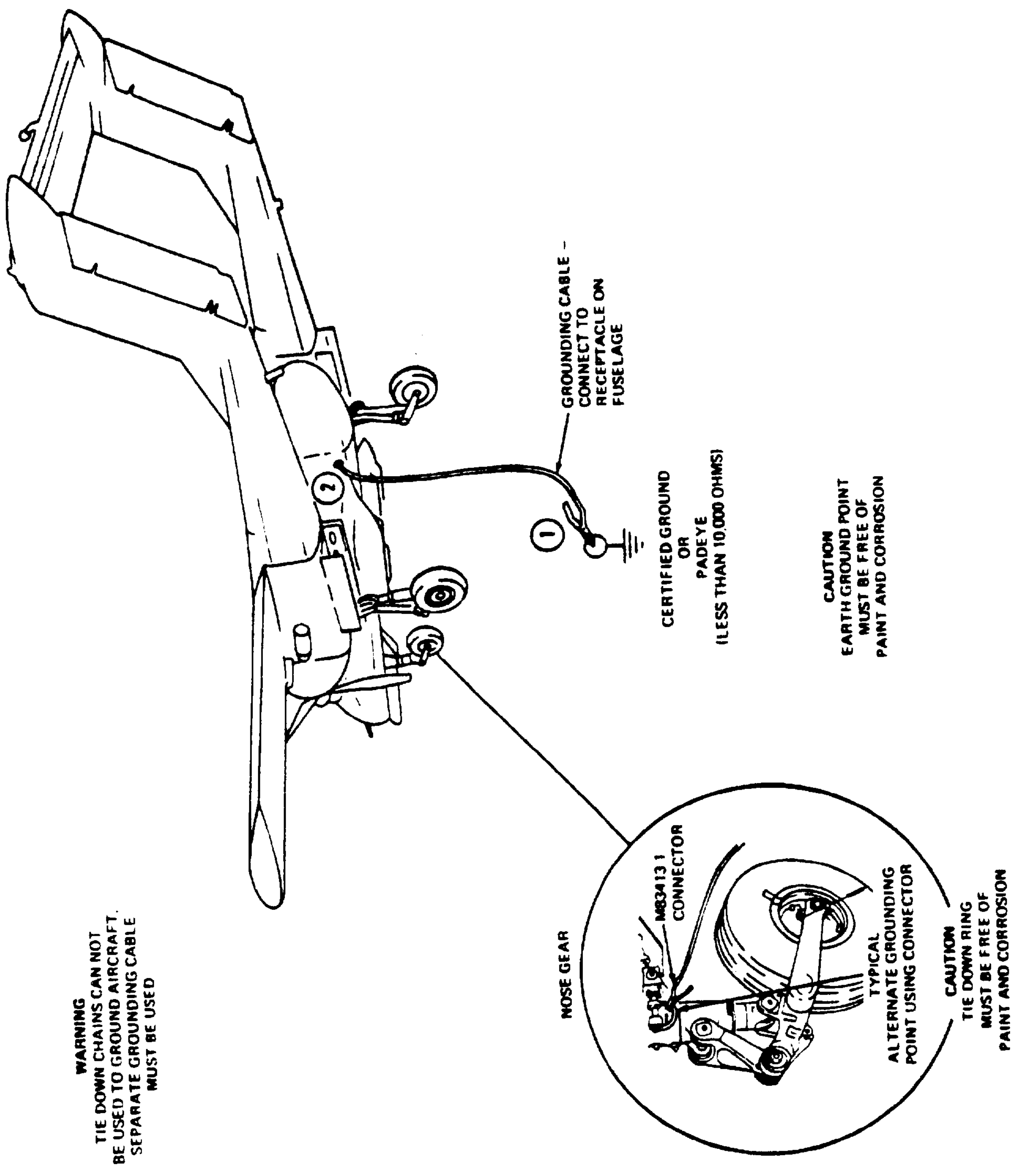


FIGURE 2-76. OV-10 aircraft grounding, stores loading/unloading evolution.

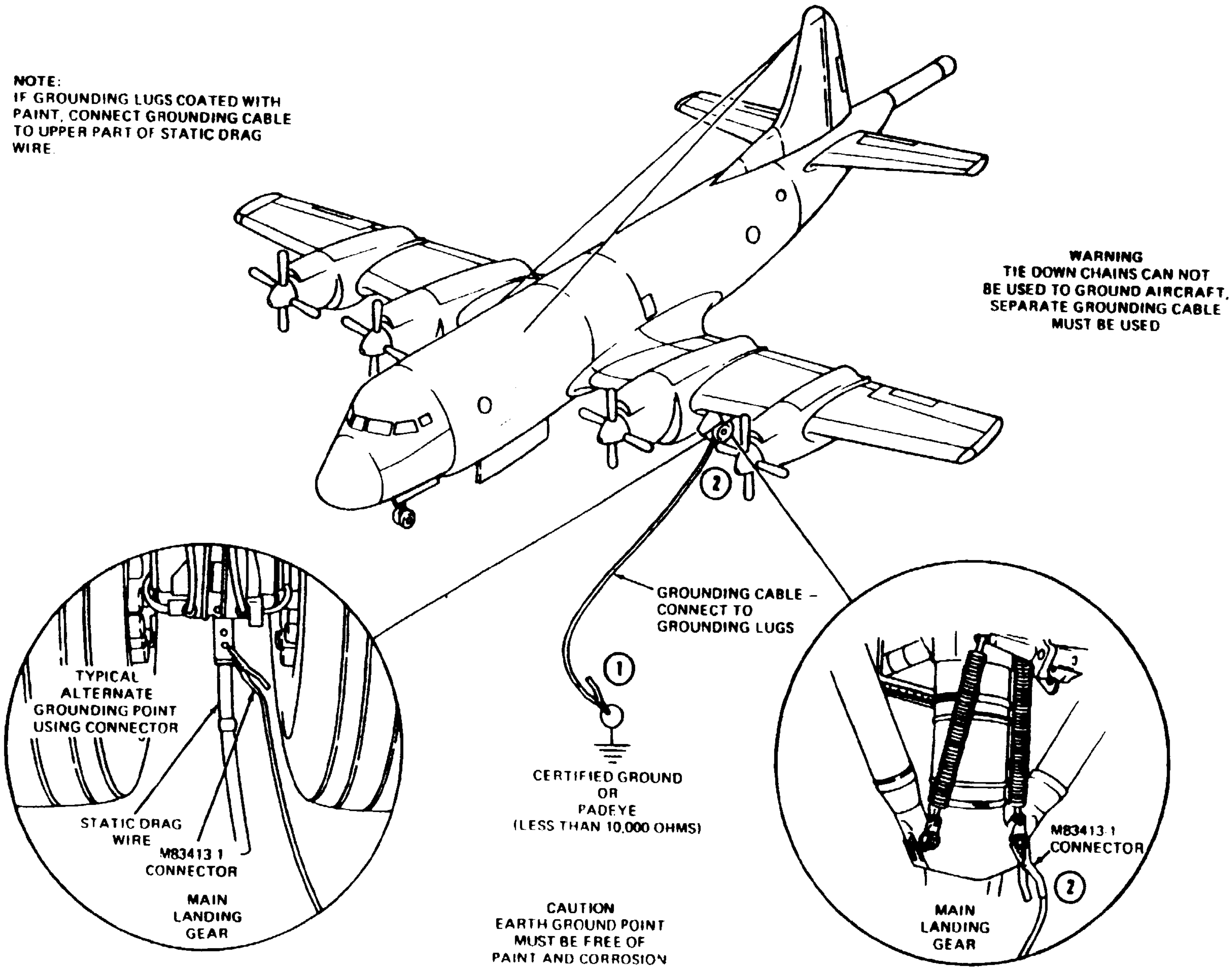


FIGURE 2-77. P-3 aircraft grounding, parked evolution.

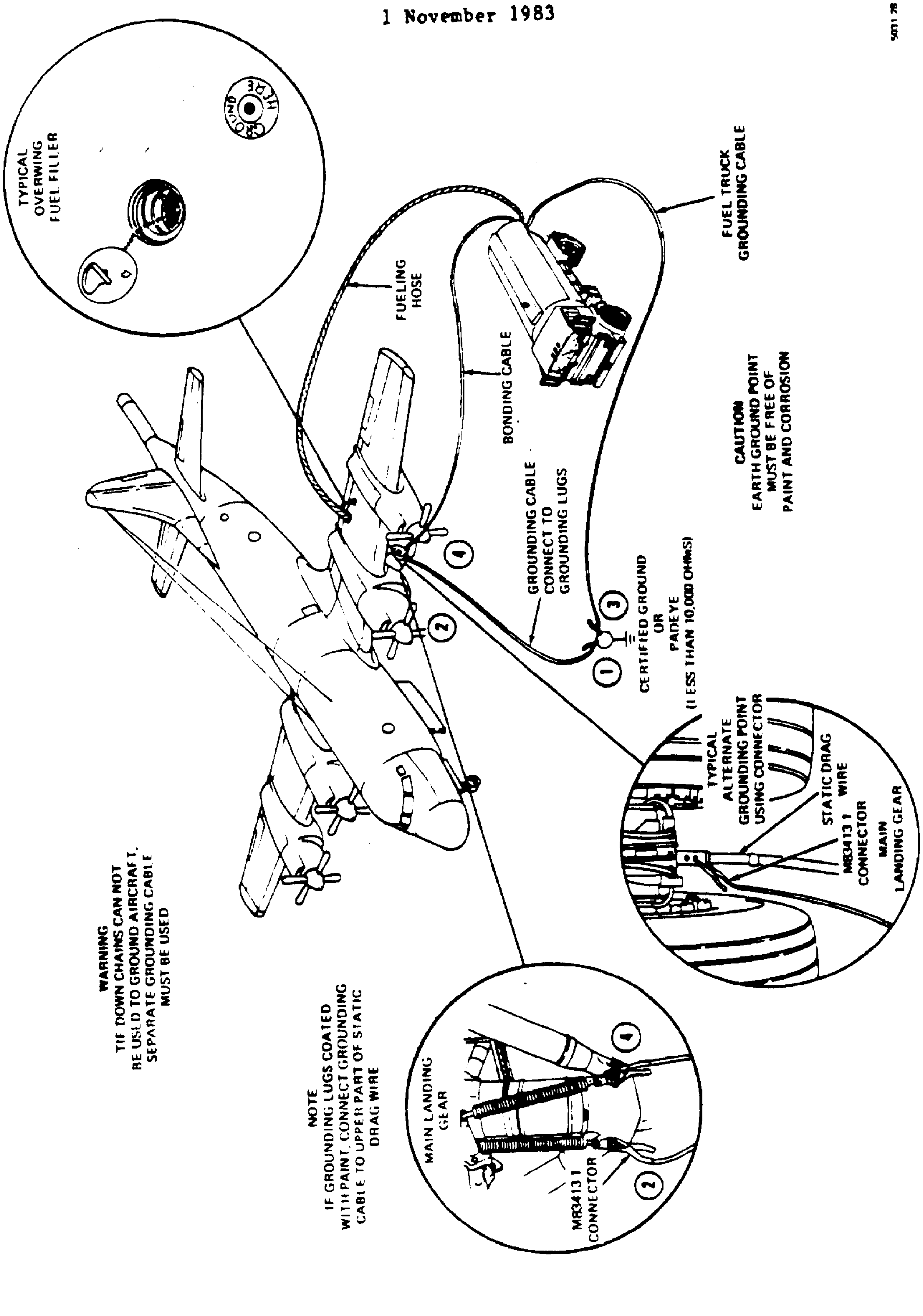


FIGURE 2-78. P-3 aircraft grounding, fueling/defueling evolution.

WARNING: P-3 airframe must be static grounded when parked and its engines are used to supply electrical power for any type of maintenance check or runup tests. The grounding straps presently mounted on the main landing wheels can not be relied upon to prevent airframe electrostatic buildup.

2.1.92 P-3 hangar-based maintenance evolution. To ground P-3 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-79):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to grounding lug on main landing gear (2). If this location is not accessible, then connect grounding cable to upper part of static drag wire (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.93 P-3 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground P-3 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-80):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to grounding lug on main landing gear (2). If this location is not accessible, then connect grounding cable to upper part of static drag wire (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to grounding lug (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.94 P-3 apron-based maintenance evolution (using FLEDS). To ground P-3 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-80):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding lug on main landing gear (2). If this location is not accessible, then connect grounding cable to upper part of static drag wire (typical alternate grounding point).

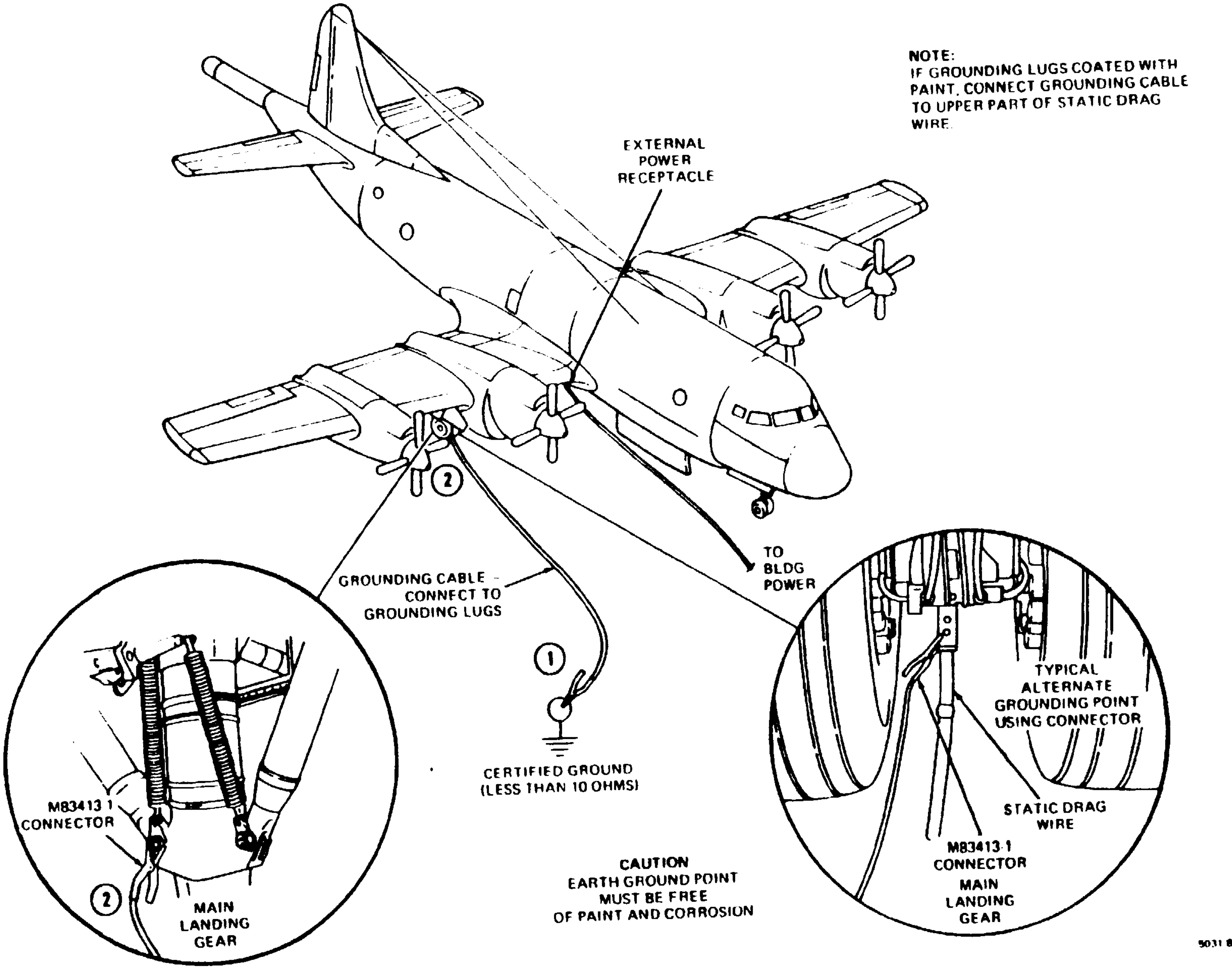


FIGURE 2-79. Hangar-based P-3 aircraft grounding, maintenance evolution.

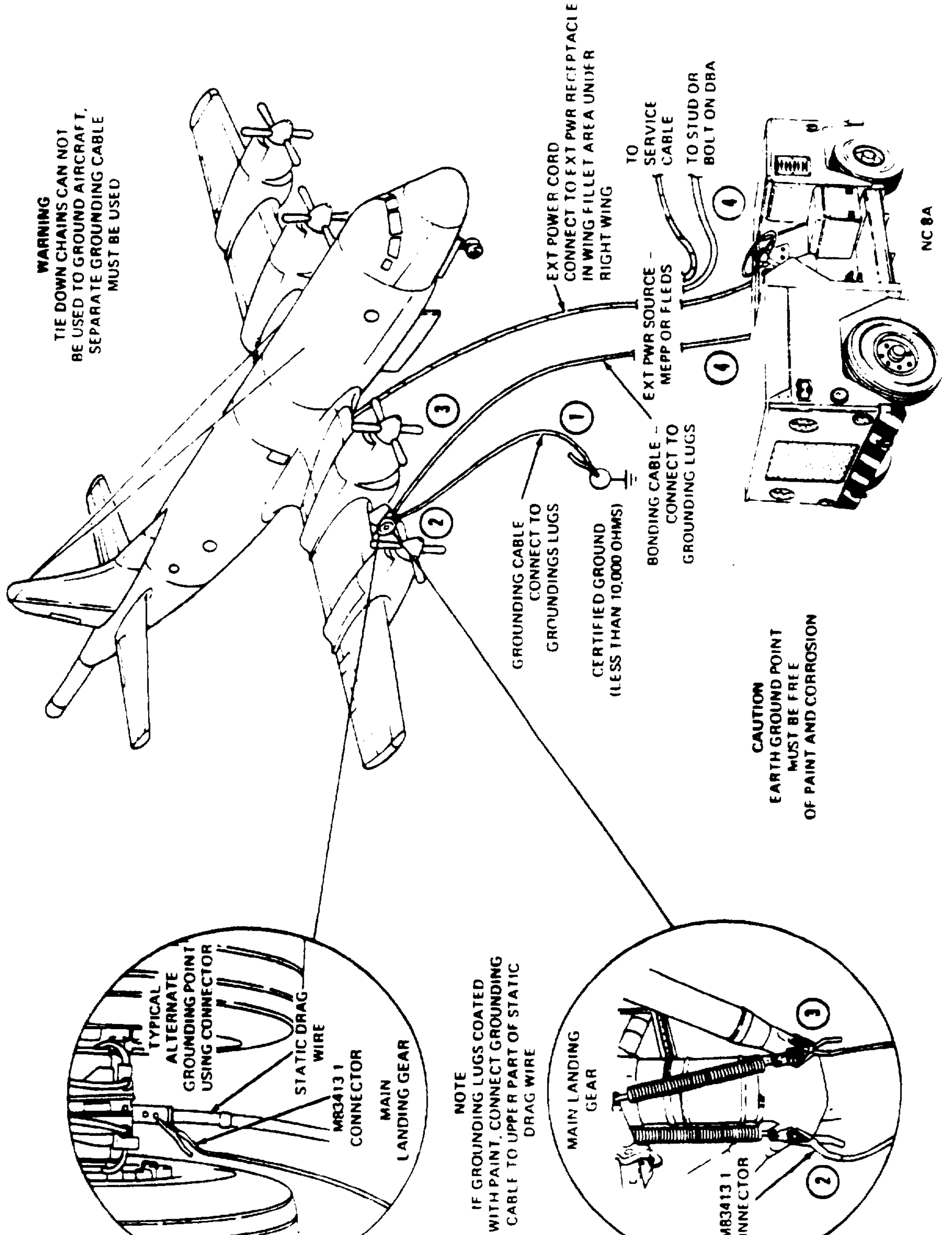


FIGURE 2-80. Apron-based P-3 aircraft grounding, maintenance evolution.

c. Attach bonding cable with M83413-1 electrical ground connector to grounding lug (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.95 P-3 stores loading/unloading evolution. To ground P-3 aircraft during stores loading/unloading, proceed as follows (see figure 2-81):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding lug on main landing gear (2). If this location is not accessible, then connect grounding cable to upper part of static drag wire (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.96 S-3 parked evolution. To ground S-3 aircraft when in the parked evolution, proceed as follows (see figure 2-82):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.97 S-3 fueling/defueling evolution. To ground S-3 aircraft when fueling or defueling, proceed as follows (see figure 2-83):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to main gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

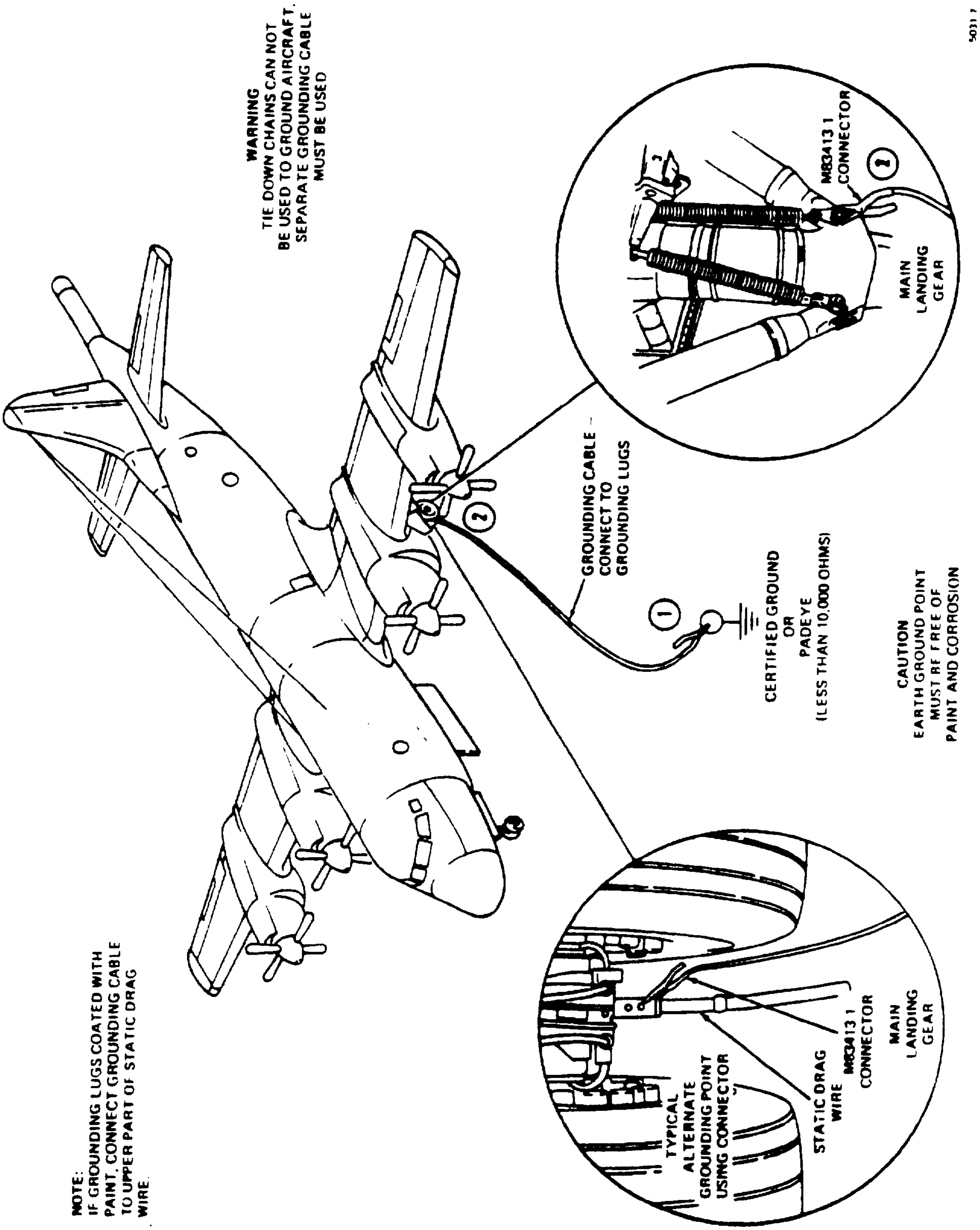


FIGURE 2-81. P-3 aircraft grounding, stores loading/unloading evolution.

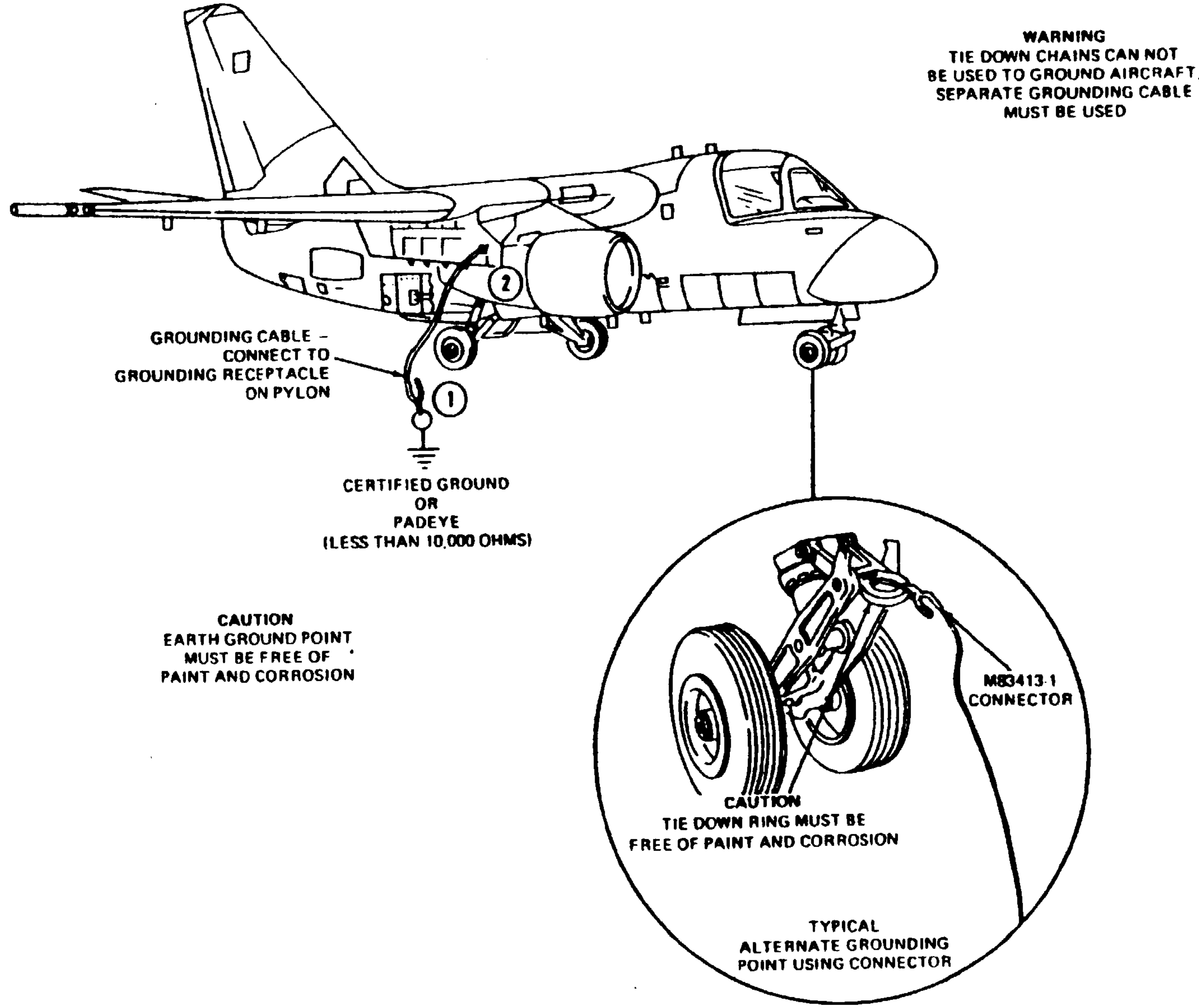


FIGURE 2-82. S-3 aircraft grounding, parked evolution.

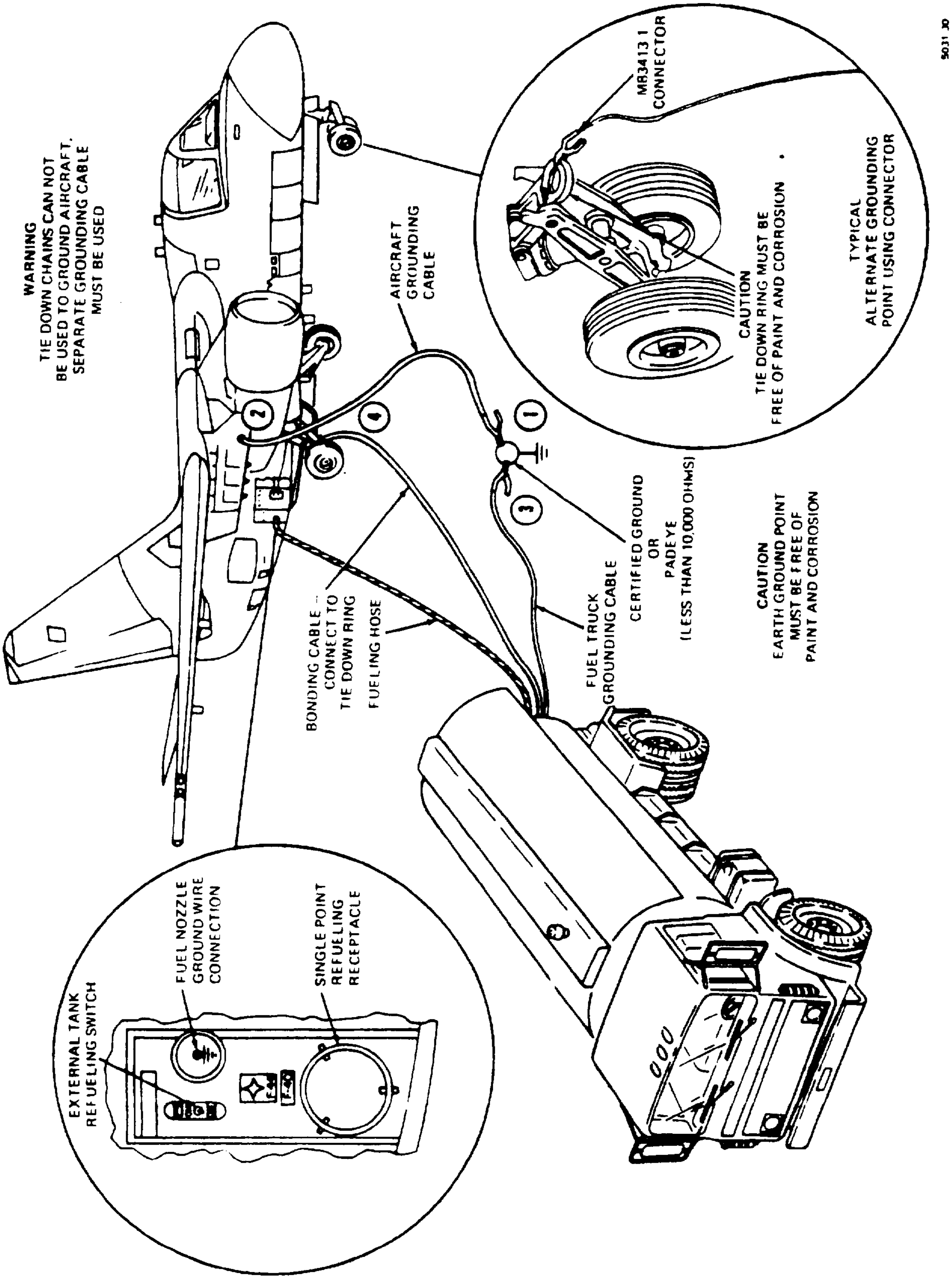


FIGURE 2-83. S-3 aircraft grounding, fueling/defueling evolution.

2.1.98 S-3 hangar-based maintenance evolution. To ground S-3 aircraft during maintenance in the hangar, proceed as follows (see figure 2-84):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.99 S-3 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground S-3 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-85):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.100 S-3 apron-based maintenance evolution (using FLEDS). To ground S-3 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-85):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

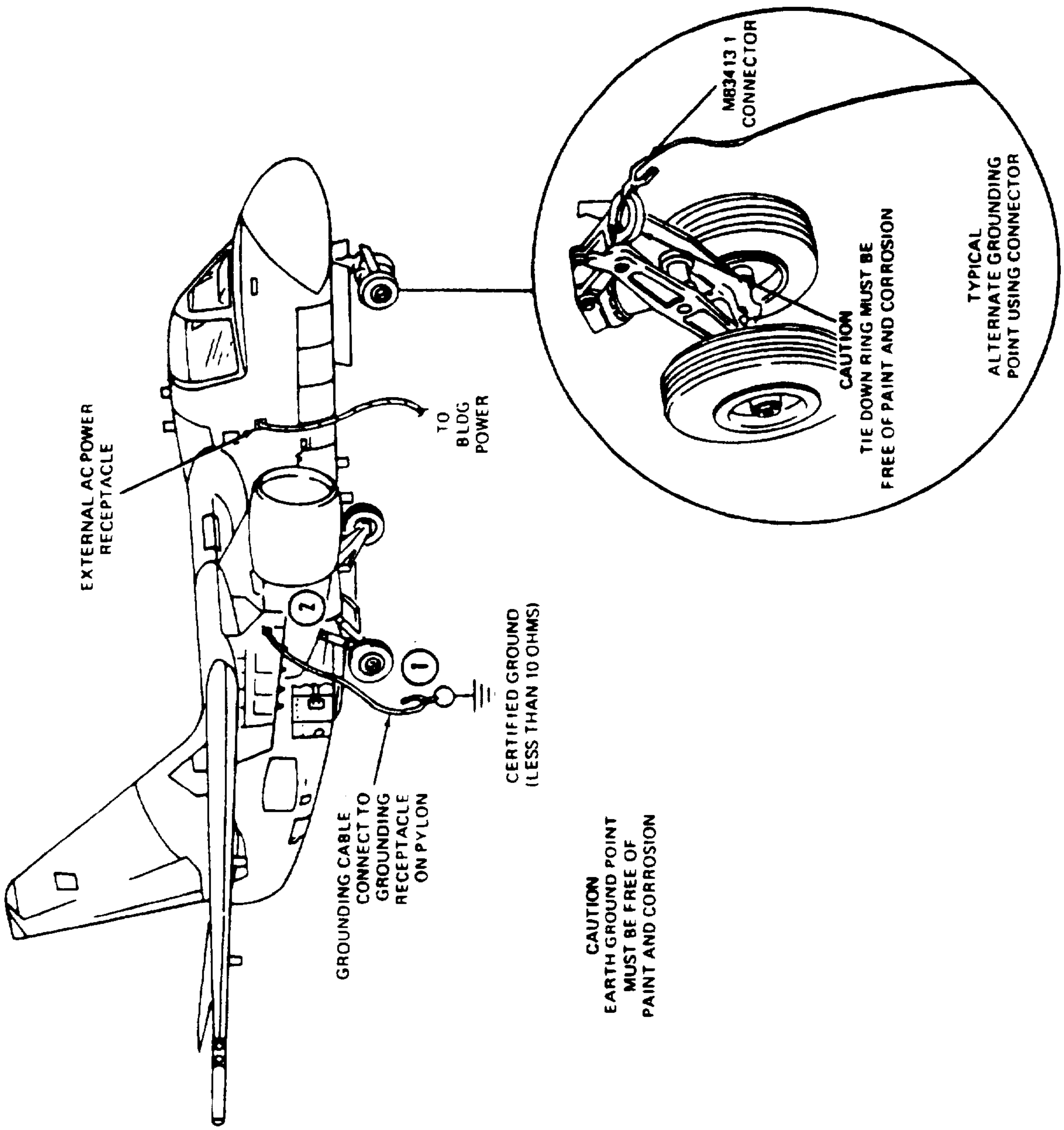


FIGURE 2-84. Hangar-based S-3 aircraft grounding, maintenance evolution.

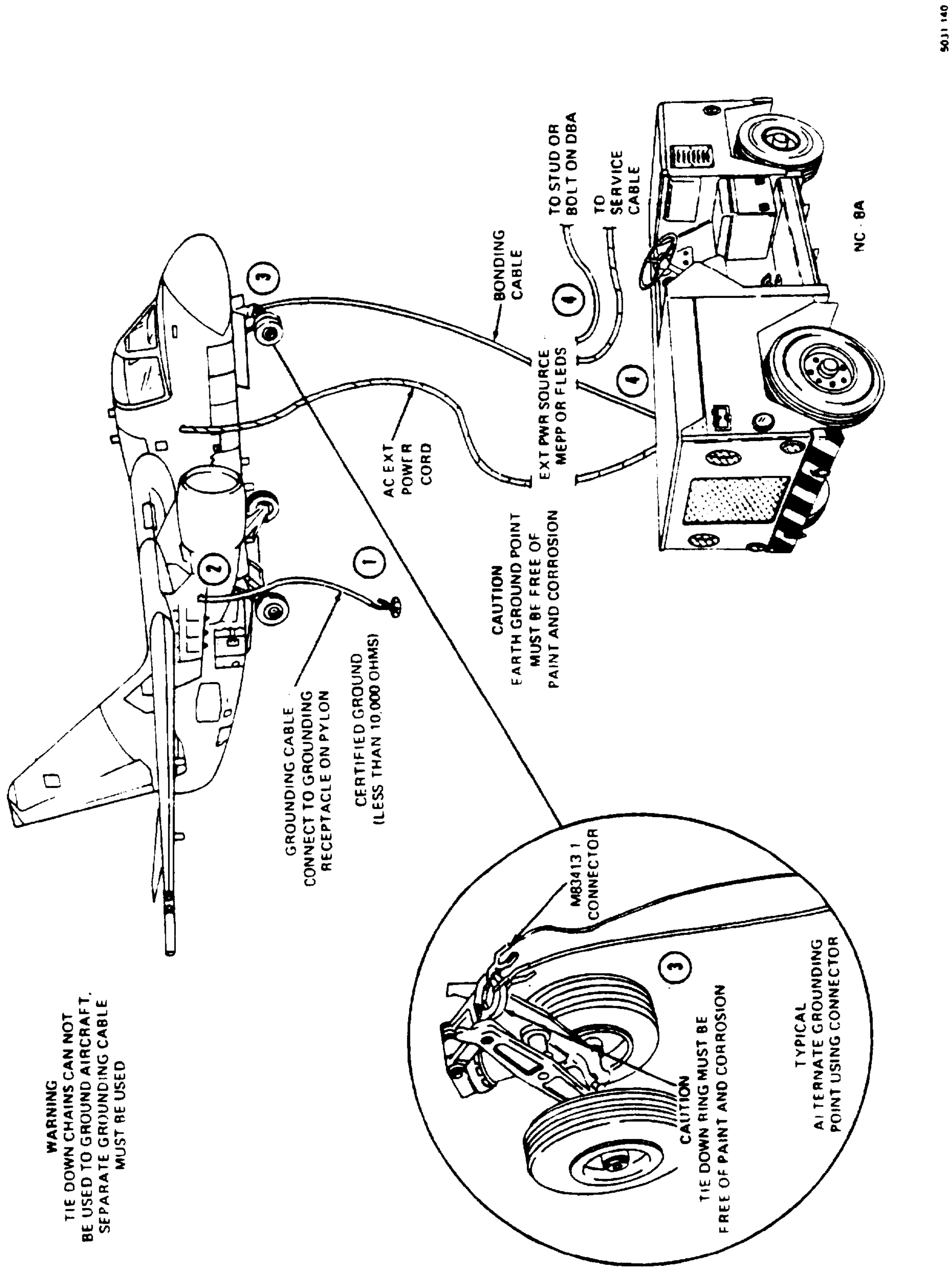


FIGURE 2-85. Apron-based S-3 aircraft grounding, maintenance evolution.

2.1.101 S-3 stores loading/unloading evolution. To ground S-3 aircraft during stores loading or unloading, proceed as follows (see figure 2-86):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.102 SH-2 parked evolution. To ground SH-2 aircraft when in the parked evolution, proceed as follows (see figure 2-87):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of cable to front left fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.103 SH-2 fueling/defueling evolution. To ground SH-2 aircraft when fueling or defueling, proceed as follows (see figure 2-88):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to main gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

2.1.104 SH-2 hangar-based maintenance evolution. To ground SH-2 aircraft during maintenance in the hangar, proceed as follows (see figure 2-89):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).

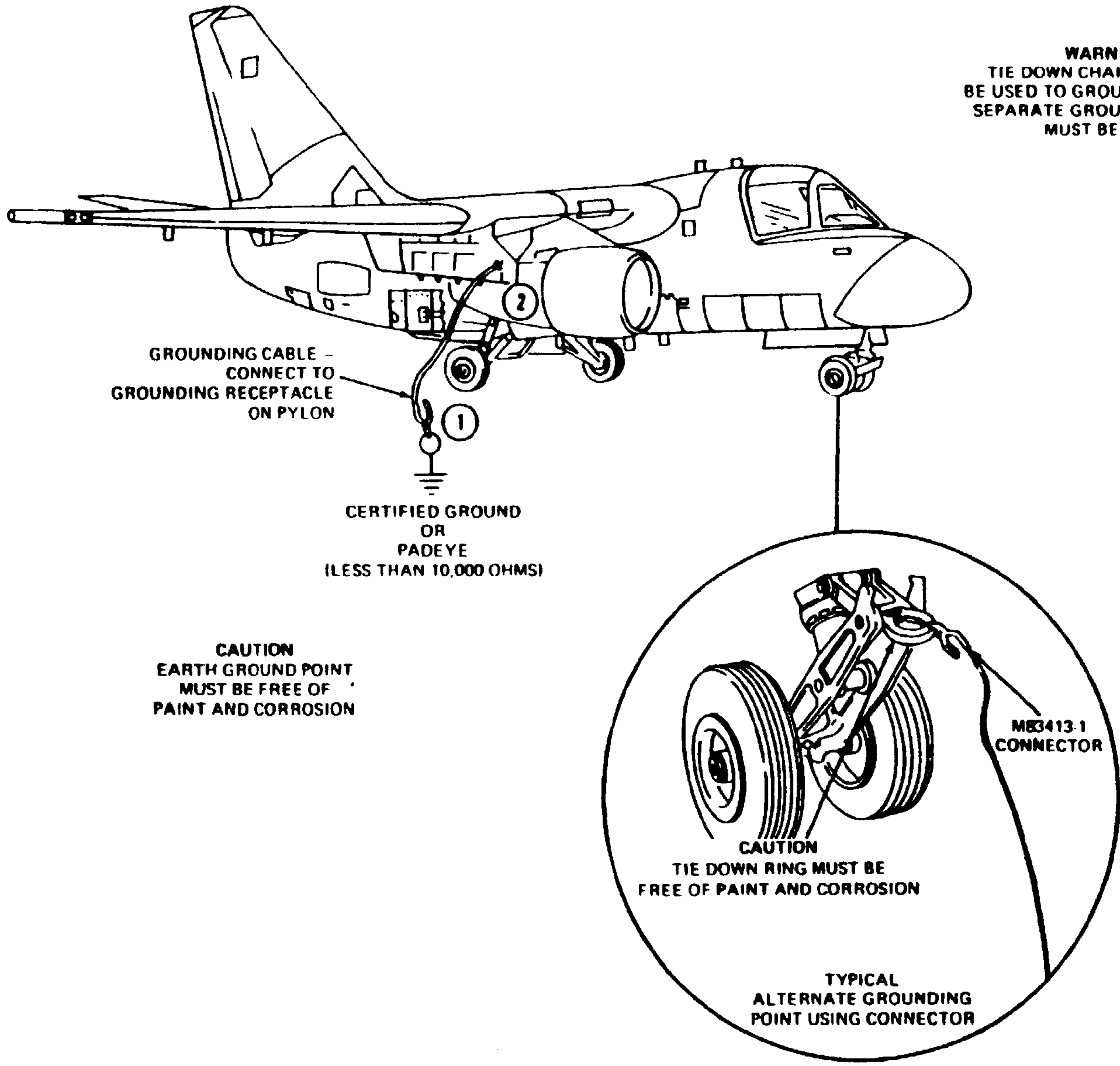


FIGURE 2-86. S-3 aircraft grounding, stores loading/unloading evolution.

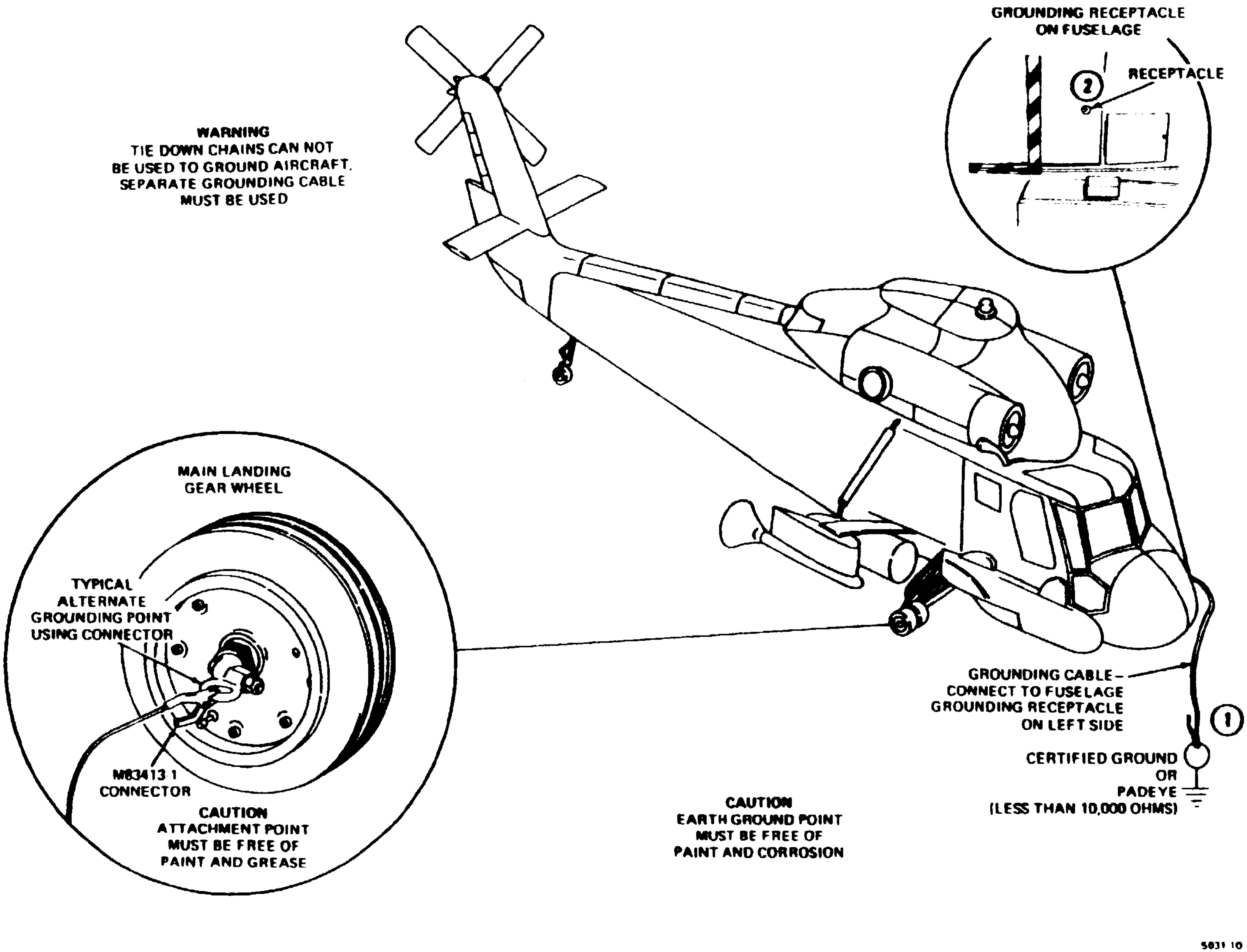


FIGURE 2-87. SH-2 aircraft grounding, parked evolution.

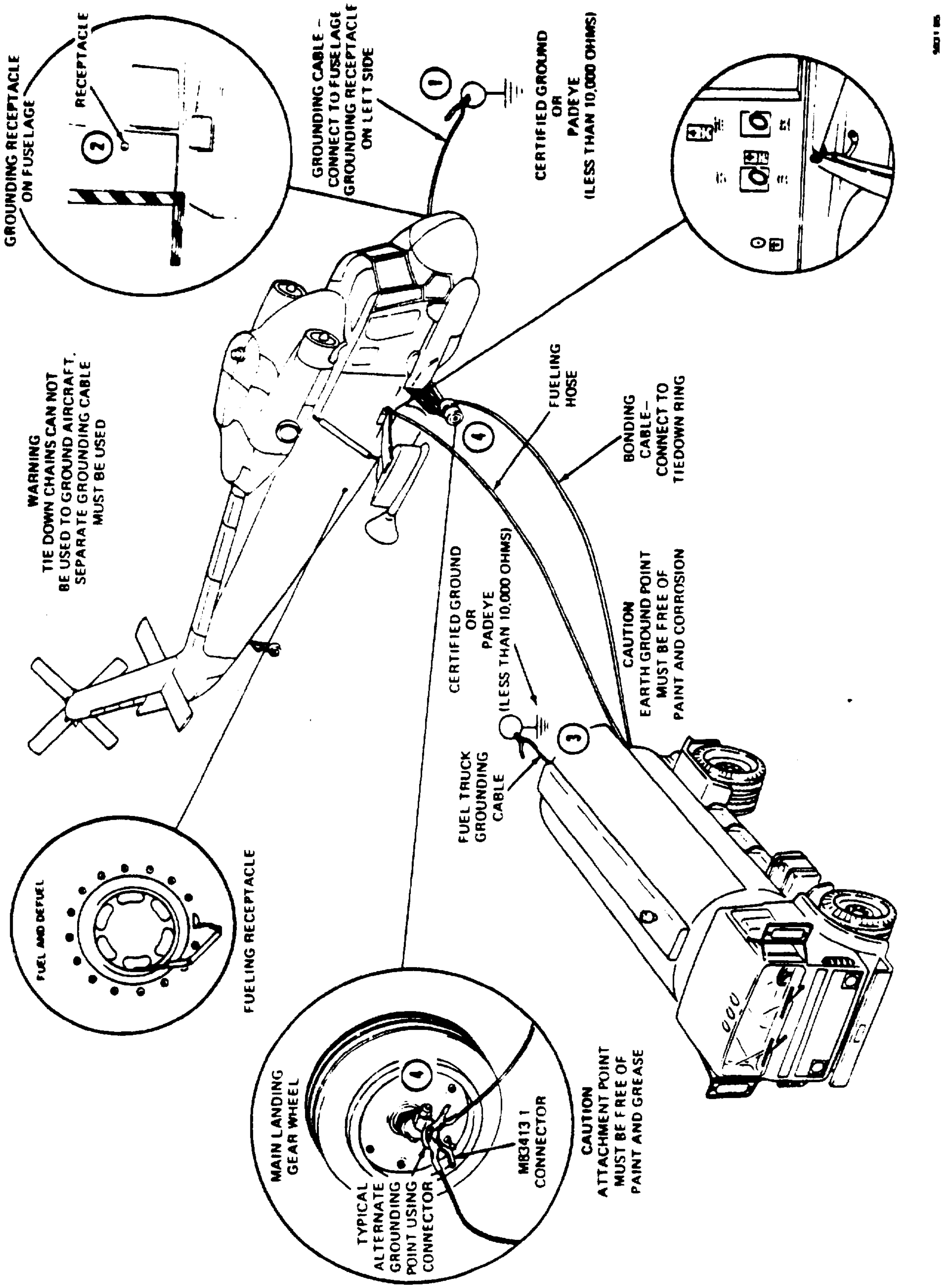


FIGURE 2-88. SH-2 aircraft grounding, fueling/defueling evolution.

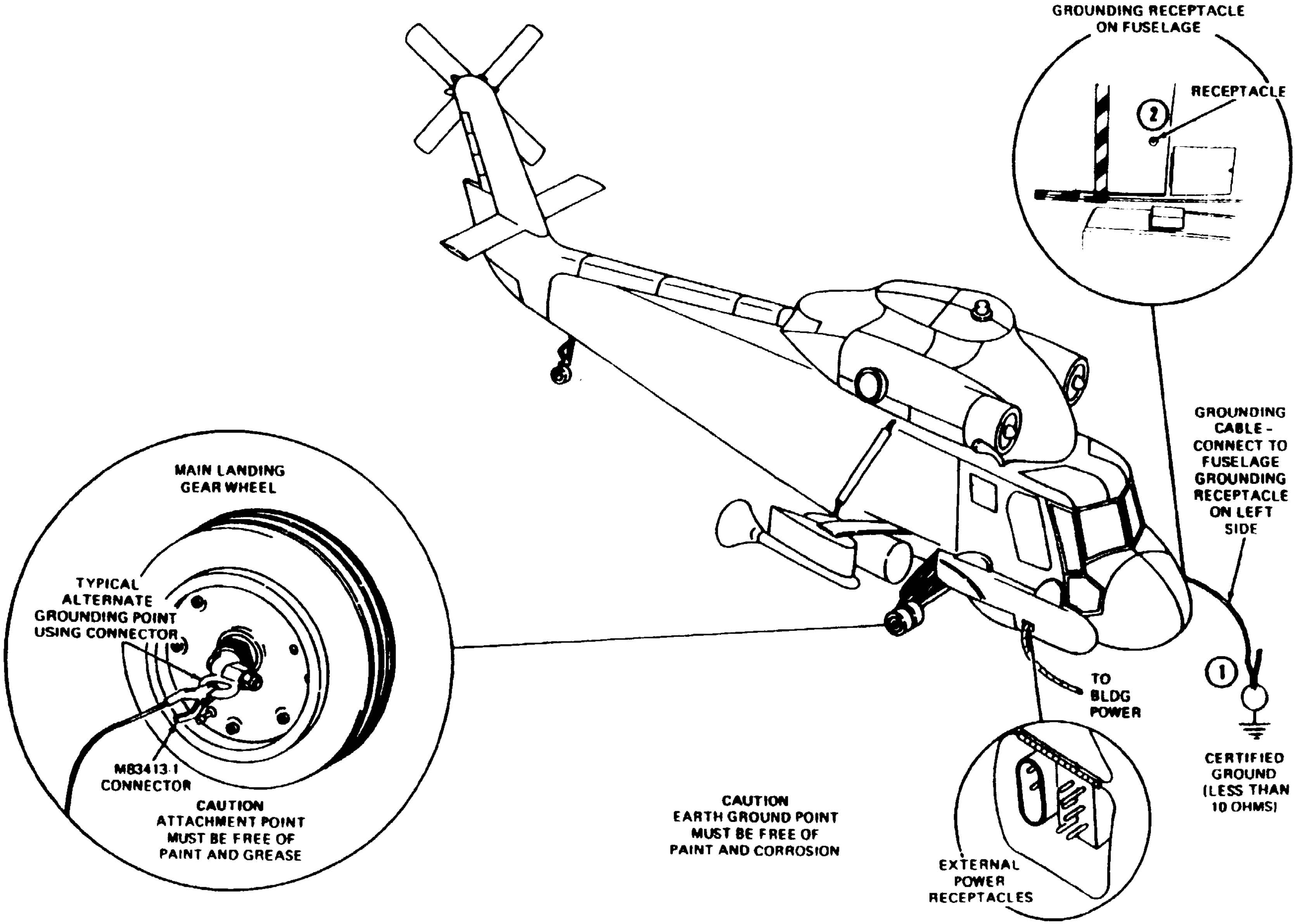


FIGURE 2-89. Hangar-based SH-2 aircraft grounding, maintenance evolution.

c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.105 SH-2 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground SH-2 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-90):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to front left fuselage grounding receptacle.
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.106 SH-2 apron-based maintenance evolution (using FLEDS). To ground SH-2 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-90):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to bare metal area on the DBA such as the sutd or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.107 SH-2 stores loading/unloading evolution. To ground SH-2 aircraft during stores loading or unloading, proceed as follows (see figure 2-91):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static or padeye (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).

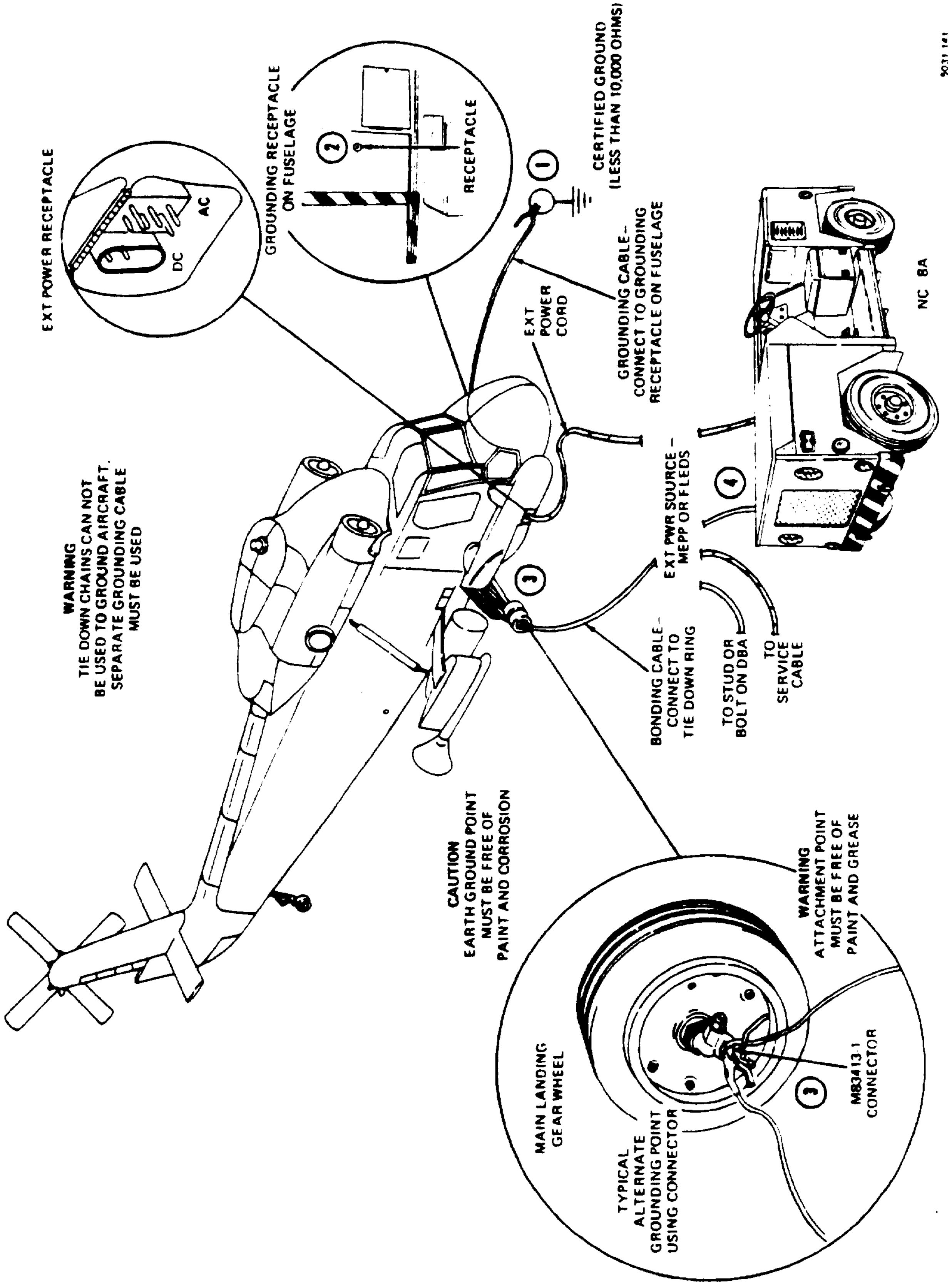


FIGURE 2-90. Apron-based SH-2 aircraft grounding, maintenance evolution.

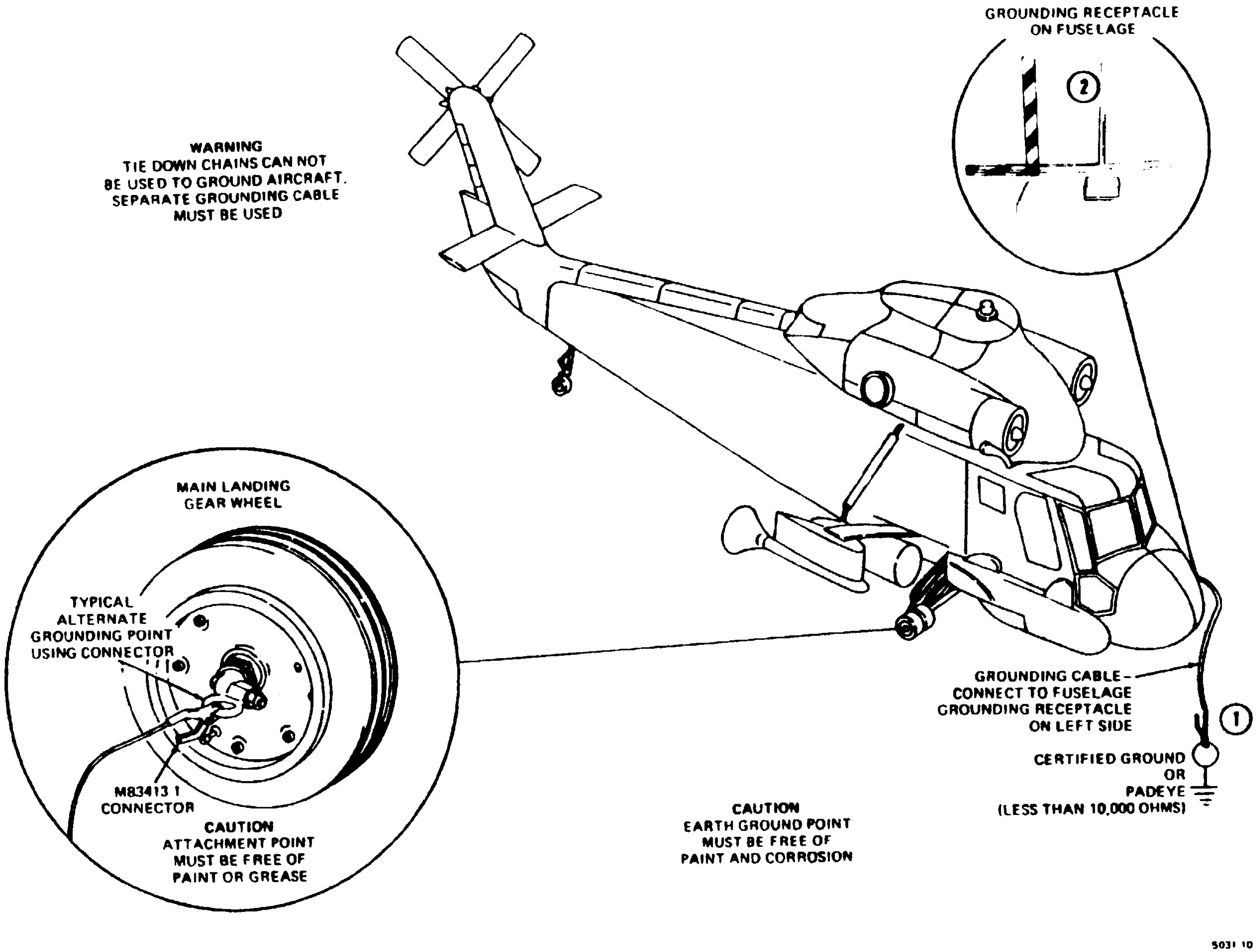


FIGURE 2-91. SH-2 aircraft grounding, stores loading/unloading evolution.

c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.108 SH-3 parked evolution. To ground SH-3 aircraft when in the parked evolution, proceed as follows (see figure 2-92):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.109 SH-3 fueling/defueling evolution. To ground SH-3 aircraft when fueling or defueling, proceed as follows (see figure 2-93):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to main gear tiedown ring (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.110 SH-3 hangar-based maintenance evolution. To ground SH-3 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-94):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.111 SH-3 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground SH-3 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-95):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

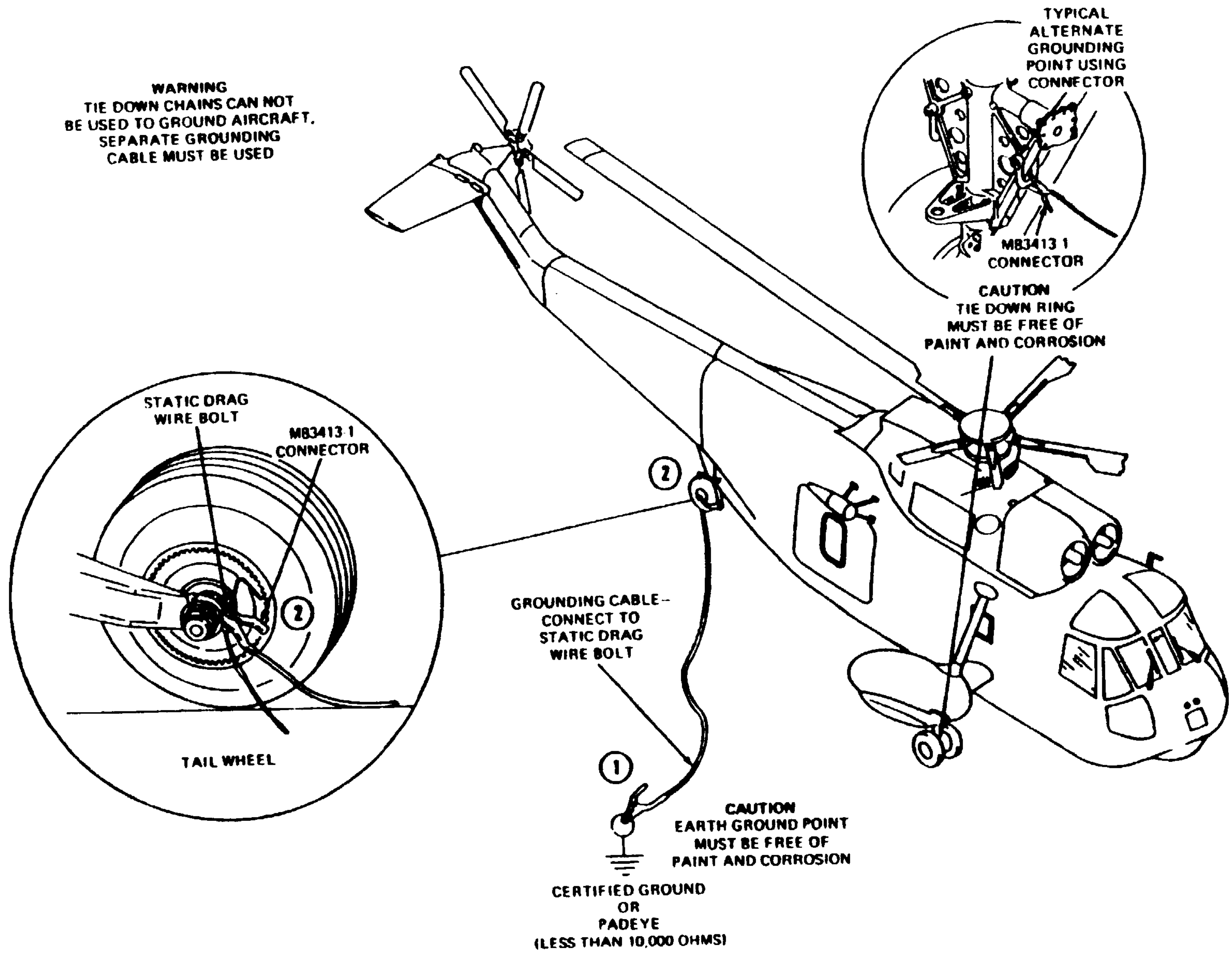


FIGURE 2-92. SH-3 aircraft grounding, parked evolution.

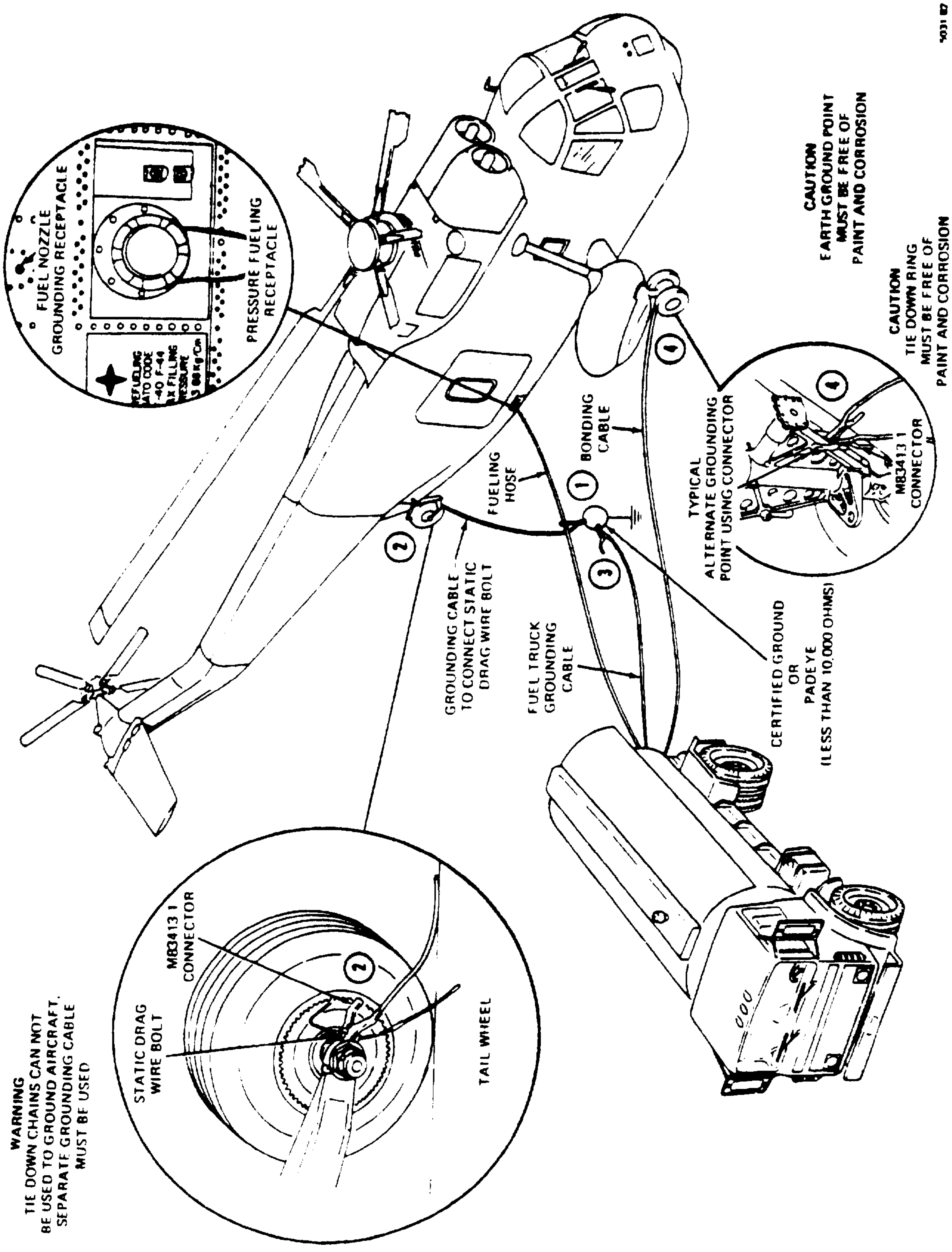


FIGURE 2-93. SH-3 aircraft grounding, fueling/defueling evolution.

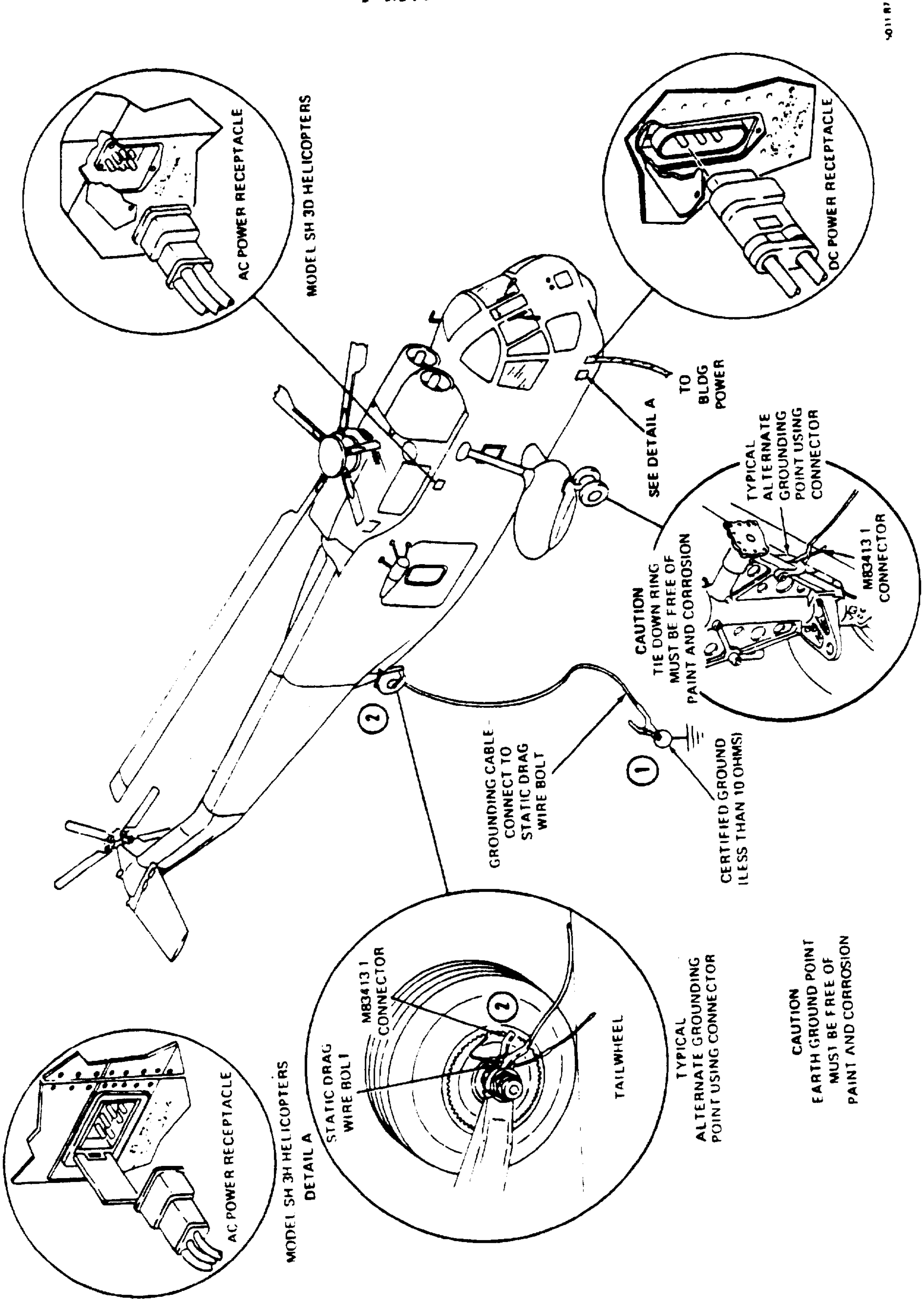


FIGURE 2-94. Hangar-based SH-3 aircraft grounding, maintenance evolution.

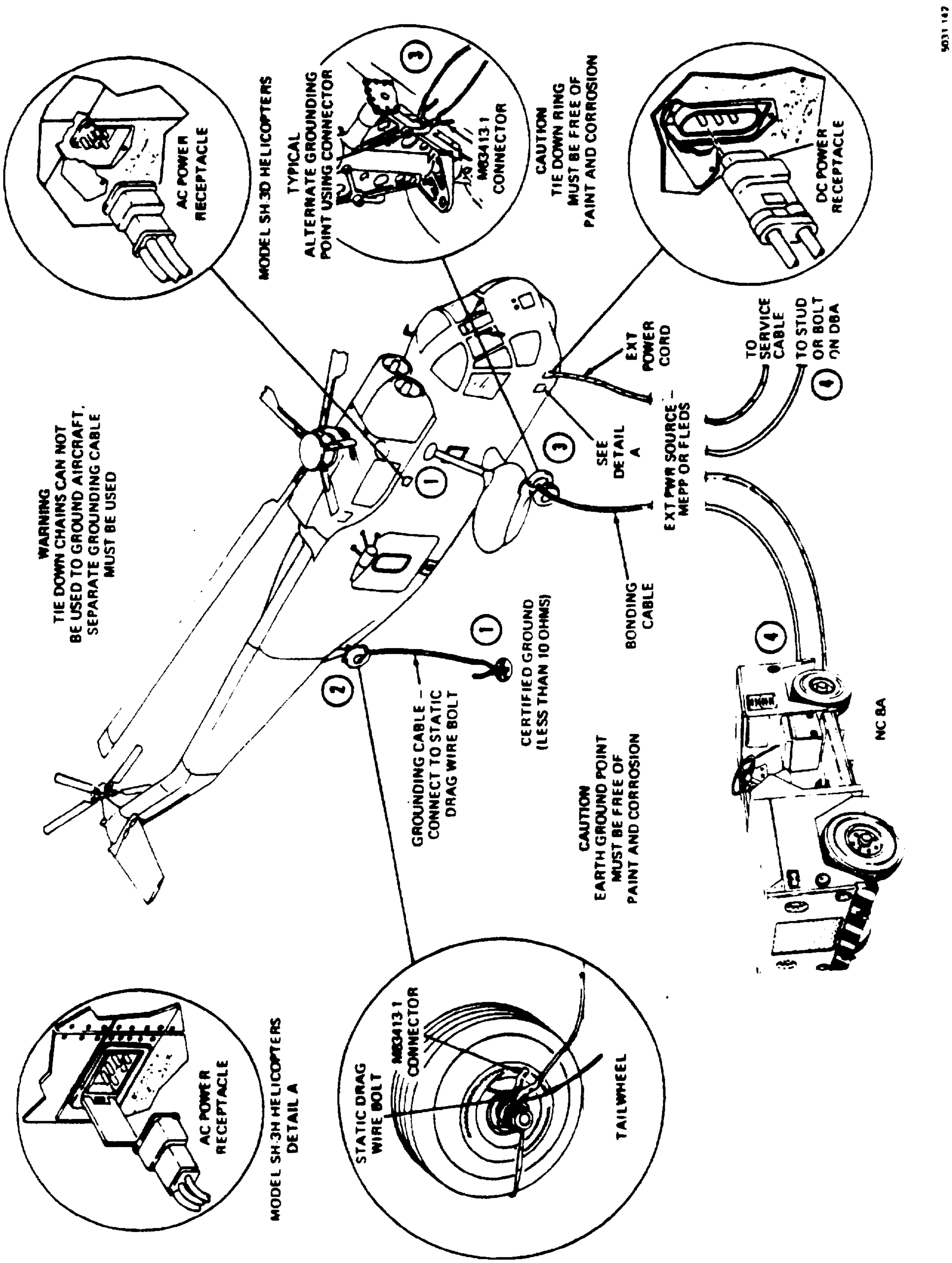


FIGURE 2-95. Apron-based SH-3 aircraft grounding, maintenance evolution.

b. Connect free end of grounding cable to static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.112 SH-3 apron-based maintenance evolution (using FLEDS). To ground SH-3 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-95):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.113 SH-3 stores loading/unloading evolution. To ground SH-3 aircraft during stores loading or unloading, proceed as follows (see figure 2-96):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.114 SH-60 parked evolution. To ground SH-60 aircraft when in the parked evolution, proceed as follows (see figure 2-97):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a. and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

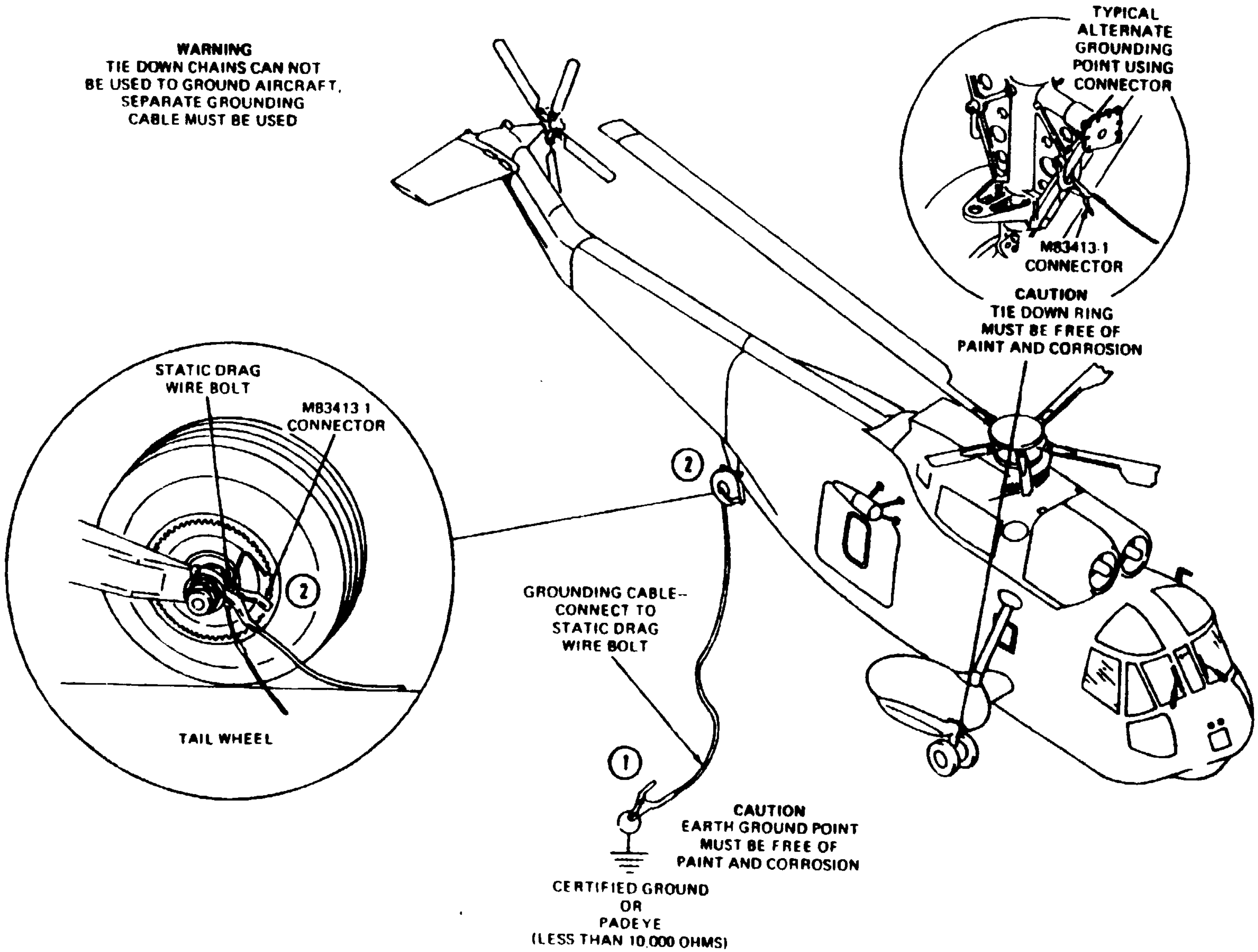


FIGURE 2-96. SH-3 aircraft grounding, stores loading/unloading evolution.

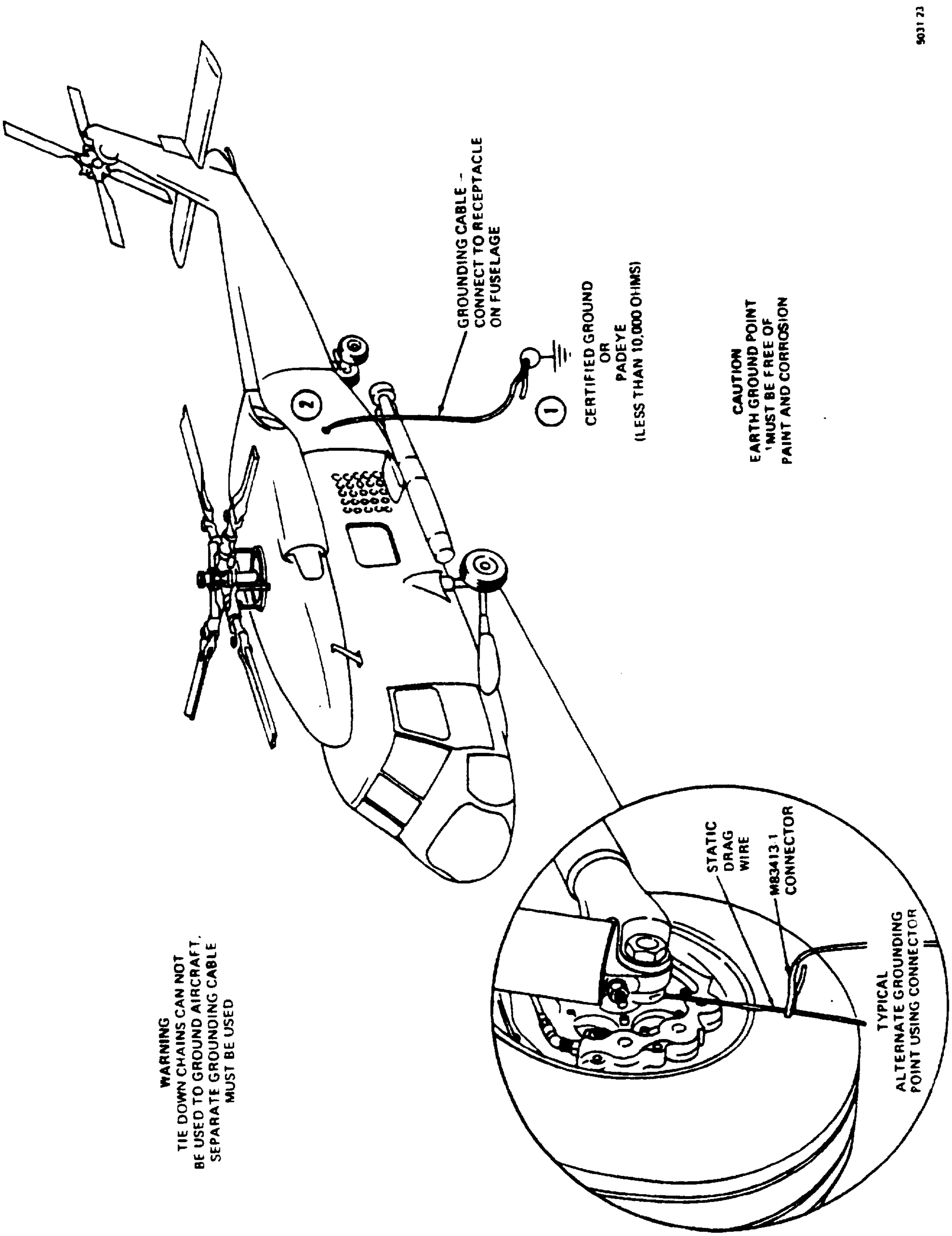


FIGURE 2-97. SH-60 aircraft grounding, parked evolution.

2.1.115 SH-60 fueling/defueling evolution. To ground SH-60 aircraft when fueling or defueling, proceed as follows (see figure 2-98):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to static drag wire (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

2.1.116 SH-60 hangar-based maintenance evolution. To ground SH-60 aircraft during maintenance in the hangar, proceed as follows (see figure 2-99):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.117 SH-60 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground SH-60 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-100):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

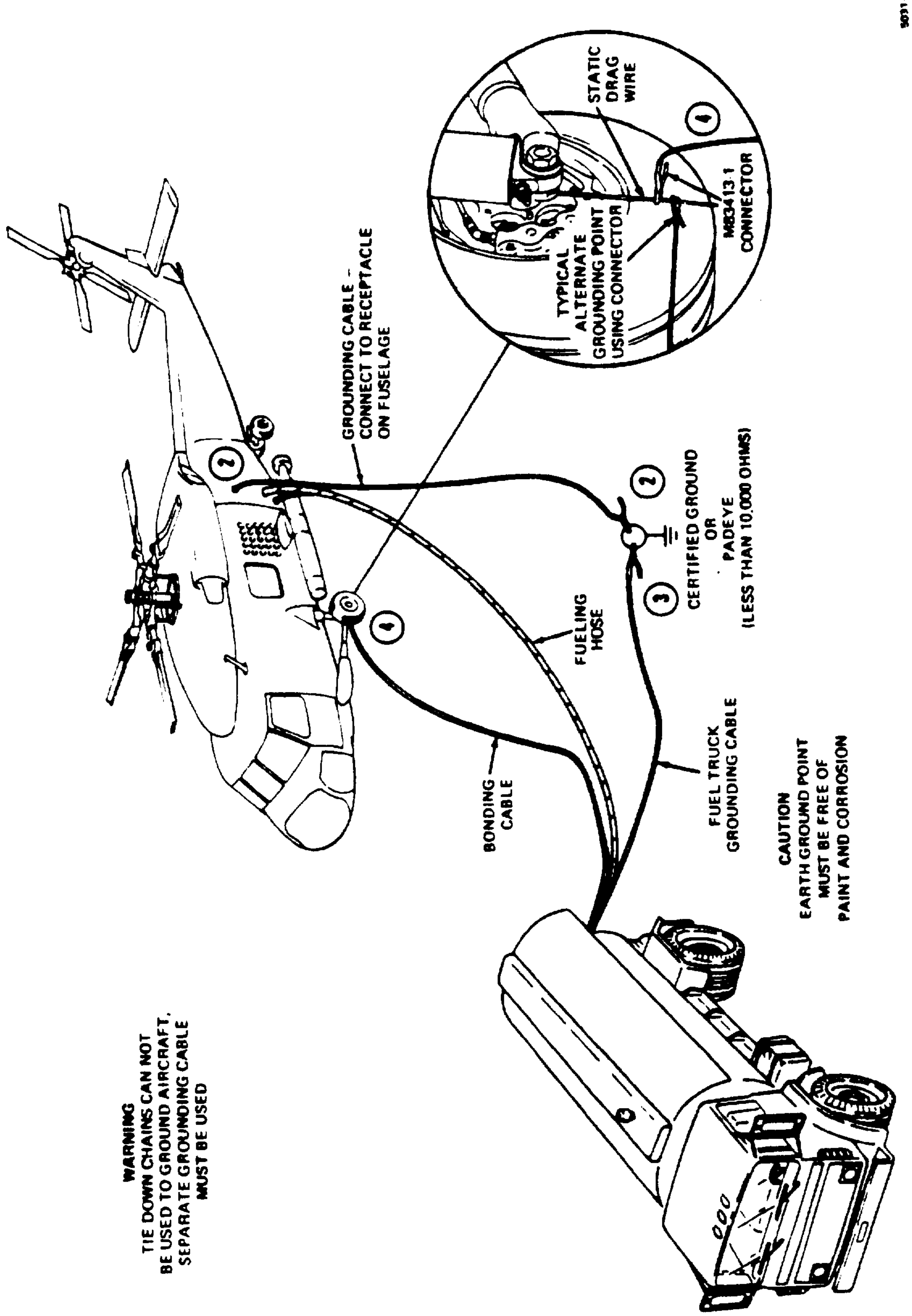


FIGURE 2-98. SH-60 aircraft grounding, fueling/defueling evolution.

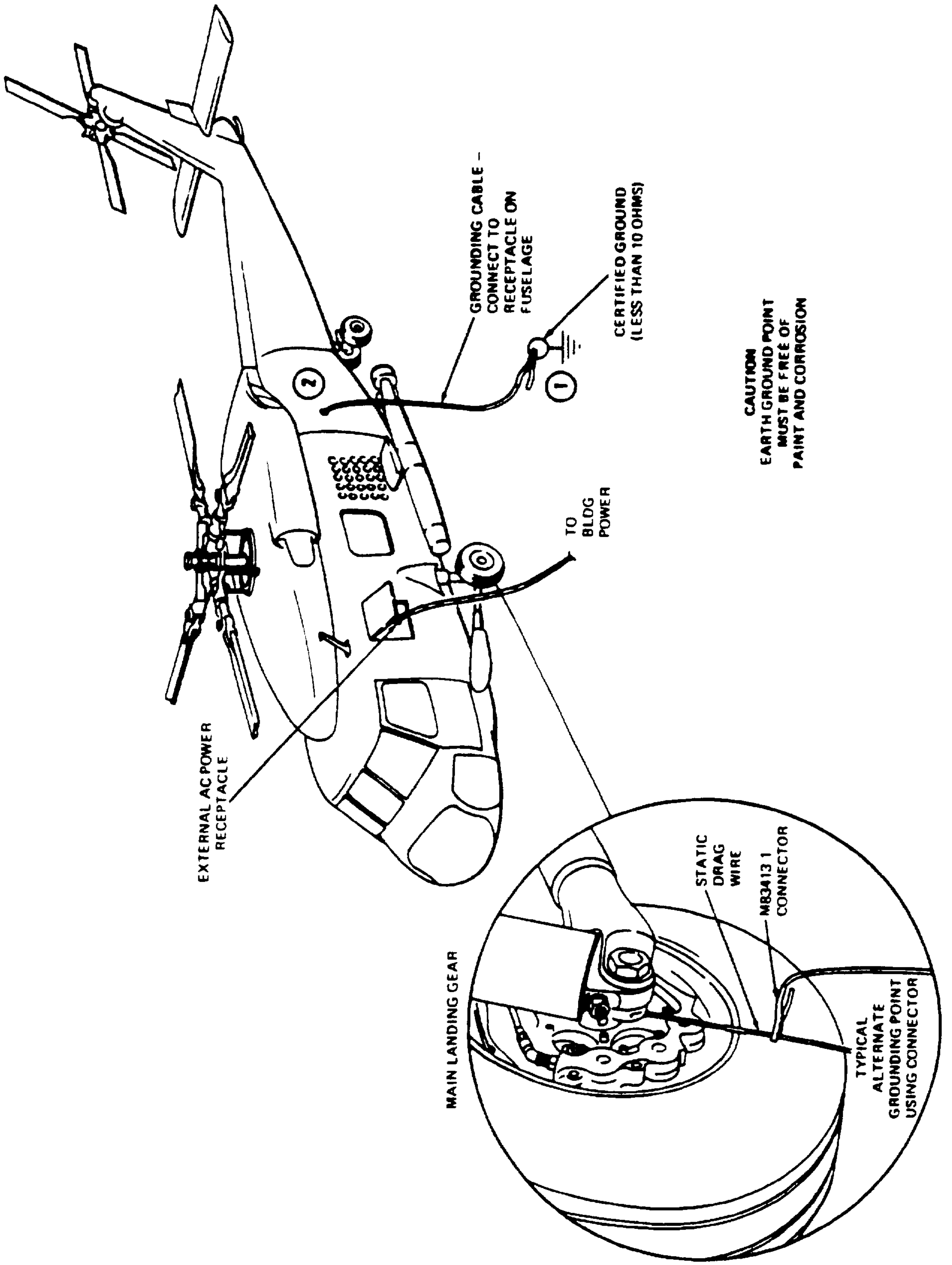


FIGURE 2-99. Hangar-based SH-60 aircraft grounding, maintenance evolution.

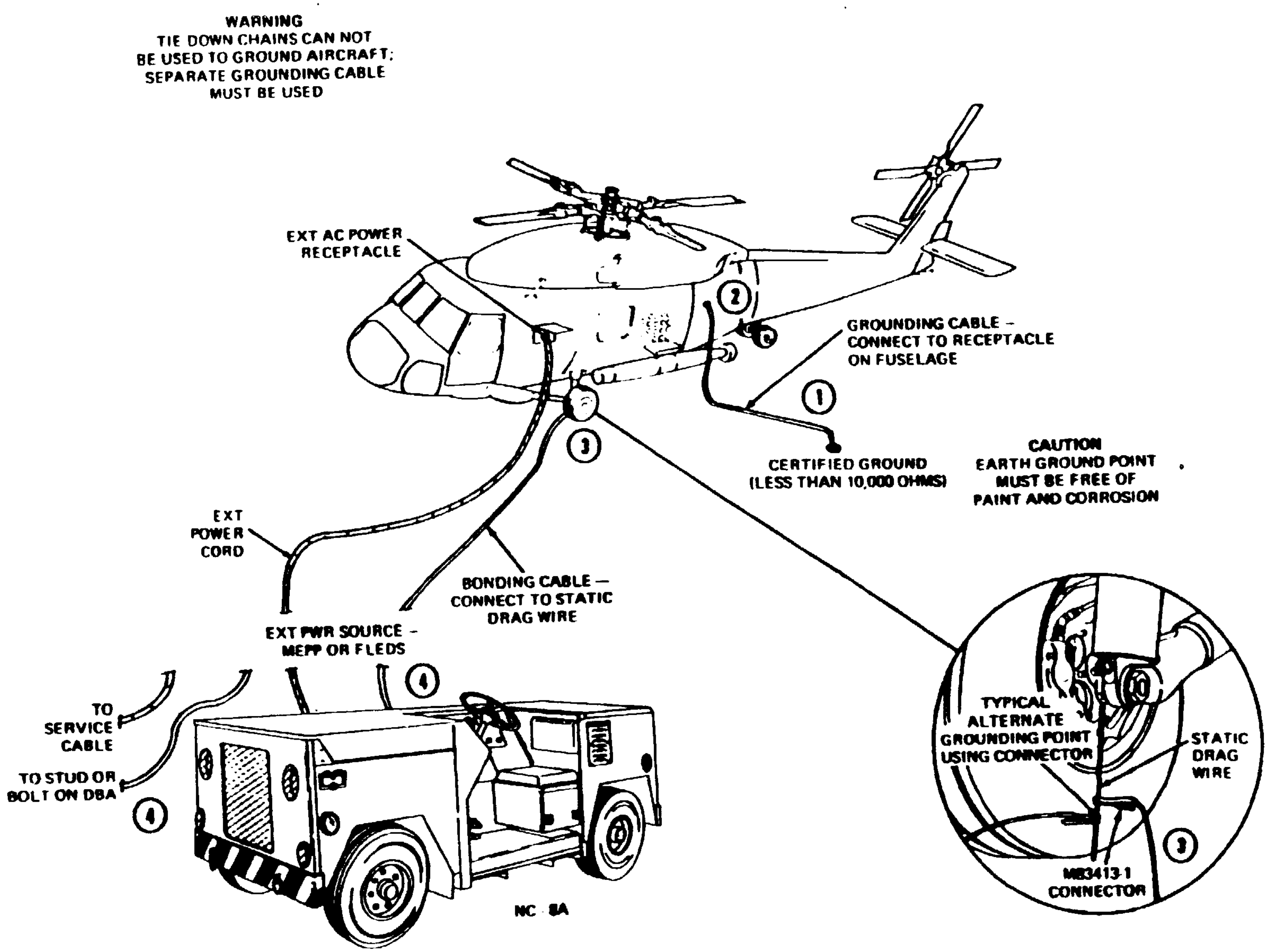


FIGURE 2-100. Apron-based SH-60 aircraft grounding, maintenance evolution.

2.1.118 SH-60 apron-based maintenance evolution (using FLEDS). To ground SH-60 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-100):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.119 SH-60 stores loading/unloading evolution. To ground SH-60 aircraft during stores loading or unloading, proceed as follows (see figure 2-101):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.120 TH-57 parked evolution. To ground TH-57 aircraft when in the parked evolution, proceed as follows (see figure 2-102):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tang on skid (2). If this location is not accessible, then connect grounding cable to tow ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.121 TH-57 fueling/defueling evolution. To ground TH-57 aircraft when fueling or defueling, proceed as follows (see figure 2-103):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tang on skid (2). If this location is not accessible, then connect grounding cable to tow ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).

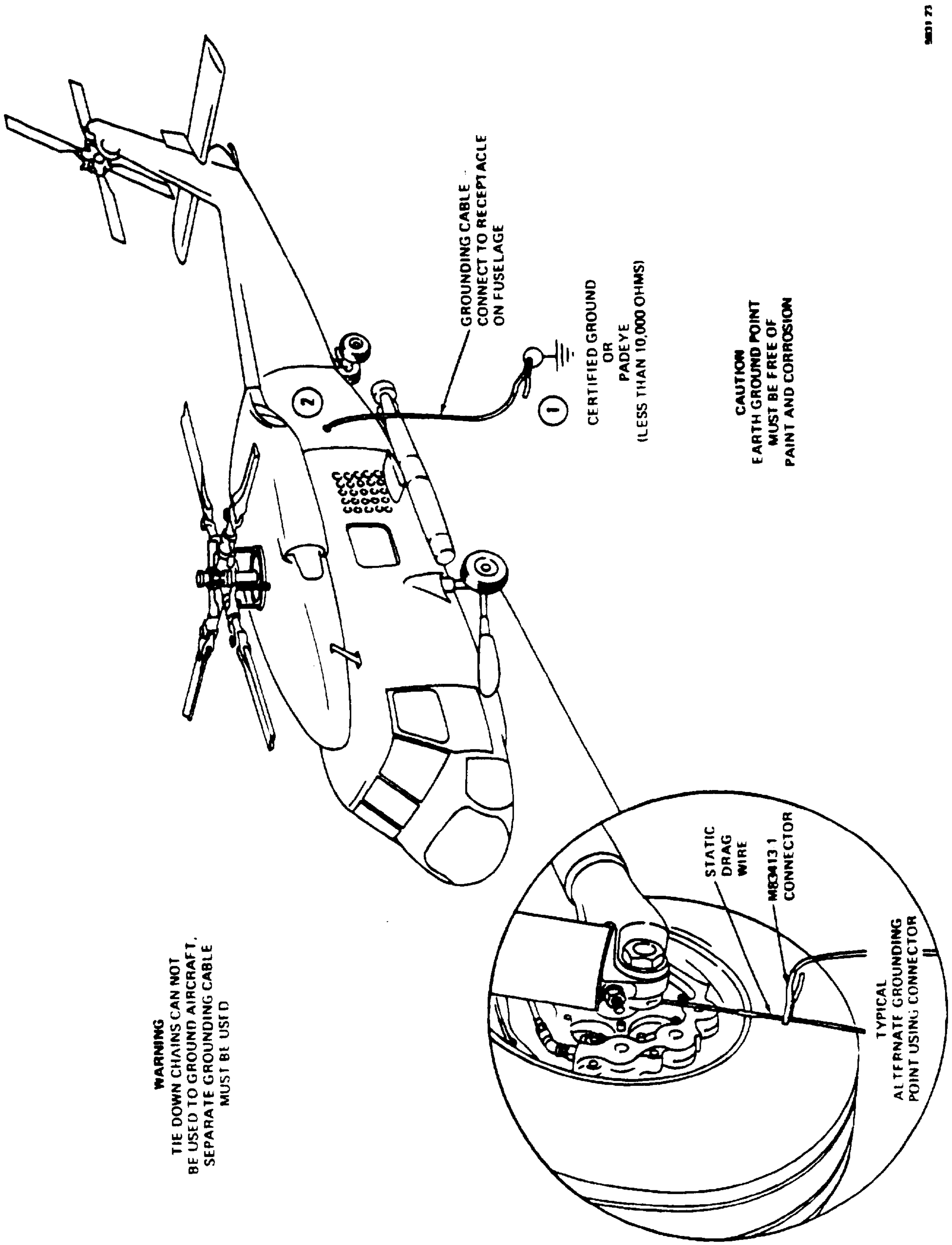


FIGURE 2-101. SH-60 aircraft grounding, stores loading/unloading evolution.

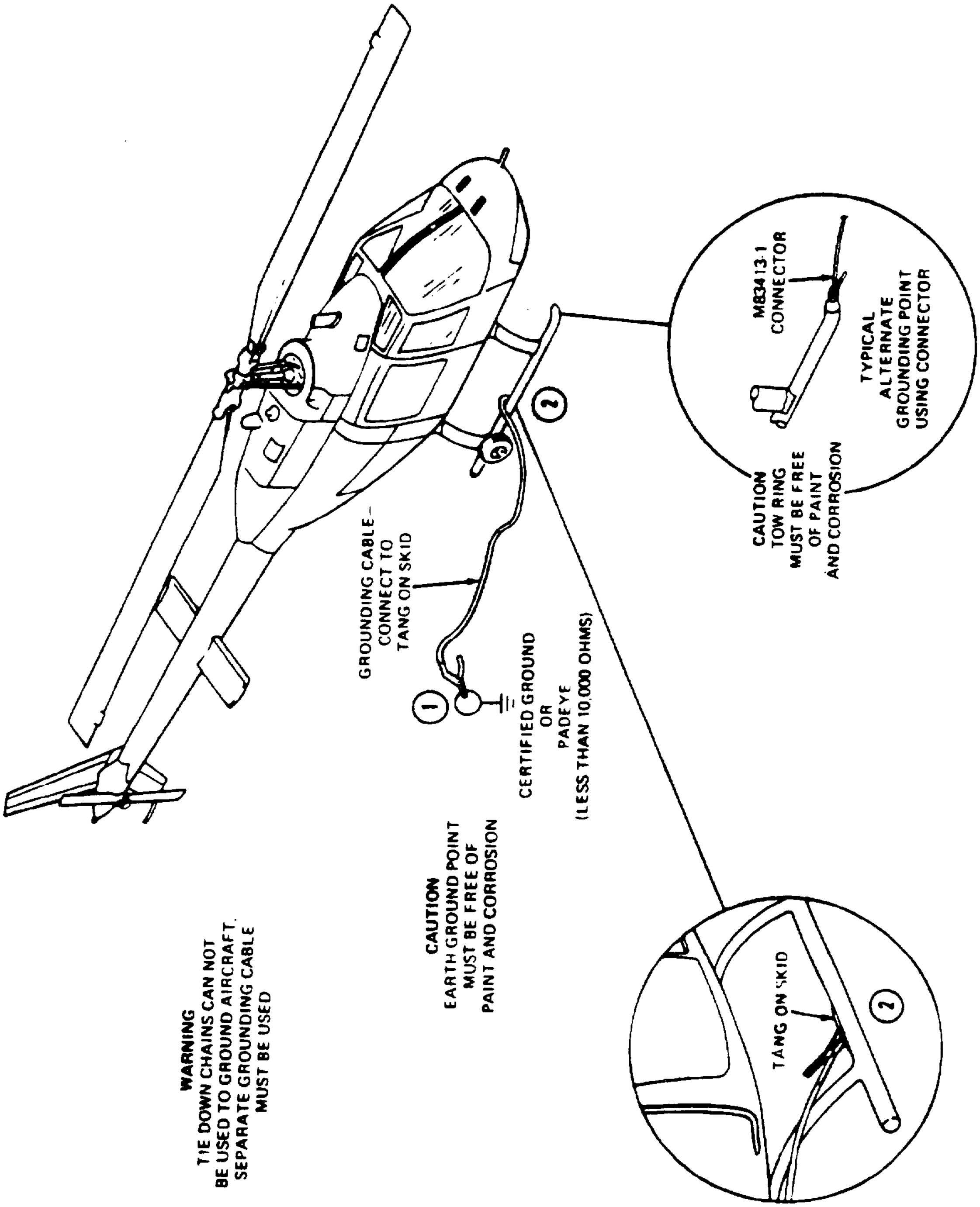


FIGURE 2-102. TH-57 aircraft grounding, parked evolution.

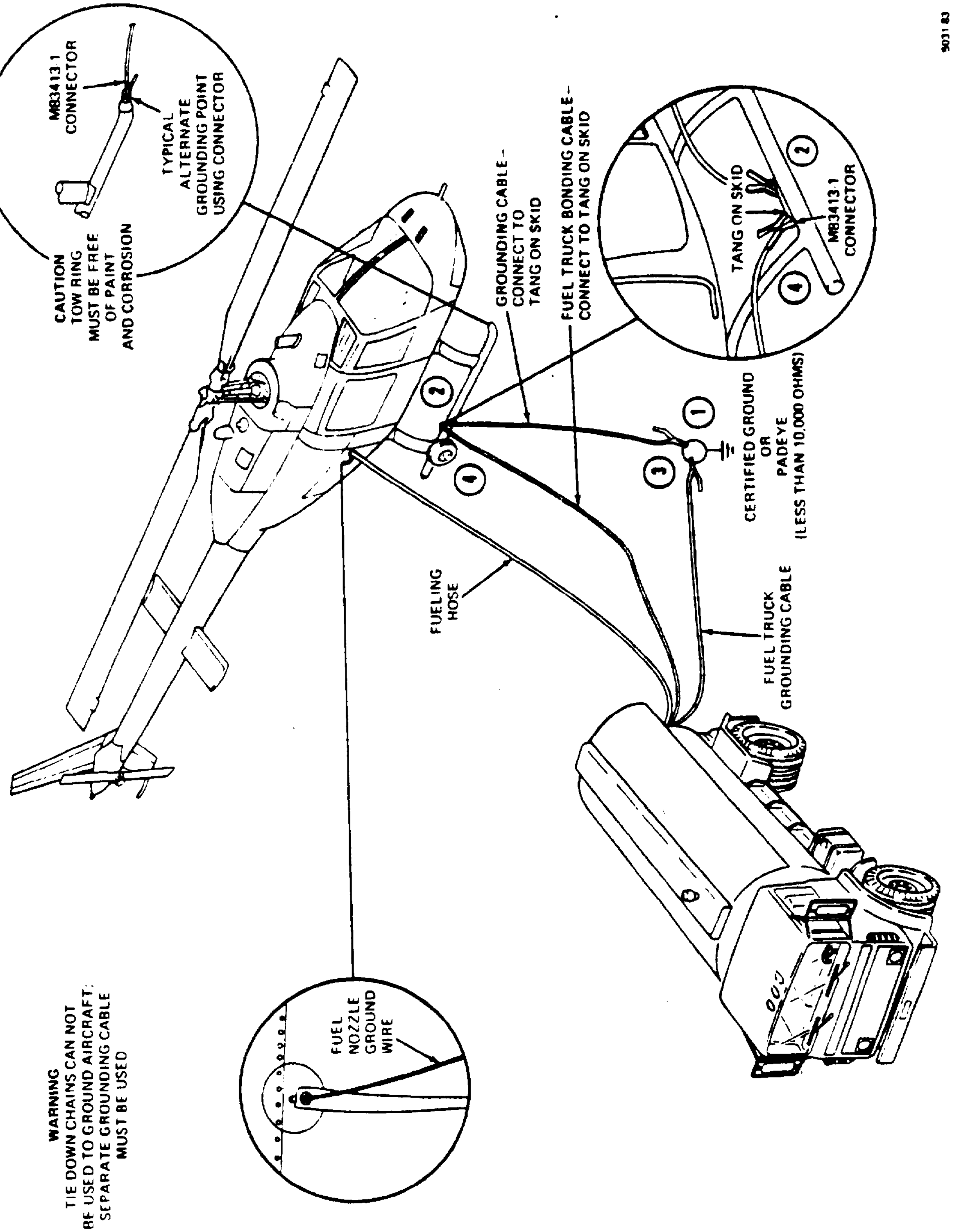


FIGURE 2-103. TH-57 aircraft grounding, fueling/defueling evolution.

d. Connect fuel truck bonding cable to tang on skid.
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.122 TH-57 hangar-based maintenance evolution. To ground aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-104):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to tang on skid (2). If this location is not accessible, then connect grounding cable to tow ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.123 TH-57 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground TH-57 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-105):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to tang on skid (2). If this location is not accessible, then connect grounding cable to tow ring (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

c. Attach bonding cable with M83413-1 electrical ground connector to tang on skid (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.124 UC-12 parked evolution. To ground UC-12 aircraft when in the parked evolution, proceed as follows (see figure 2-106):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.125 UC-12 fueling/defueling evolution. To ground UC-12 aircraft when fueling or defueling, proceed as follows (see figure 2-107):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

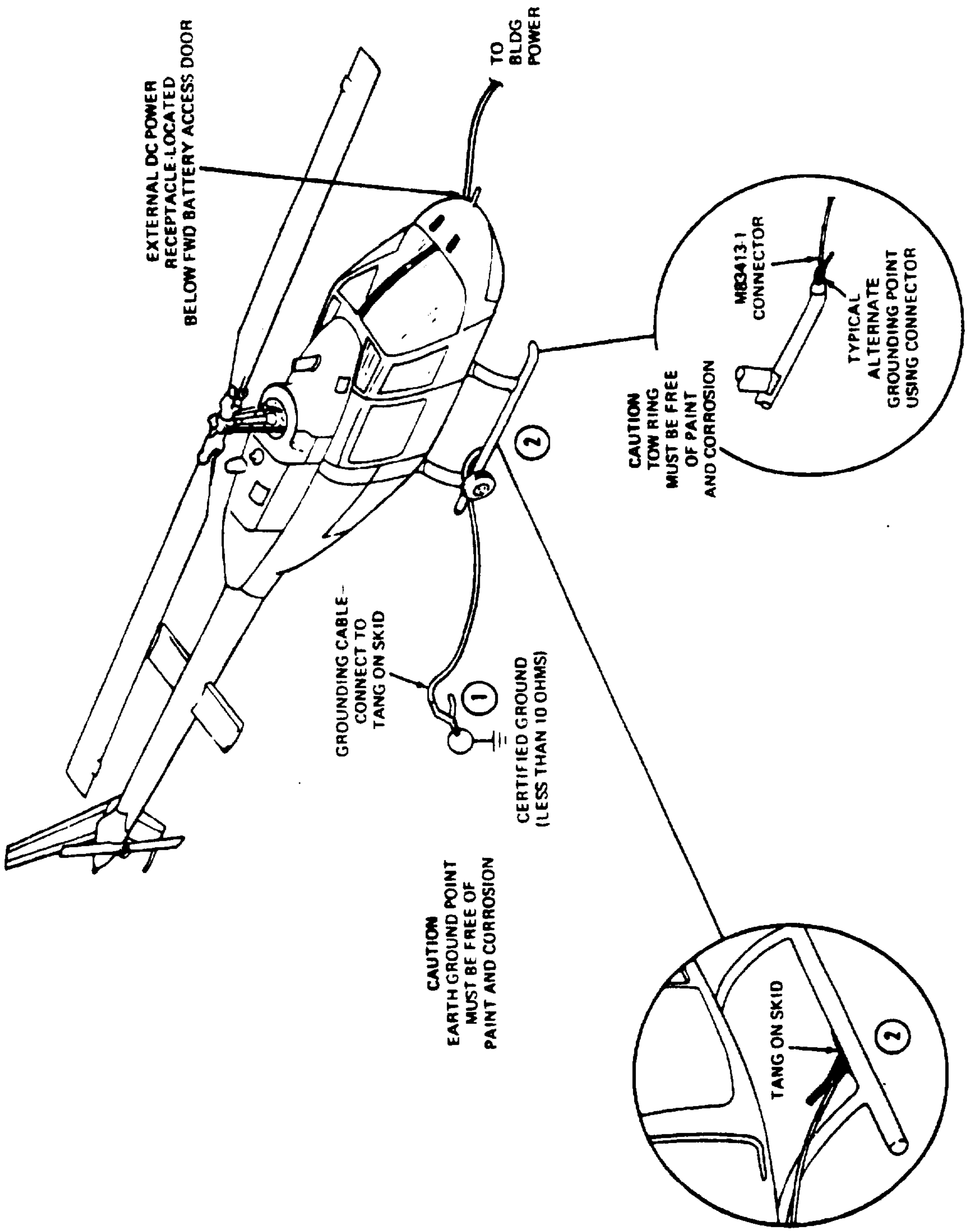


FIGURE 2-104. Hangar-based TH-57 aircraft grounding, maintenance evolution.

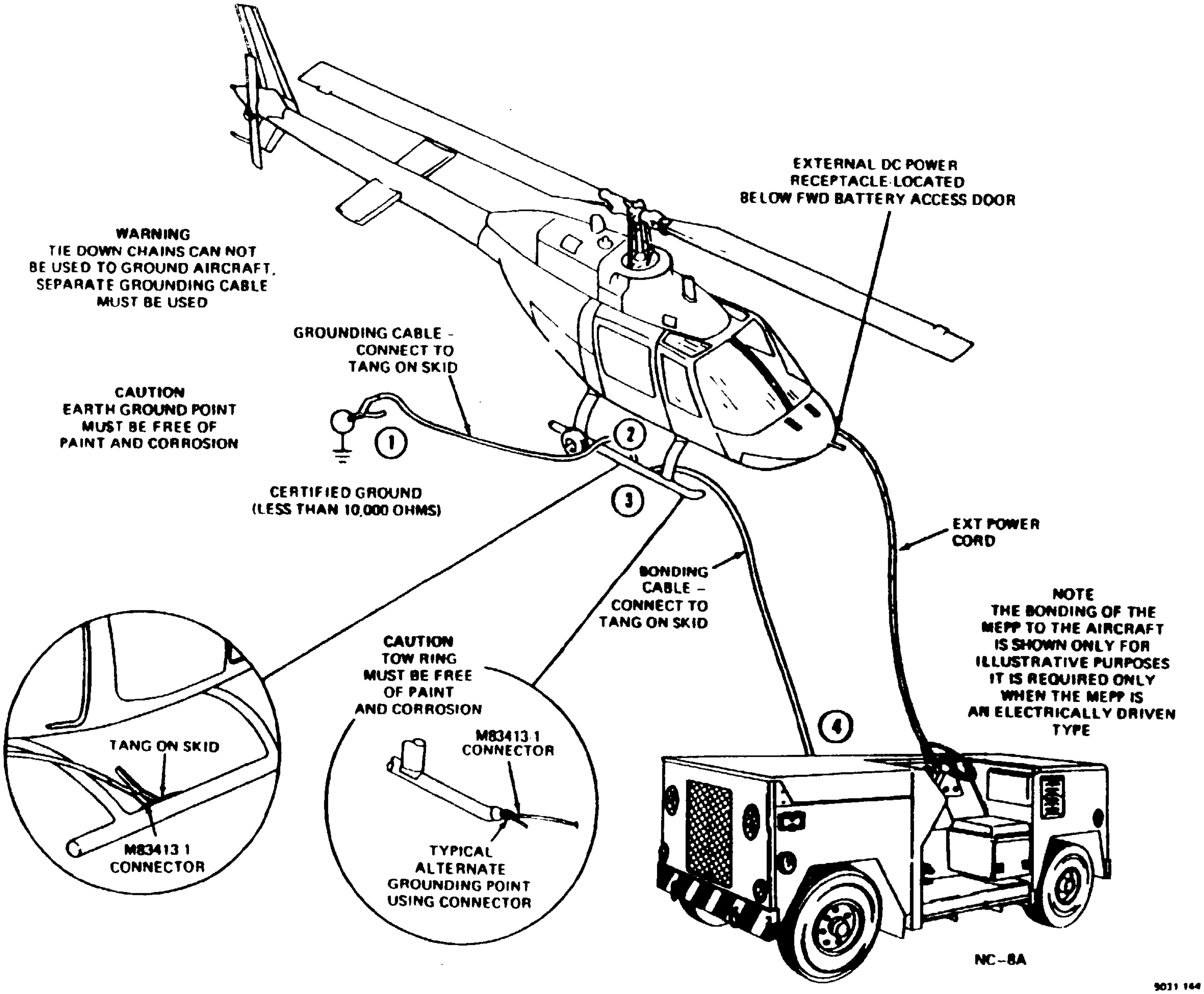


FIGURE 2-105. Apron-based TH-57 aircraft grounding, maintenance evolution.

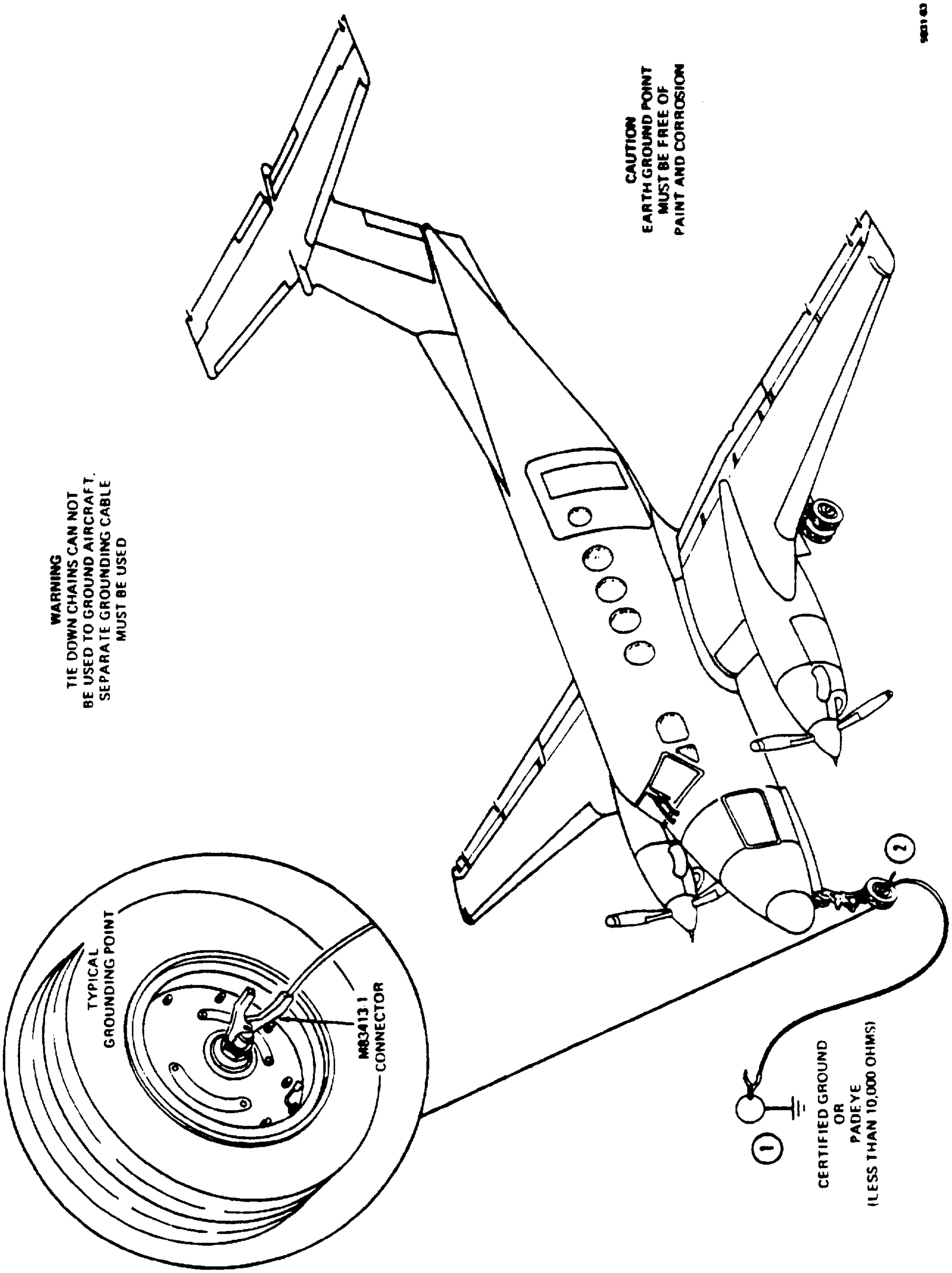


FIGURE 2-106. UC-12 aircraft grounding, parked evolution.

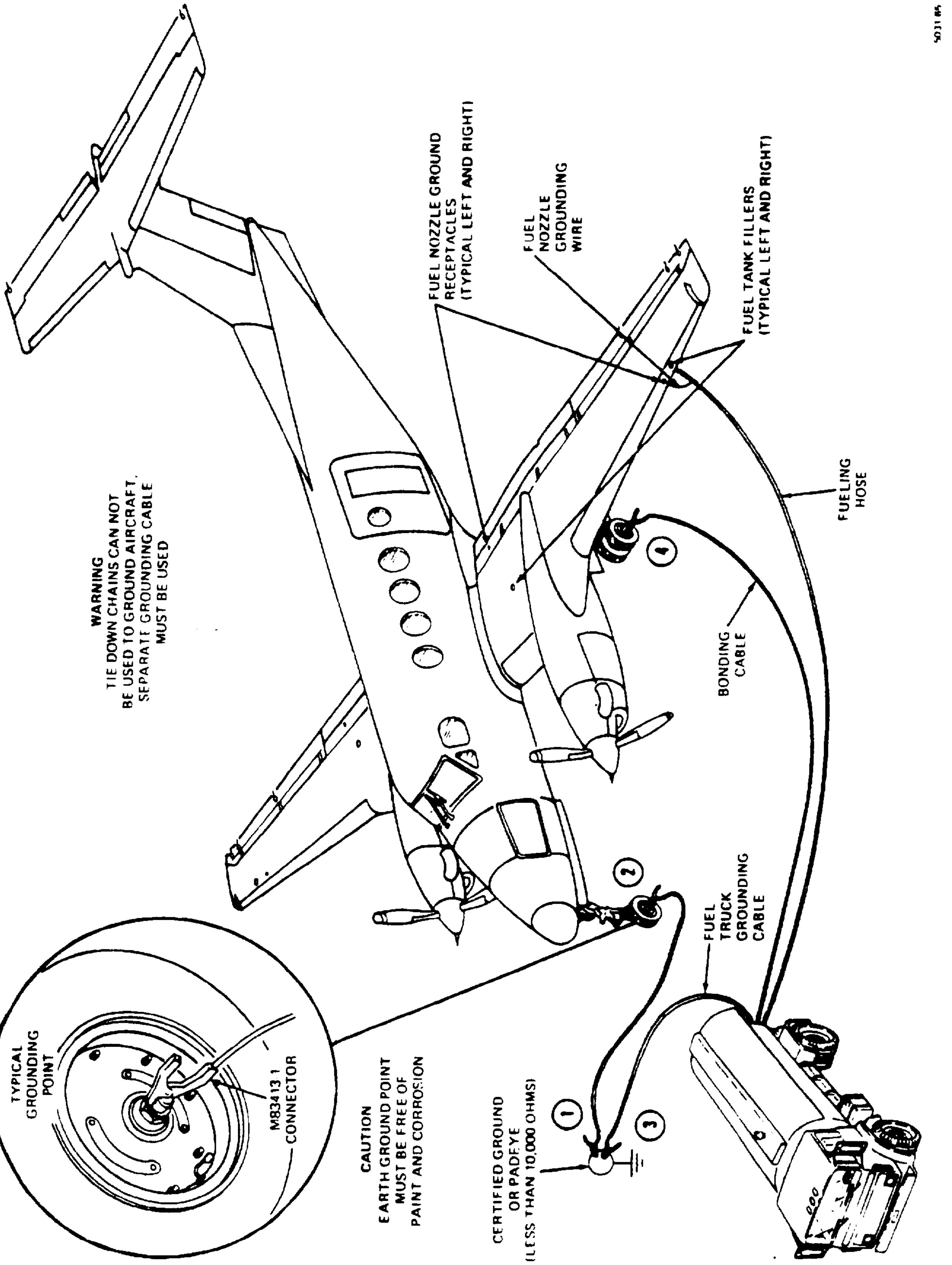


FIGURE 2-107. UC-12 aircraft grounding, fueling/defueling evolution.

b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to main wheel axle (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.126 UC-12 hangar-based maintenance evolution. To ground UC-12 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-108):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.127 UC-12 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground UC-12 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-109):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

c. Attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2 Carrier-based aircraft. The following paragraphs provide step-by-step procedures for grounding carrier-based aircraft. Note that the word ''carrier'' is meant to refer to any ship which supports aircraft flight operations. Before attaching grounding cables, ensure that the aircraft has been tied down and secured to the carrier deck. Tiedown chains cannot be relied upon for grounding. A grounding cable must be used to properly implement the grounding methods presented in this section.

Maintenance evolutions and fueling evolutions are represented for each aircraft type while the parked and stores loading/unloading evolutions are illustrated for

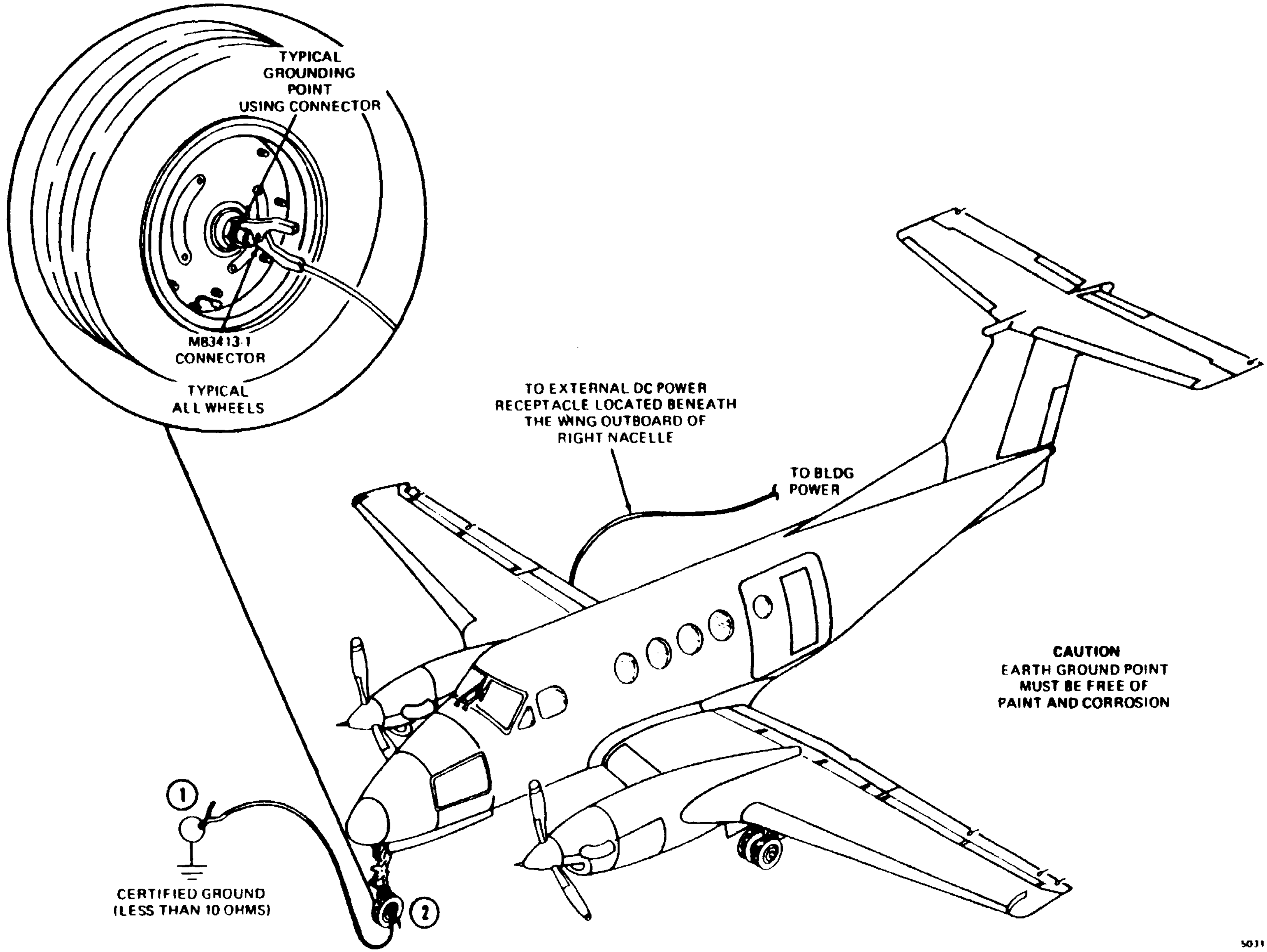


FIGURE 2-108. Hangar-based UC-12 aircraft grounding, maintenance evolution.

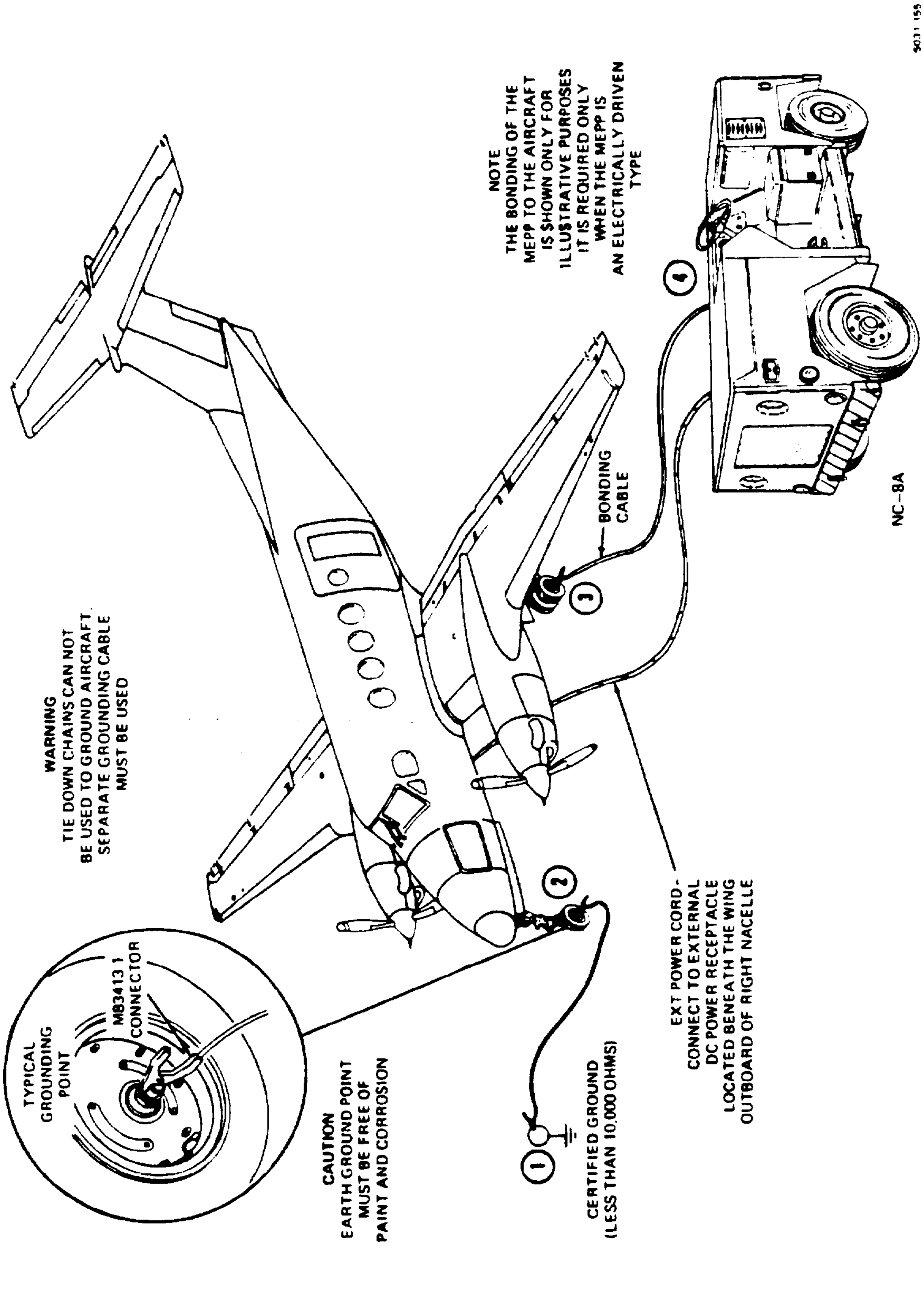


FIGURE 2-109. Apron-based UC-12 aircraft grounding, maintenance evolution.

aircraft series only (eg, attack, fighter, etc). The aircraft series, their typical examples, and their figure numbers are listed below:

Aircraft Series	Typical Example	Figure No.
Attack	A-7	2-116
Special Electronics	E-2	2-127
Fighter	F-14	2-134
Anti-Submarine	S-3	2-141
Helicopter	SH-2	2-144

2.2.1 Carrier-based A-3 fueling/defueling evolution. To ground carrier-based A-3 aircraft when fueling or defueling, proceed as follows (see figure 2-110):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose landing gear (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.2 Carrier-based A-3 maintenance evolution. To ground carrier-based A-3 aircraft when in the maintenance evolution, proceed as follows (see figure 2-111):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose landing gear (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose landing gear (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.3 Carrier-based A-4 fueling/defueling evolution. To ground carrier-based A-4 aircraft when fueling or defueling, proceed as follows (see figure 2-112):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).

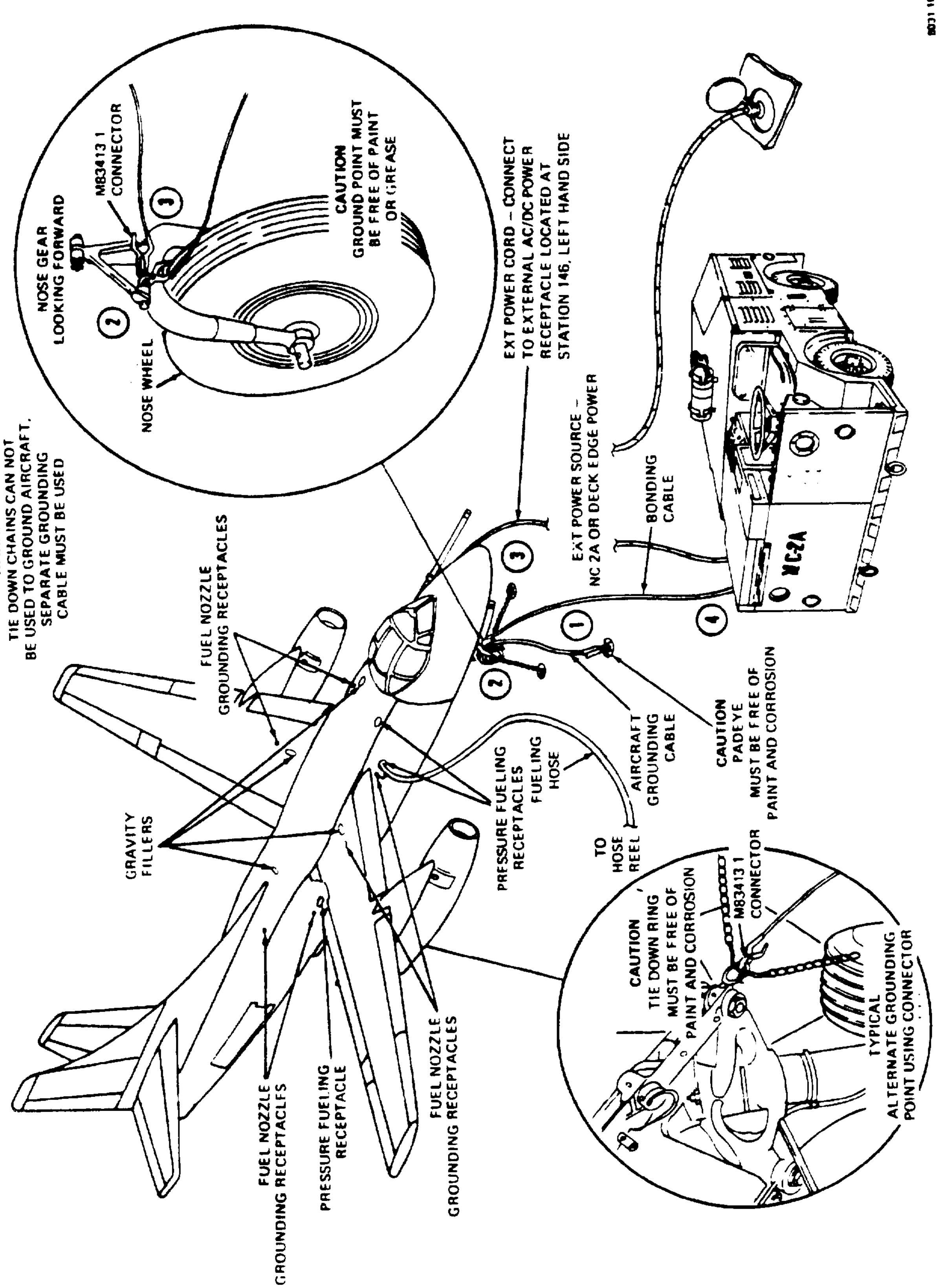


FIGURE 2-110. Carrier-based A-3 aircraft, fueling/defueling evolution.

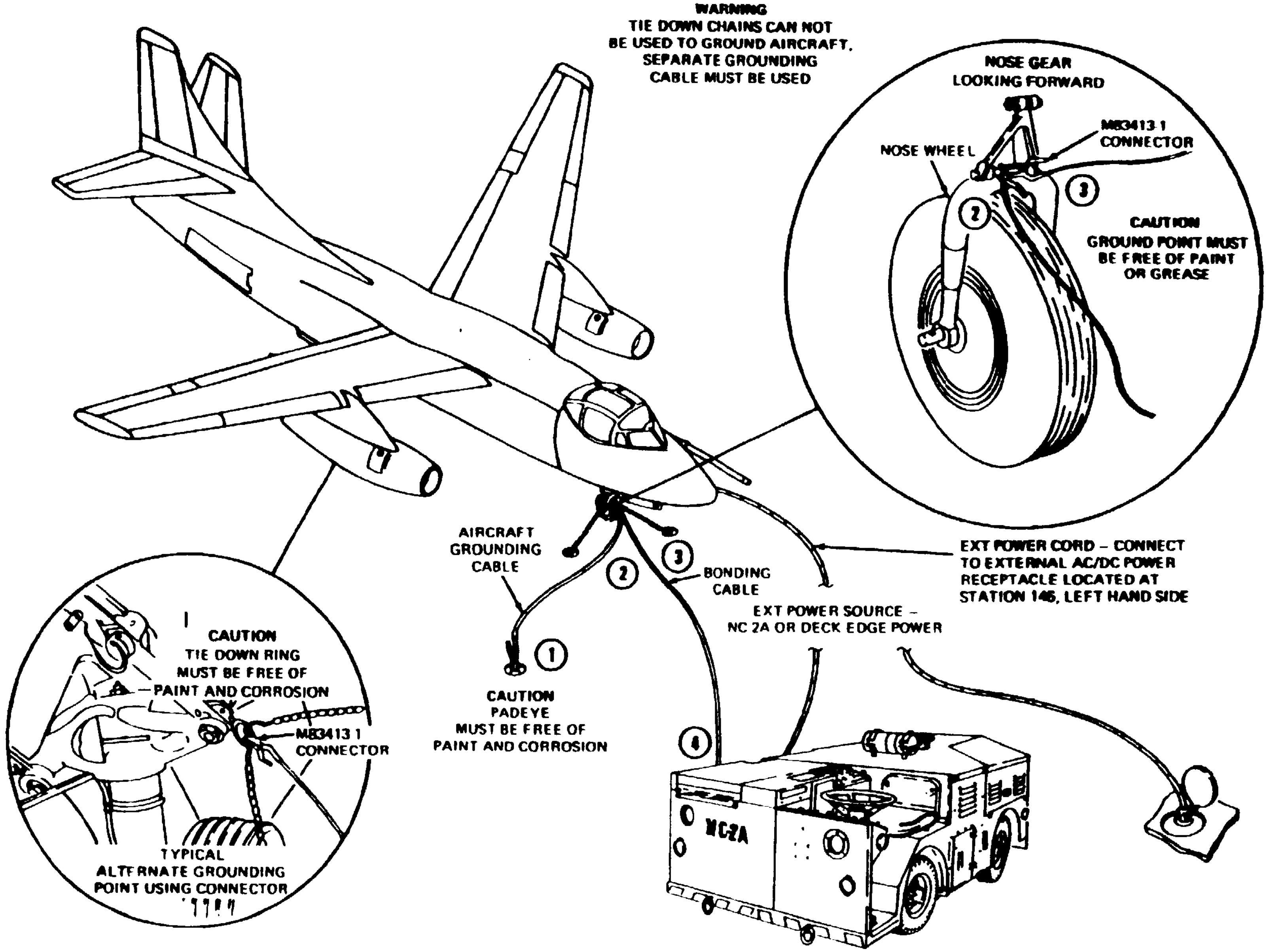


FIGURE 2-111. Carrier-based A-3 aircraft, maintenance evolution.

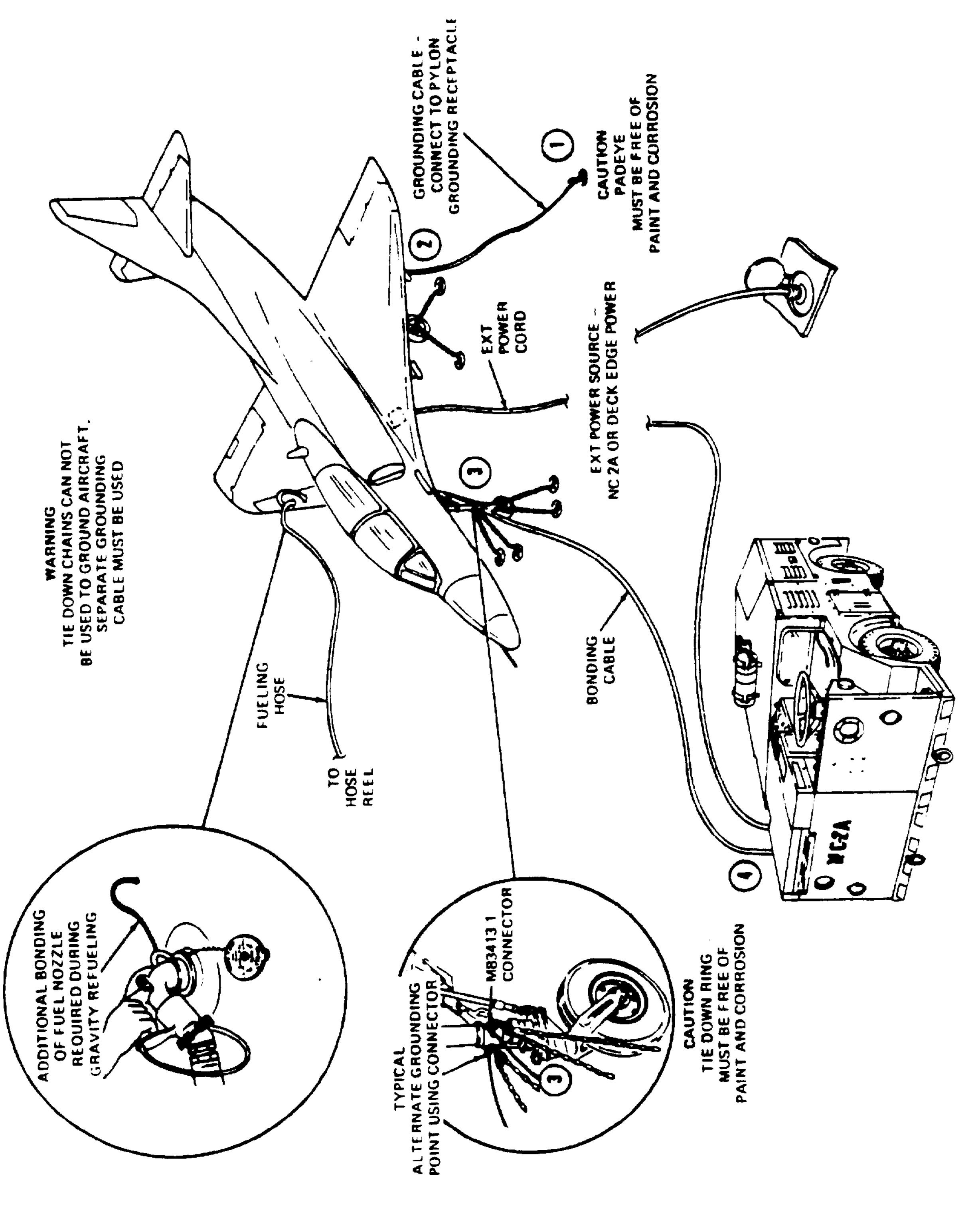


FIGURE 2-112. Carrier-based A-4 aircraft, fueling/defueling evolution.

e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.4 Carrier-based A-4 maintenance evolution. To ground carrier-based A-4 aircraft when in the maintenance evolution, proceed as follows (see figure 2-113):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.5 Carrier-based A-6 fueling/defueling evolution. To ground carrier-based A-6 aircraft when fueling or defueling, proceed as follows (see figure 2-114):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to tail bumper (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.6 Carrier-based A-6 maintenance evolution. To ground carrier-based A-6 aircraft when in the maintenance evolution, proceed as follows (see figure 2-115):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to tail bumper (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.7 Carrier-based attack aircraft (A-3, A-4, A-6, A-7, AV-8, EA-6) parked evolution and stores loading/unloading evolution. To ground carrier-based attack

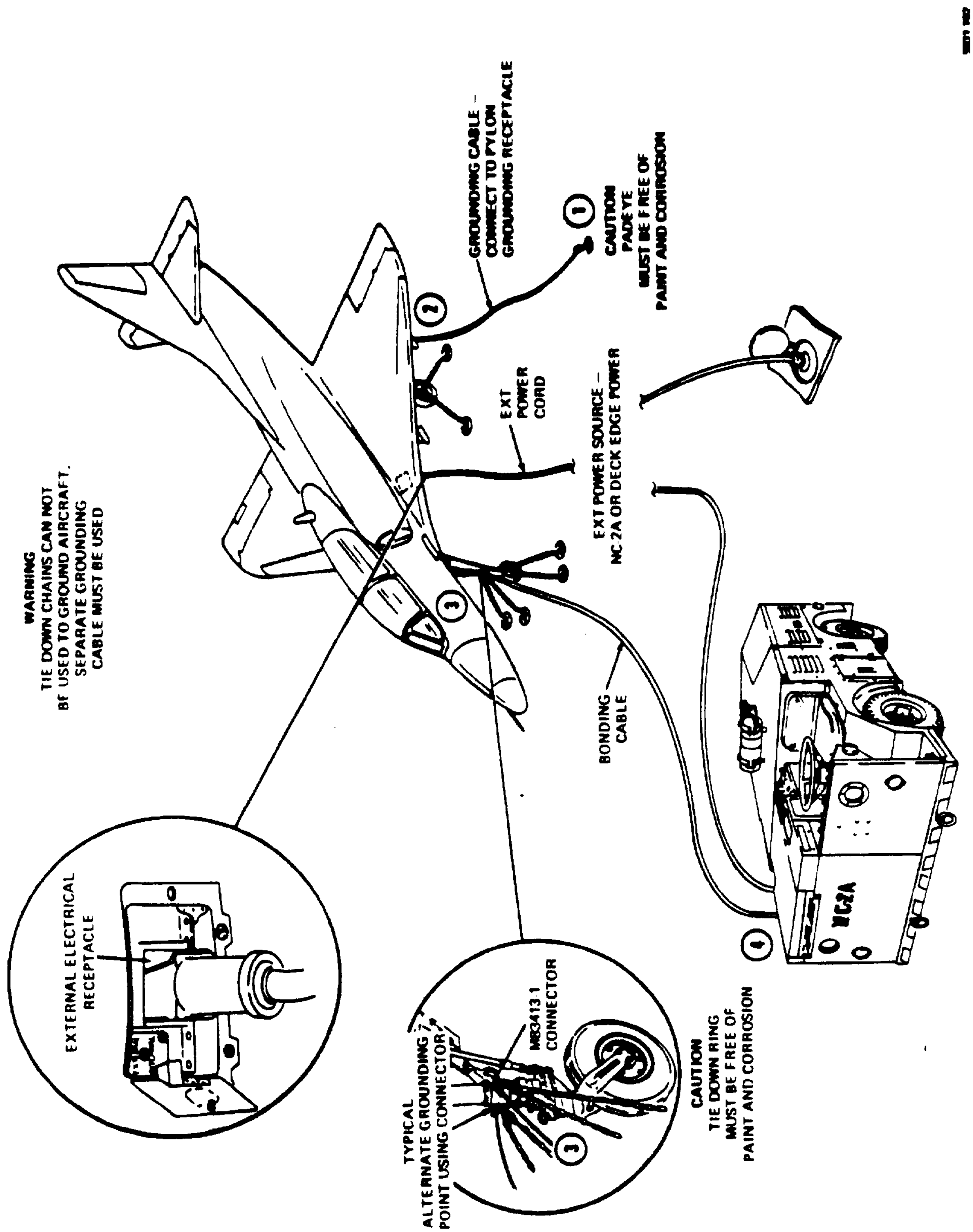


FIGURE 2-113. Carrier-based A-4 aircraft, maintenance evolution.

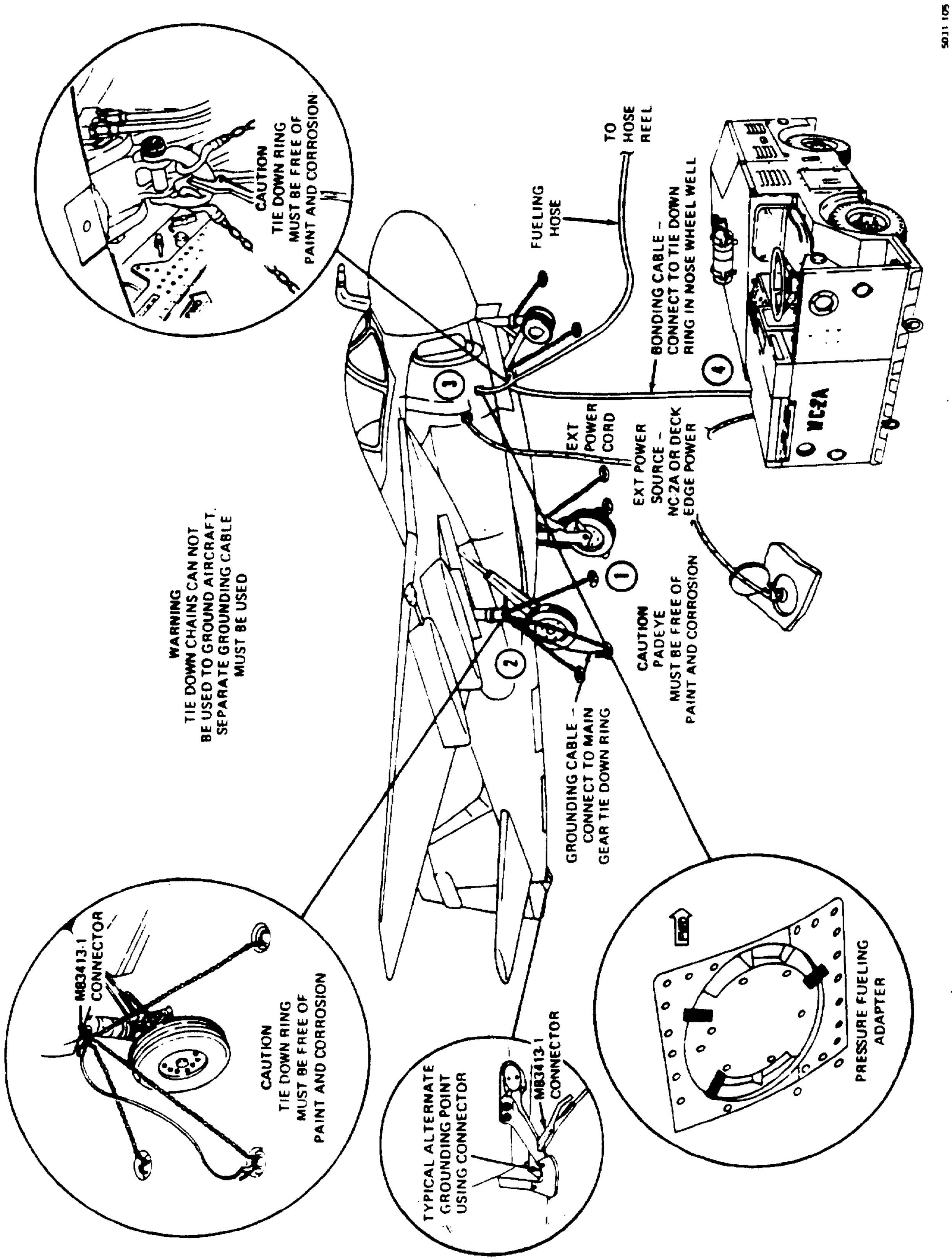


FIGURE 2-114. Carrier-based A-6 aircraft, fueling/defueling evolution.

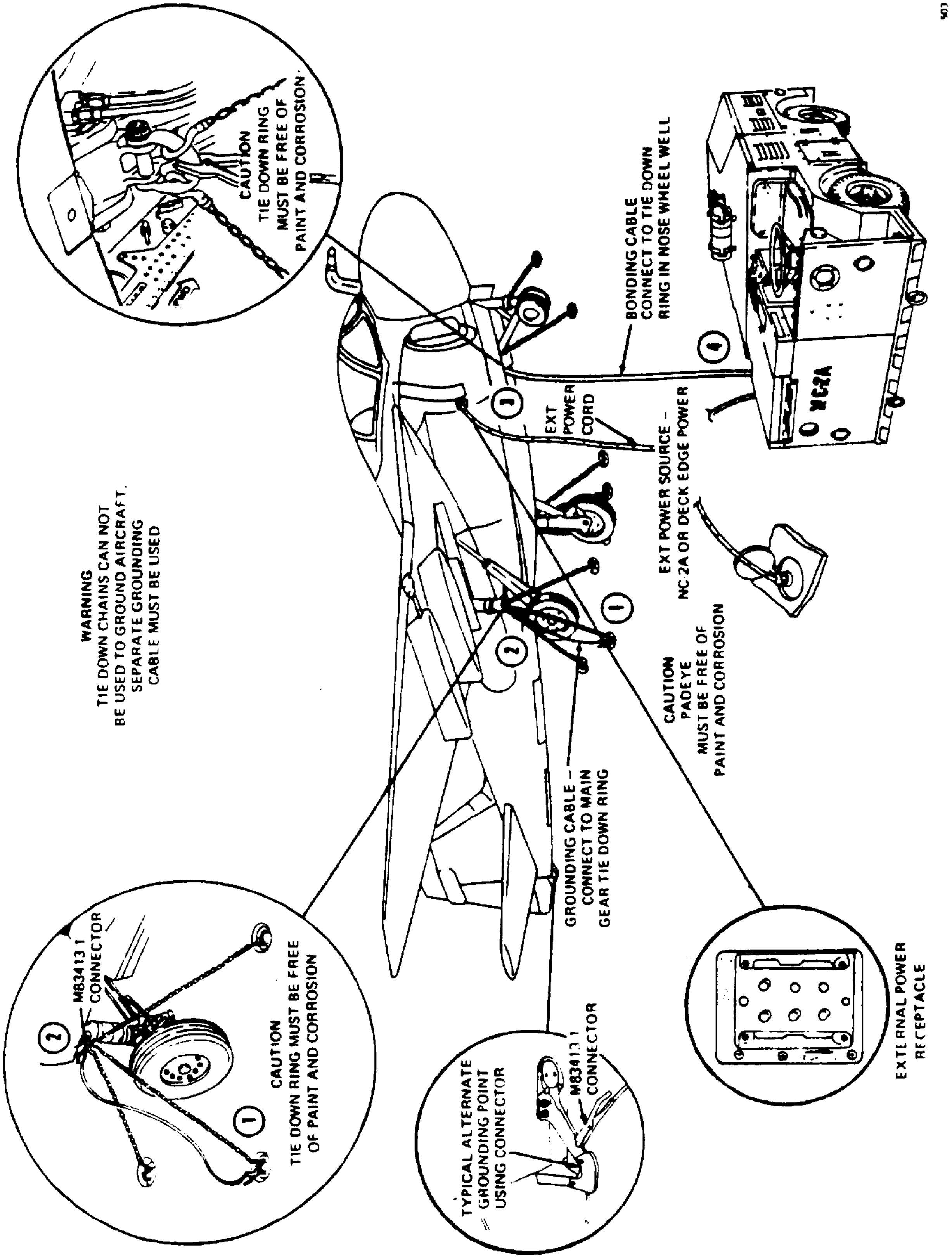


FIGURE 2-115. Carrier-based A-6 aircraft, maintenance evolution.

aircraft when in the parked evolution and stores loading/unloading evolution, proceed as follows (see figure 2-116):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.2.8 Carrier-based A-7 fueling/defueling evolution. To ground carrier-based A-7 aircraft when fueling or defueling, proceed as follows (see figure 2-117):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.9 Carrier-based A-7 maintenance evolution. To ground carrier-based A-7 aircraft when in the maintenance evolution, proceed as follows (see figure 2-118):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to forward fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.10 Carrier-based AH-1 fueling/defueling evolution. To ground carrier-based AH-1 aircraft when fueling or defueling, proceed as follows (see figure 2-119):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).

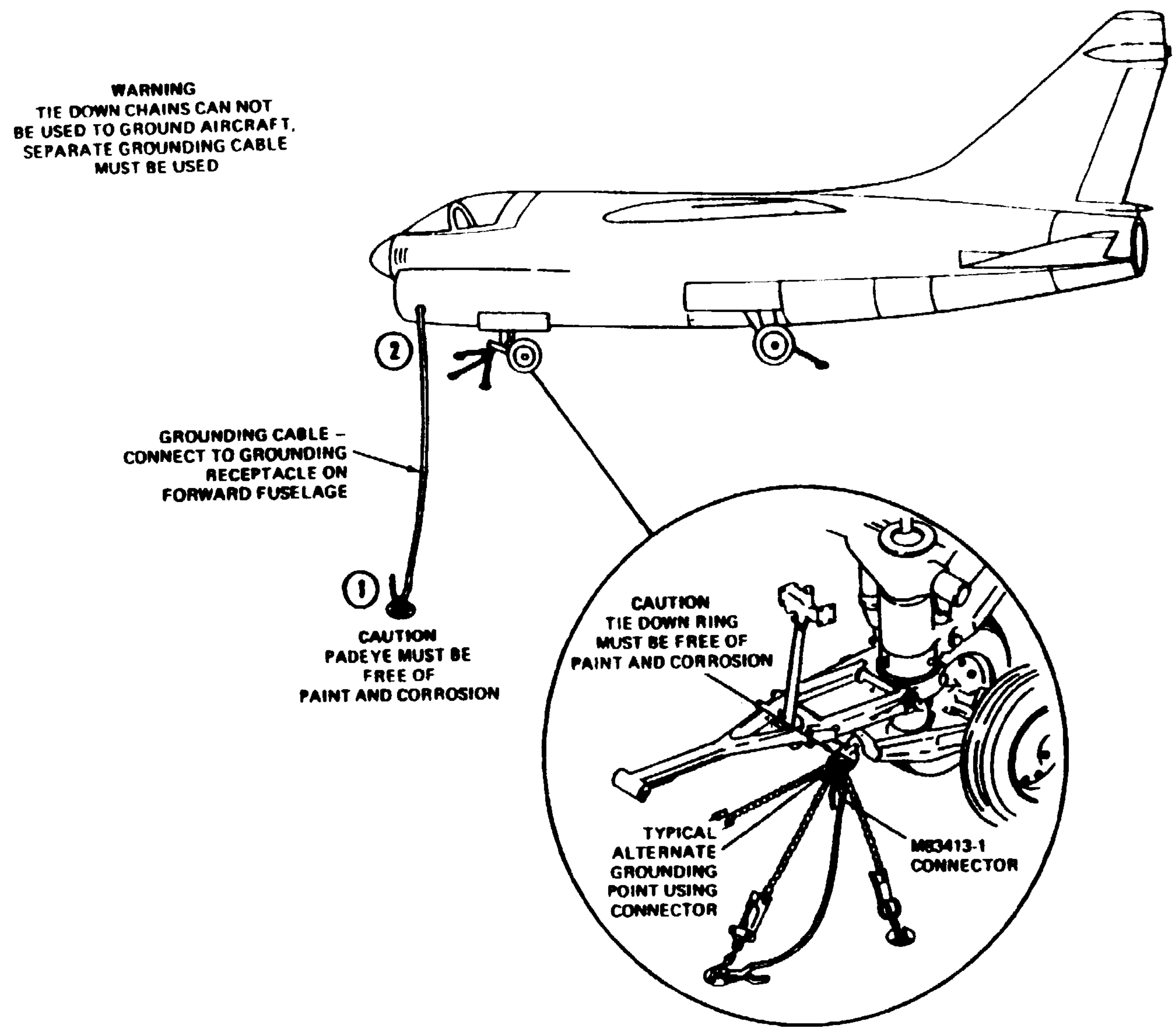


FIGURE 2-116. Carrier-based attack (A-3, A-4, A-6, A-7, AV-8, EA-6) aircraft, parked evolution and stores loading/unloading evolution.

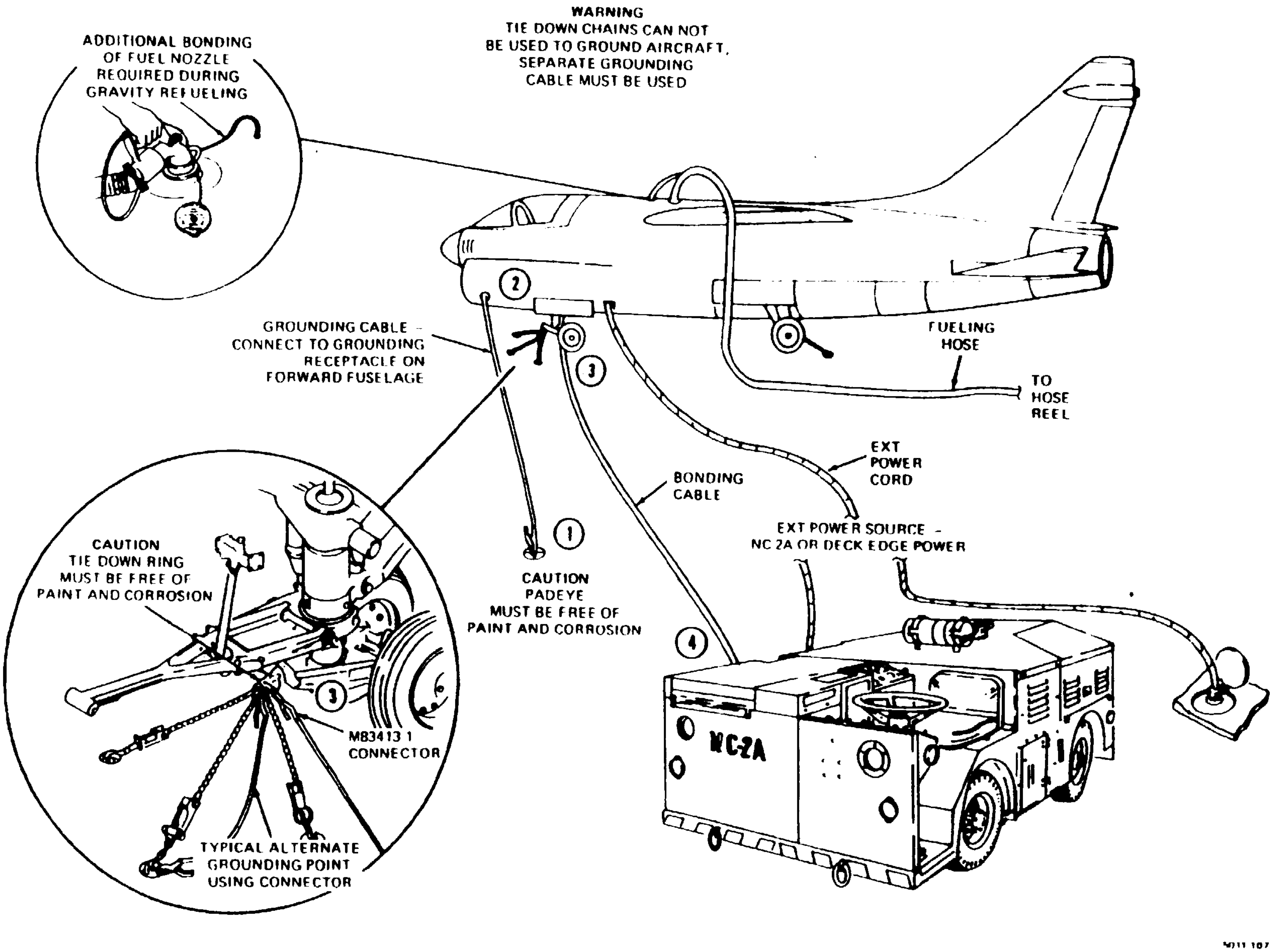


FIGURE 2-117. Carrier-based A-7 aircraft, fueling/defueling evolution.

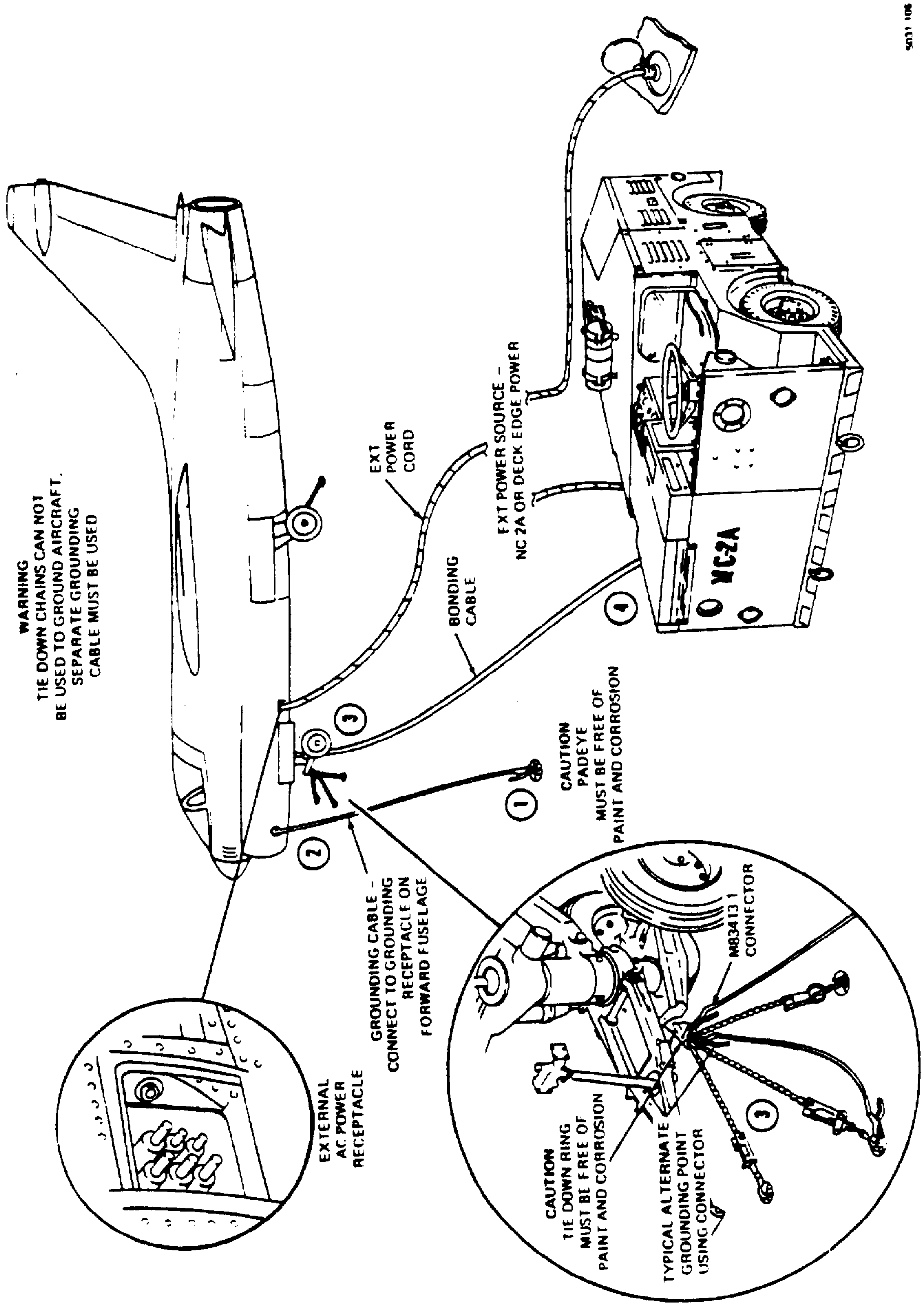


FIGURE 2-118. Carrier-based A-7 aircraft, maintenance evolution.

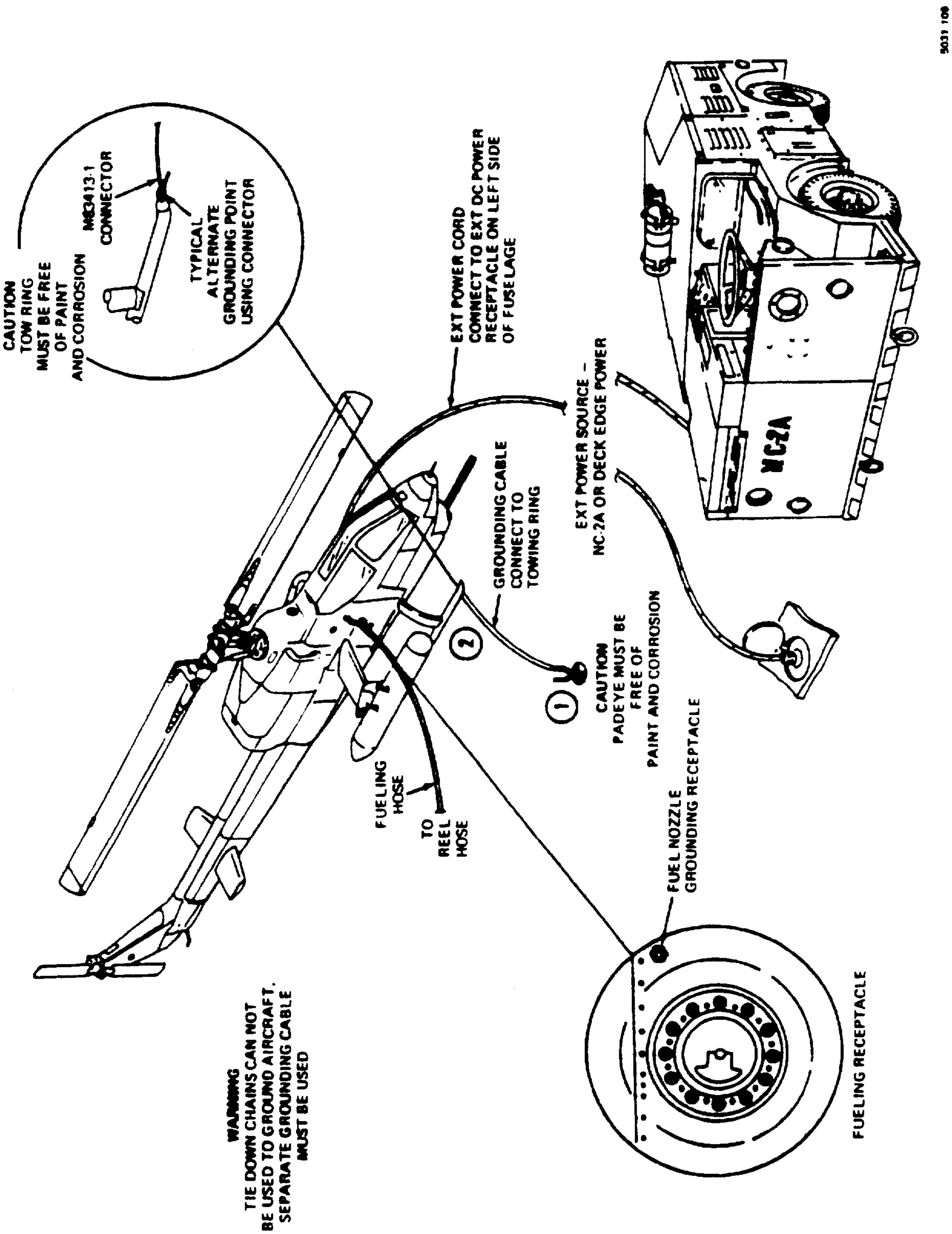


FIGURE 2-119. Carrier-based AH-1 aircraft, fueling/defueling evolution.

b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.2.11 Carrier-based AH-1 maintenance evolution. To ground carrier-based AH-1 aircraft when in the maintenance evolution, proceed as follows (see figure 2-120):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.2.12 Carrier-based AV-8 fueling/defueling evolution. To ground carrier-based AV-8 aircraft when fueling or defueling, proceed as follows (see figure 2-121):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.13 Carrier-based AV-8 maintenance evolution. To ground carrier-based AV-8 aircraft when in the maintenance evolution, proceed as follows (see figure 2-122):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable reverse above procedures.

2.2.14 Carrier-based C-1 fueling/defueling evolution. To ground carrier-based C-1 aircraft when fueling or defueling, proceed as follows (see figure 2-123):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

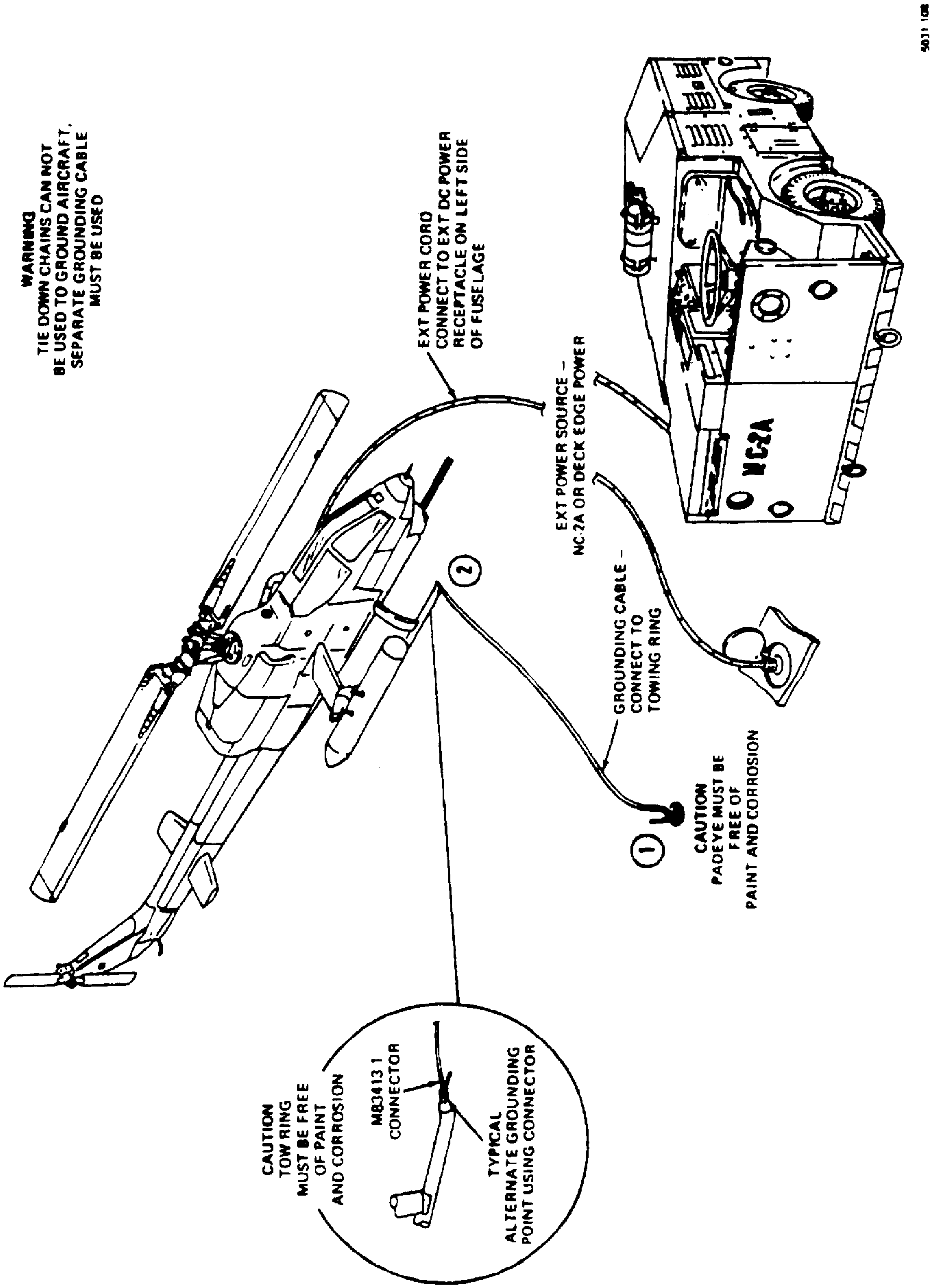


FIGURE 2-120. Carrier-based AH-1 aircraft, maintenance evolution.

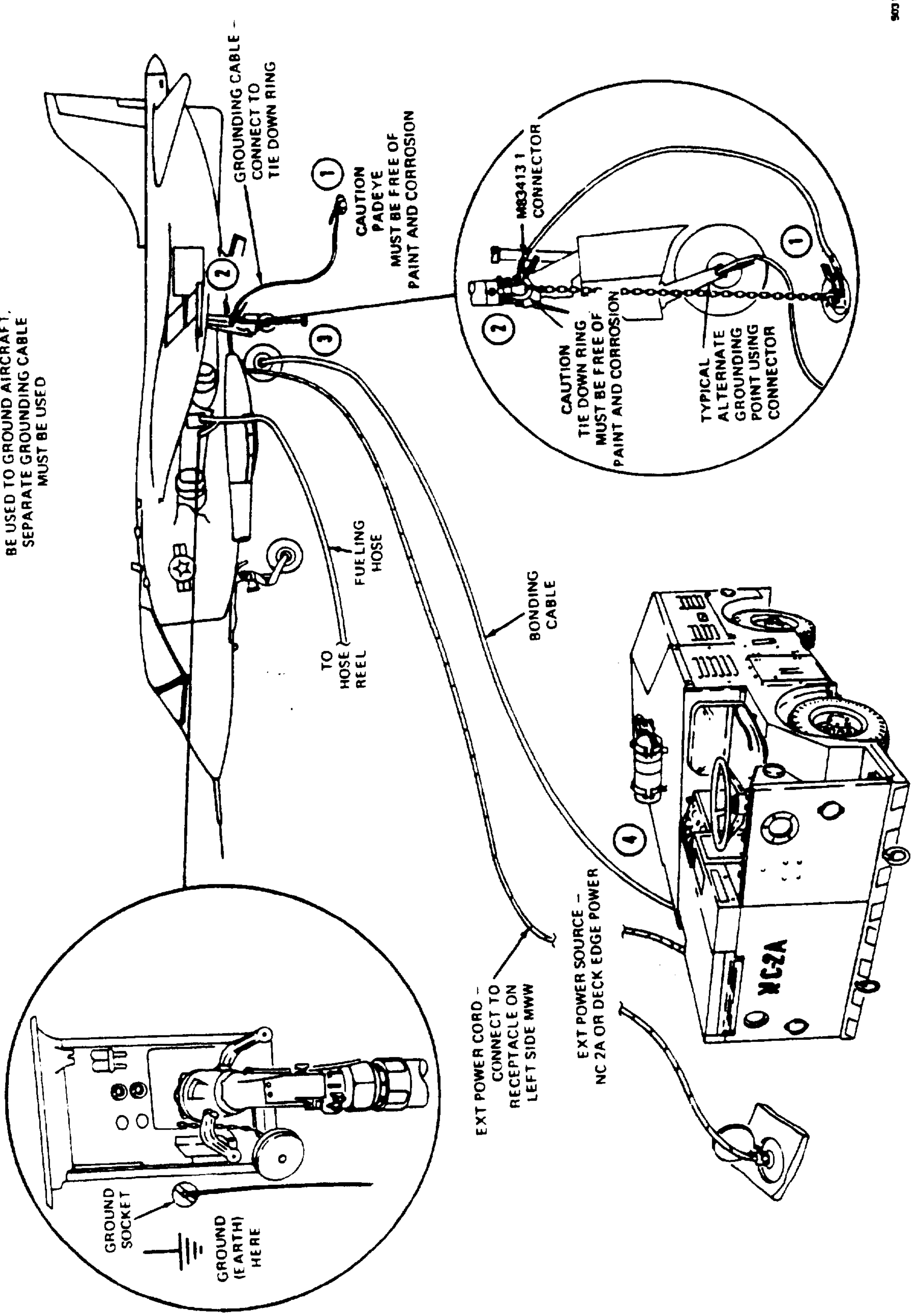


FIGURE 2-121. Carrier-based AV-8 aircraft, fueling/defueling evolution.

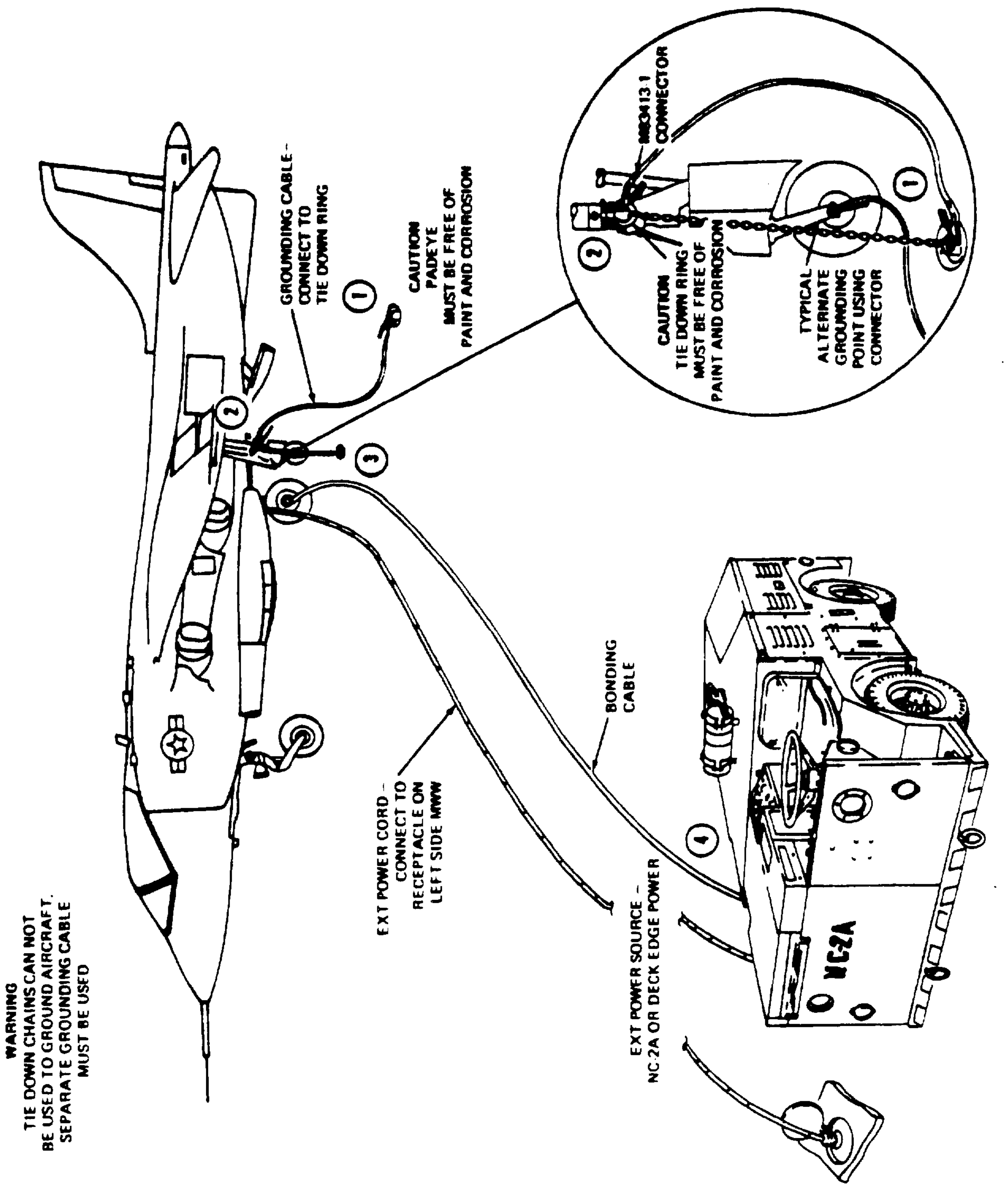


FIGURE 2-122. Carrier-based AV-8 aircraft, maintenance evolution.

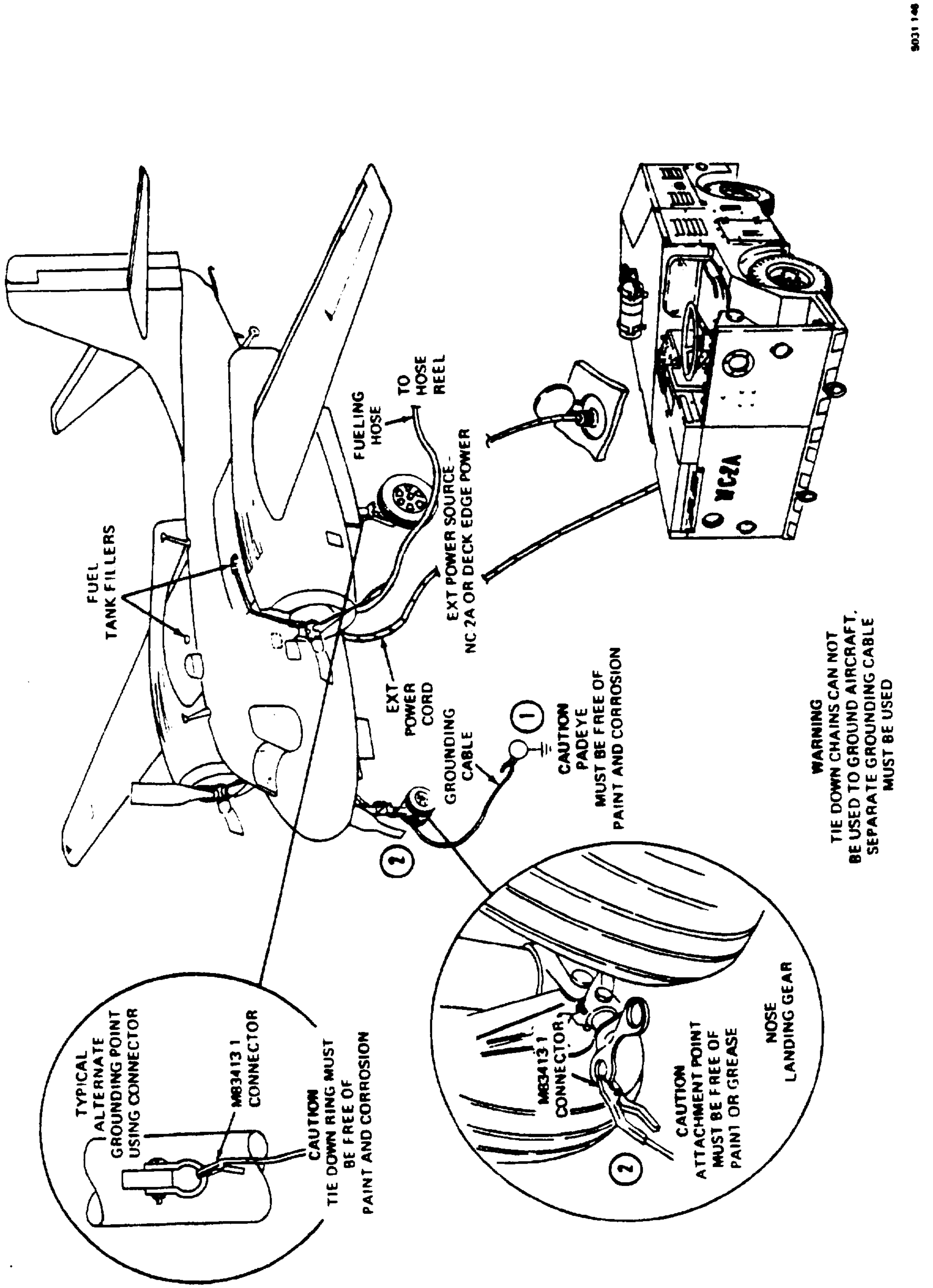


FIGURE 2-123. Carrier-based C-1 aircraft, fueling/defueling evolution.

2.2.15 Carrier-based C-1 maintenance evolution. To ground carrier-based C-1 aircraft when in the maintenance evolution, proceed as follows (see figure 2-124):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.2.16 Carrier-based CH-53 fueling/defueling evolution. To ground carrier-based CH-53 aircraft when fueling or defueling, proceed as follows (see figure 2-125):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.17 Carrier-based CH-53 maintenance evolution. To ground carrier-based CH-53 aircraft when in the maintenance evolution, proceed as follows (see figure 2-126):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to left rear fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear static drag wire (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.18 Carrier-based special electronics aircraft (E-2) parked evolution and stores loading/unloading evolution. To ground carrier-based special electronics (E-2) aircraft when in the parked evolution and in the stores loading/unloading evolution, proceed as follows (see figure 2-127):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).

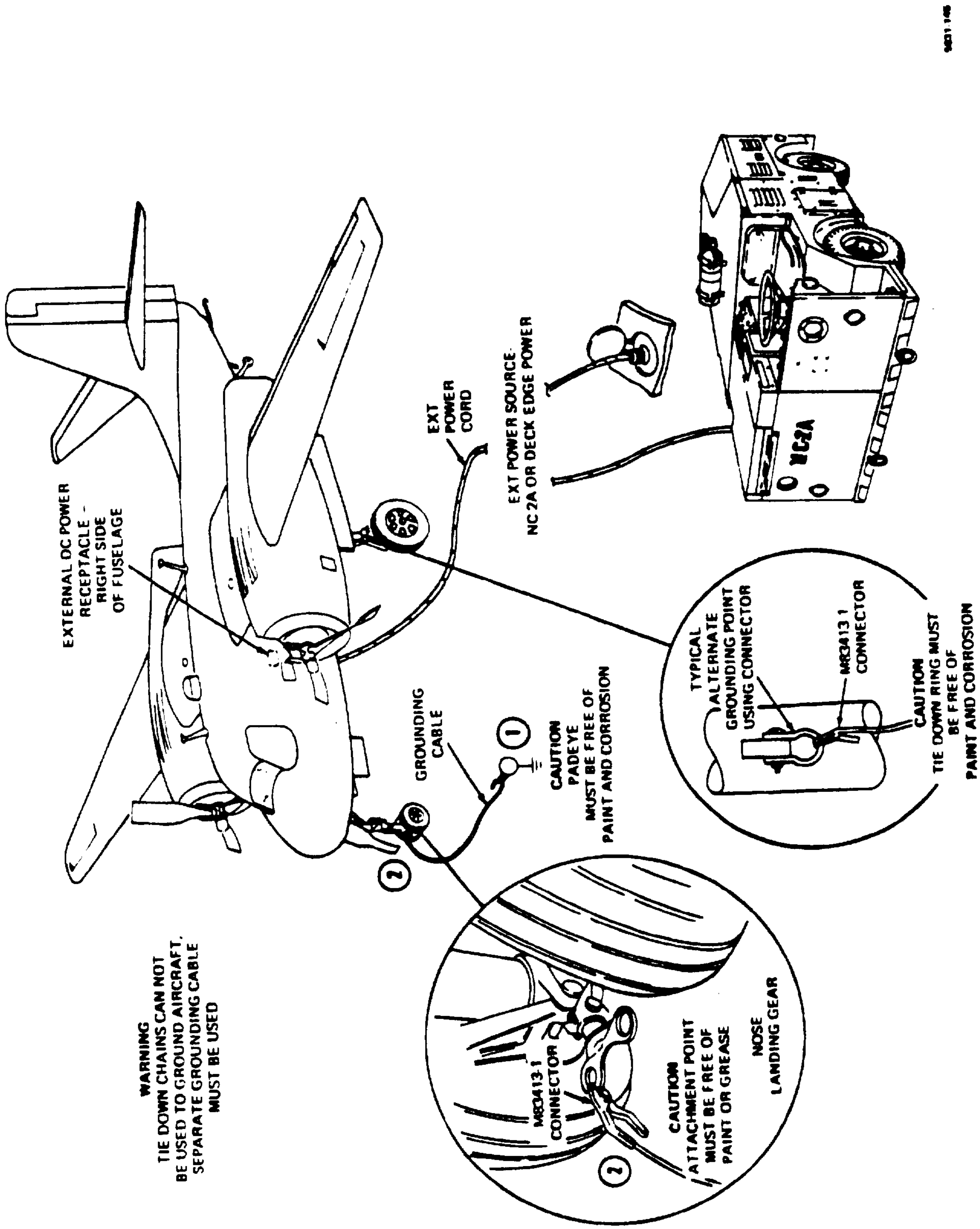


FIGURE 2-124. Carrier-based C-1 aircraft, maintenance evolution.

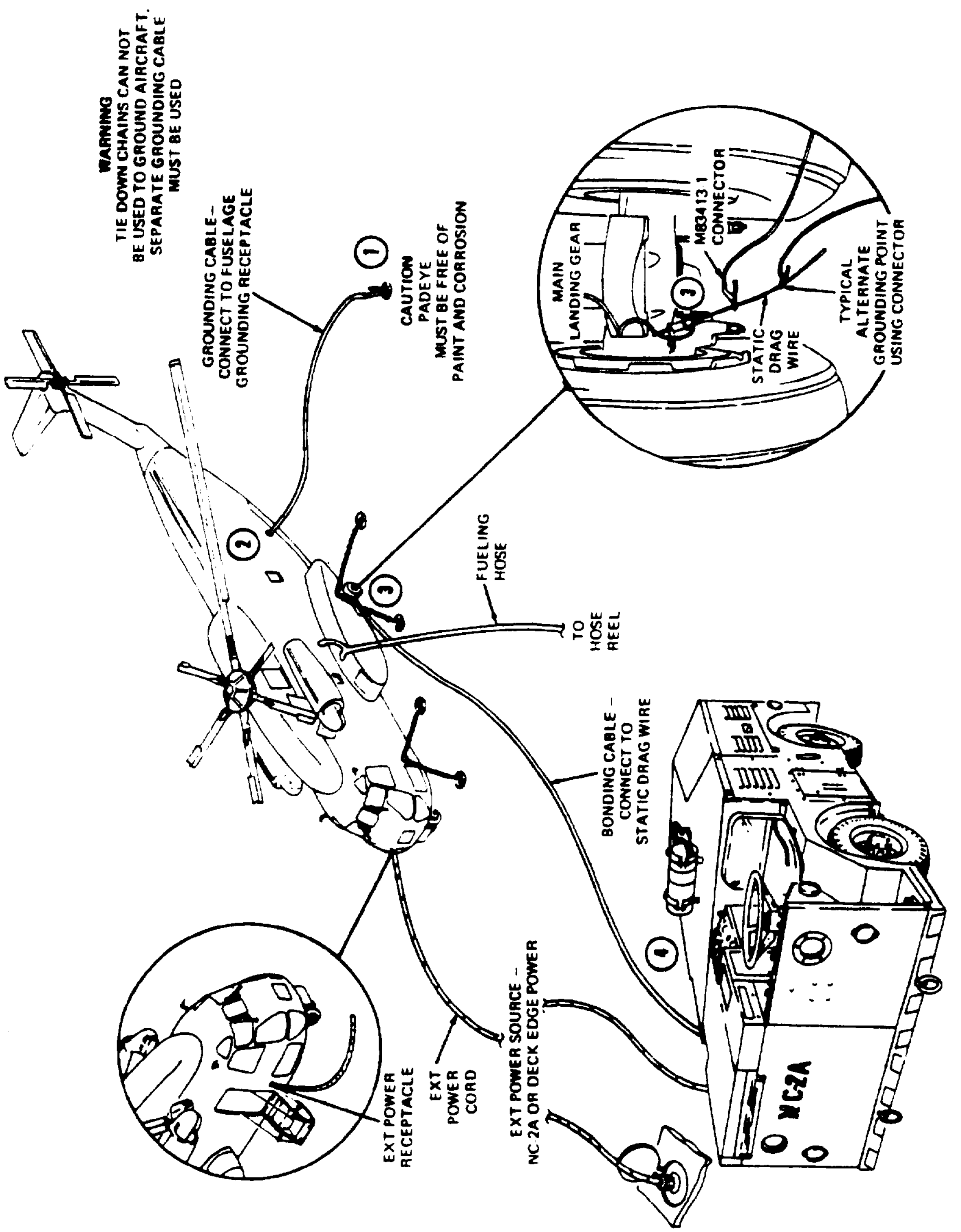


FIGURE 2-125. Carrier-based CH-53 aircraft, fueling/defueling evolution.

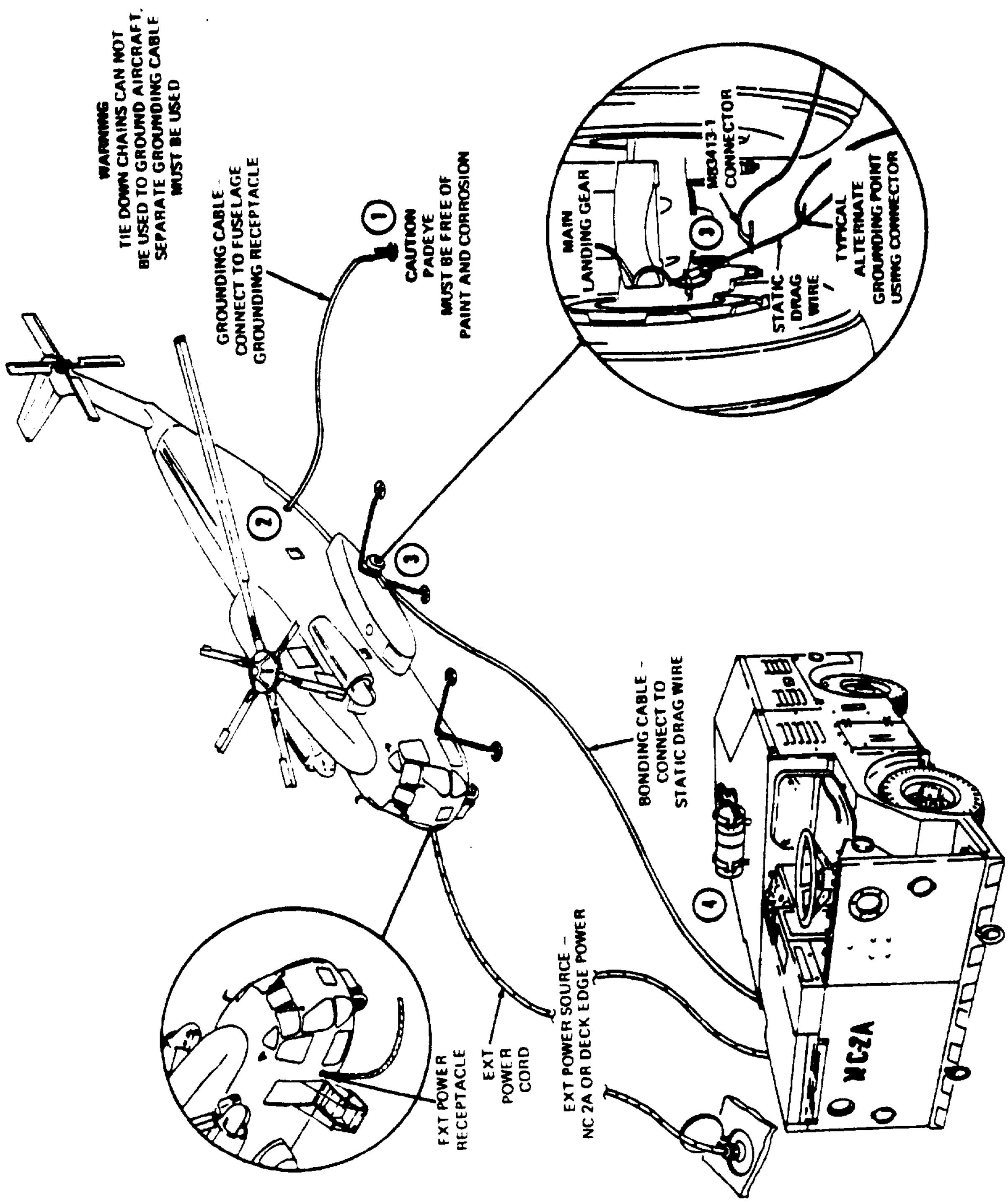


FIGURE 2-126. Carrier-based CH-53 aircraft, maintenance evolution.

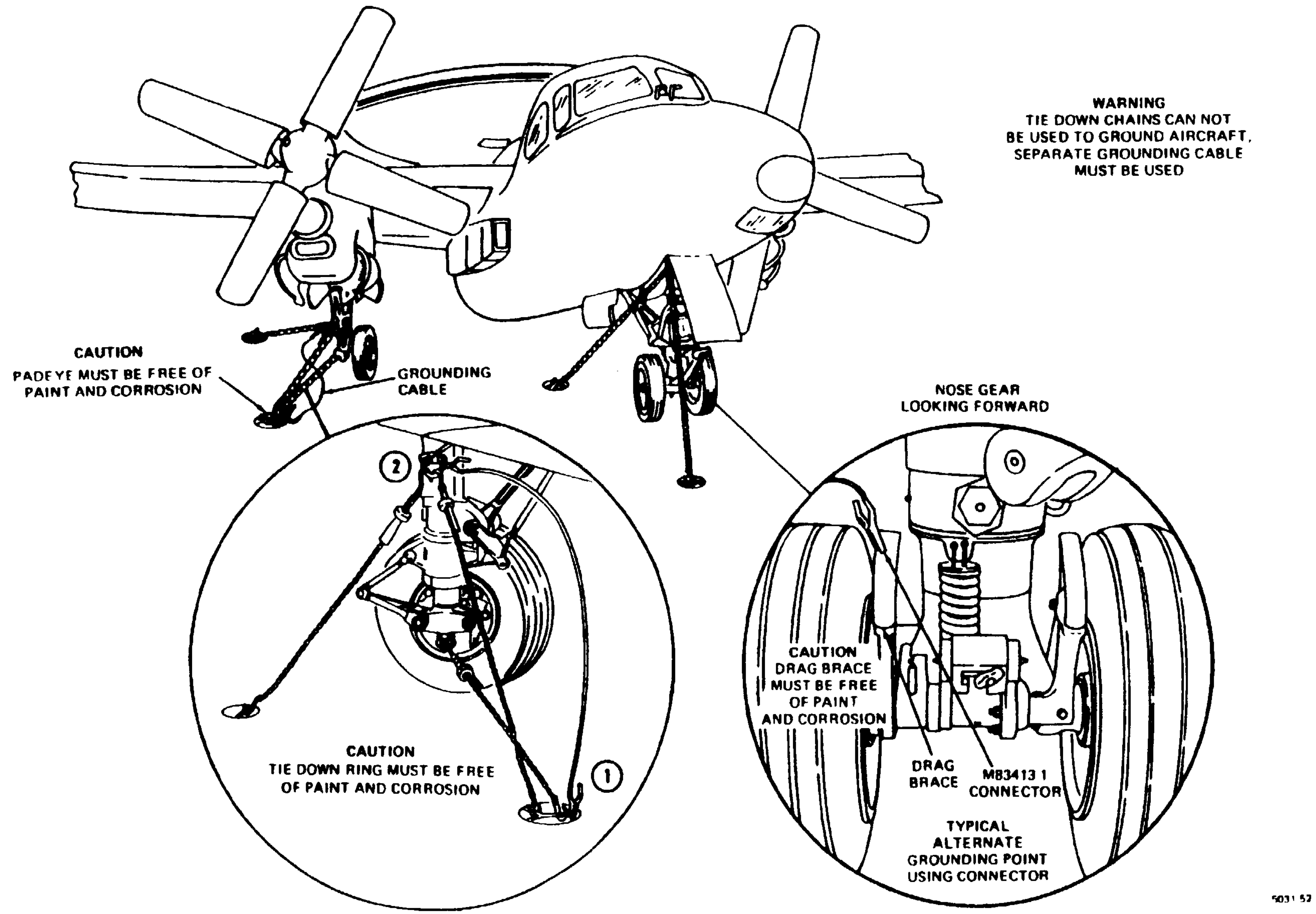


FIGURE 2-127. Carrier-based special electronics (E-2) aircraft, parked evolution and stores loading/unloading evolution.

b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on nose gear (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.2.19 Carrier-based E-2 fueling/defueling evolution. To ground carrier-based E-2 aircraft when fueling or defueling, proceed as follows (see figure 2-128):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on nose gear (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.20 Carrier-based E-2 maintenance evolution. To ground carrier-based E-2 aircraft when in the maintenance evolution, proceed as follows (see figure 2-129):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to drag brace on nose gear (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.21 Carrier-based EA-6 fueling/defueling evolution. To ground carrier-based EA-6 aircraft when fueling or defueling, proceed as follows (see figure 2-130):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.22 Carrier-based EA-6 maintenance evolution. To ground carrier-based EA-6 aircraft when in the maintenance evolution, proceed as follows (see figure 2-131):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).

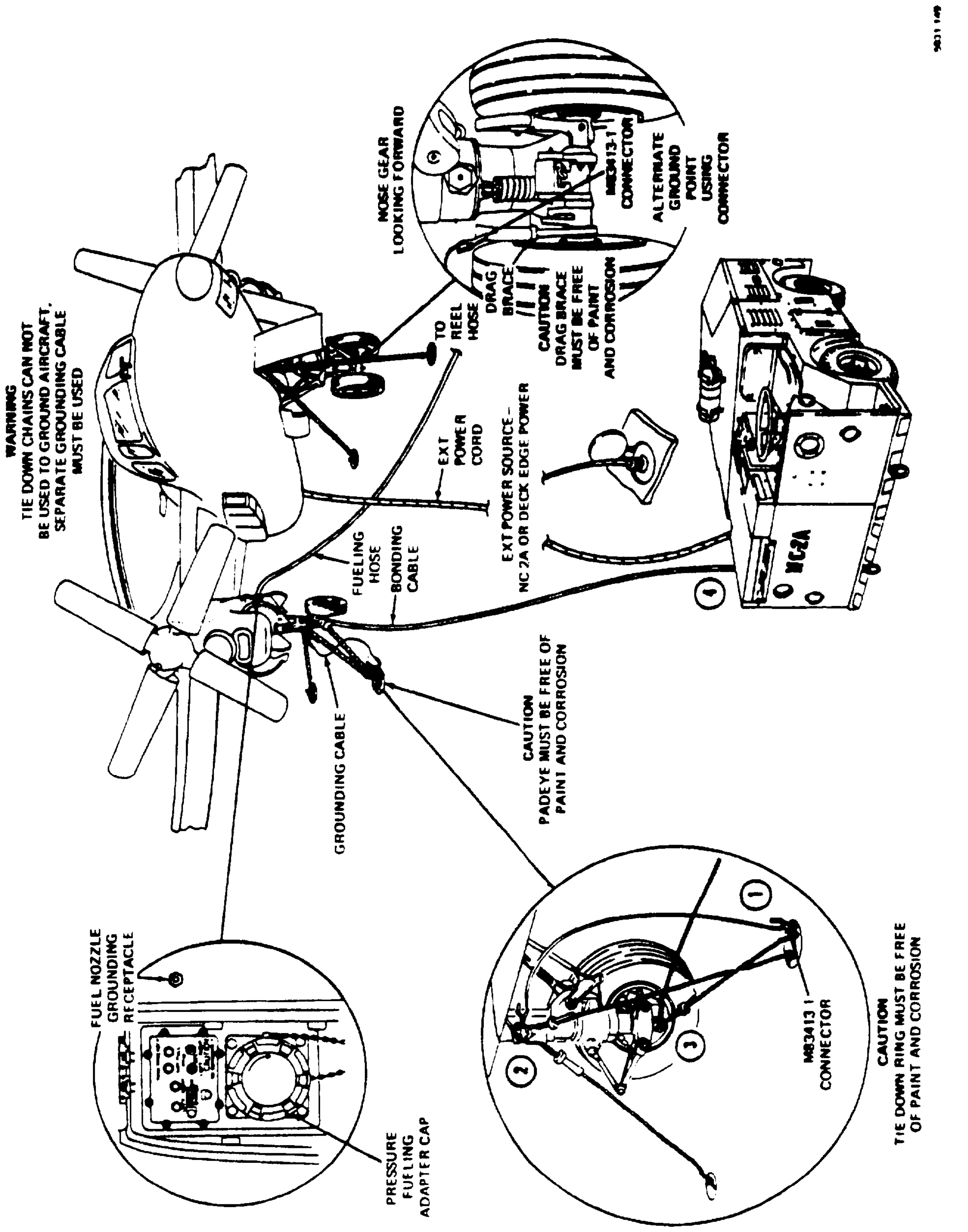


FIGURE 2-128. Carrier-based E-2 aircraft, fueling/defueling evolution.

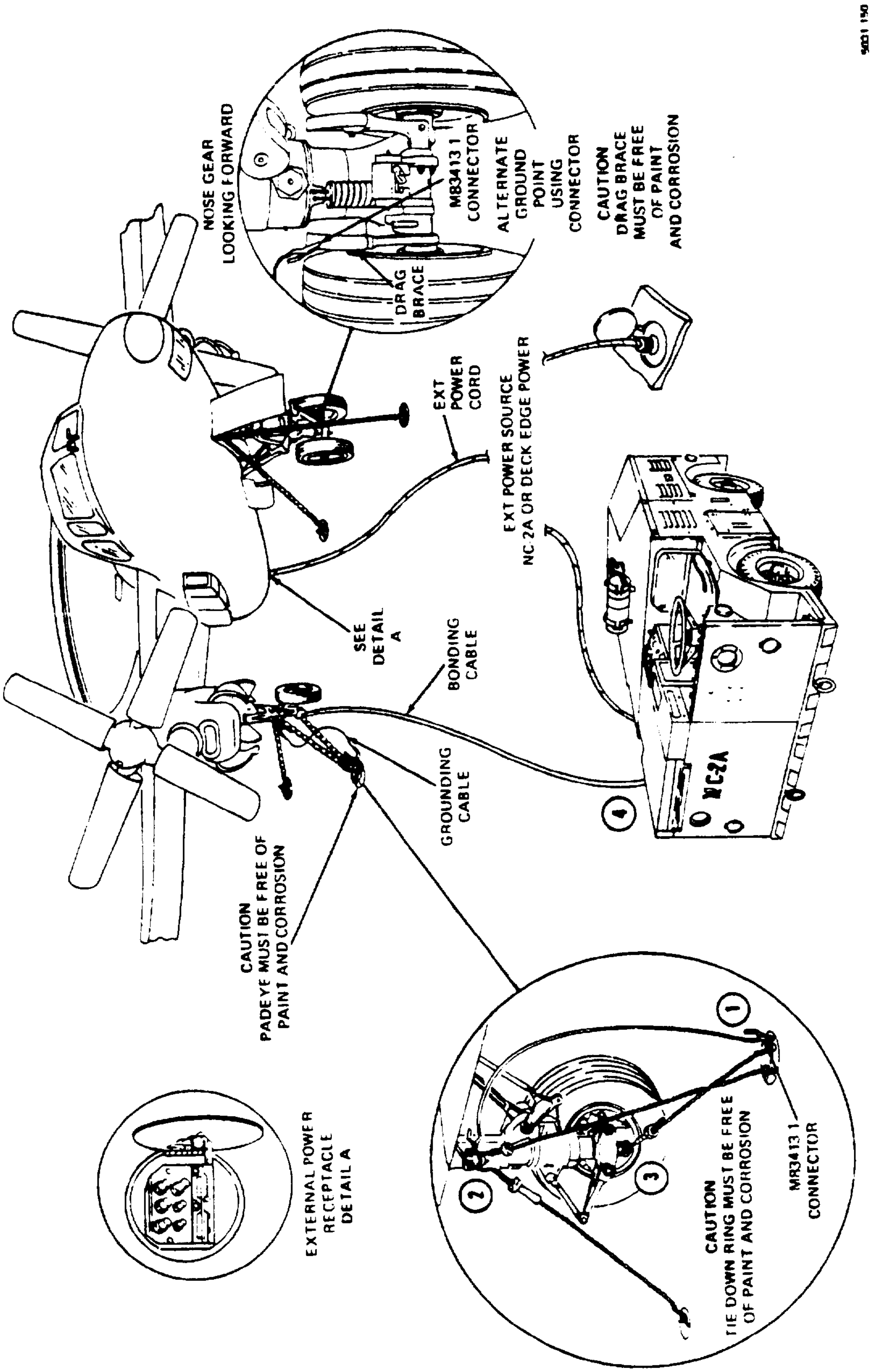


FIGURE 2-129. Carrier-based E-2 aircraft, maintenance evolution.

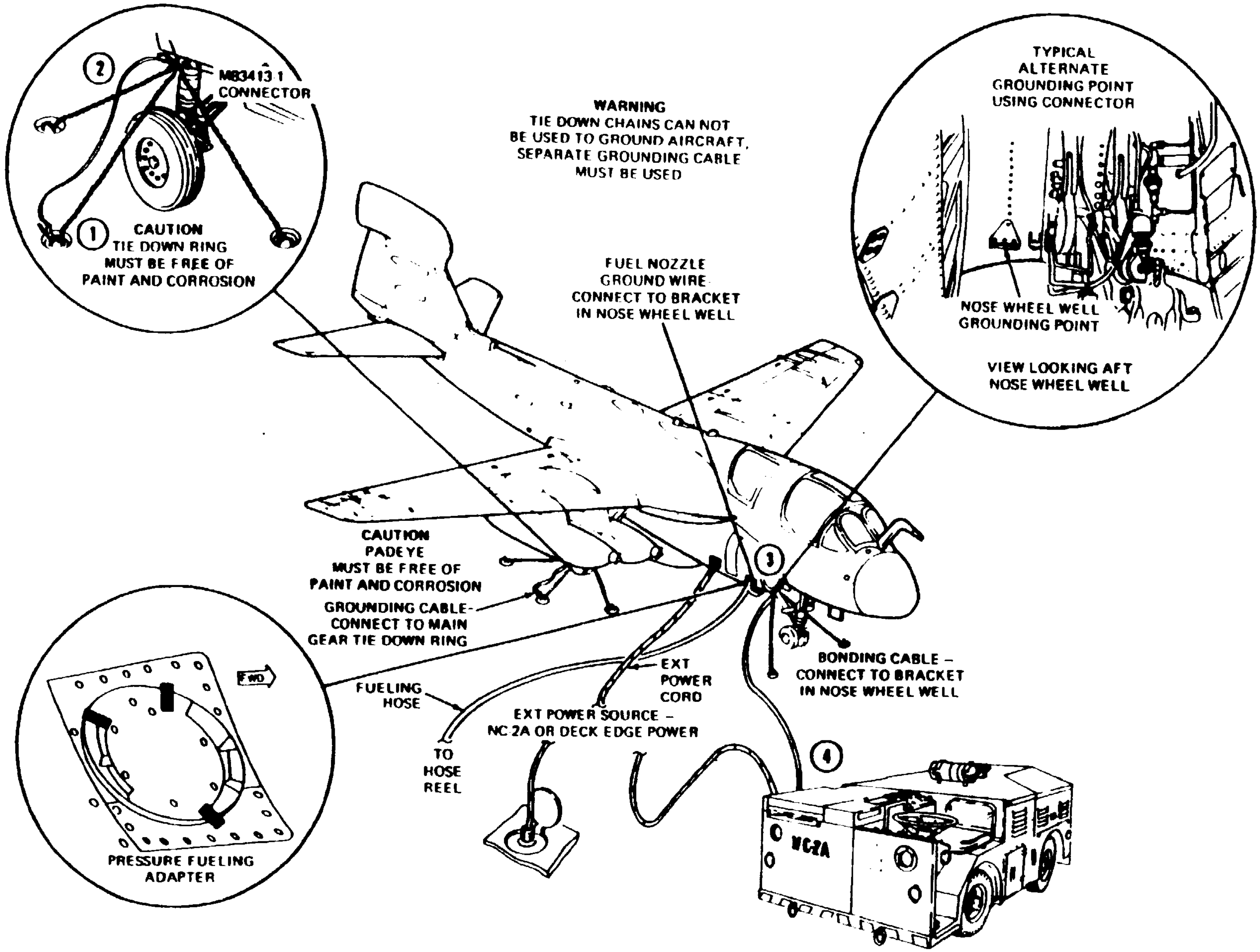


FIGURE 2-130. Carrier-based EA-6 aircraft, fueling/defueling evolution.

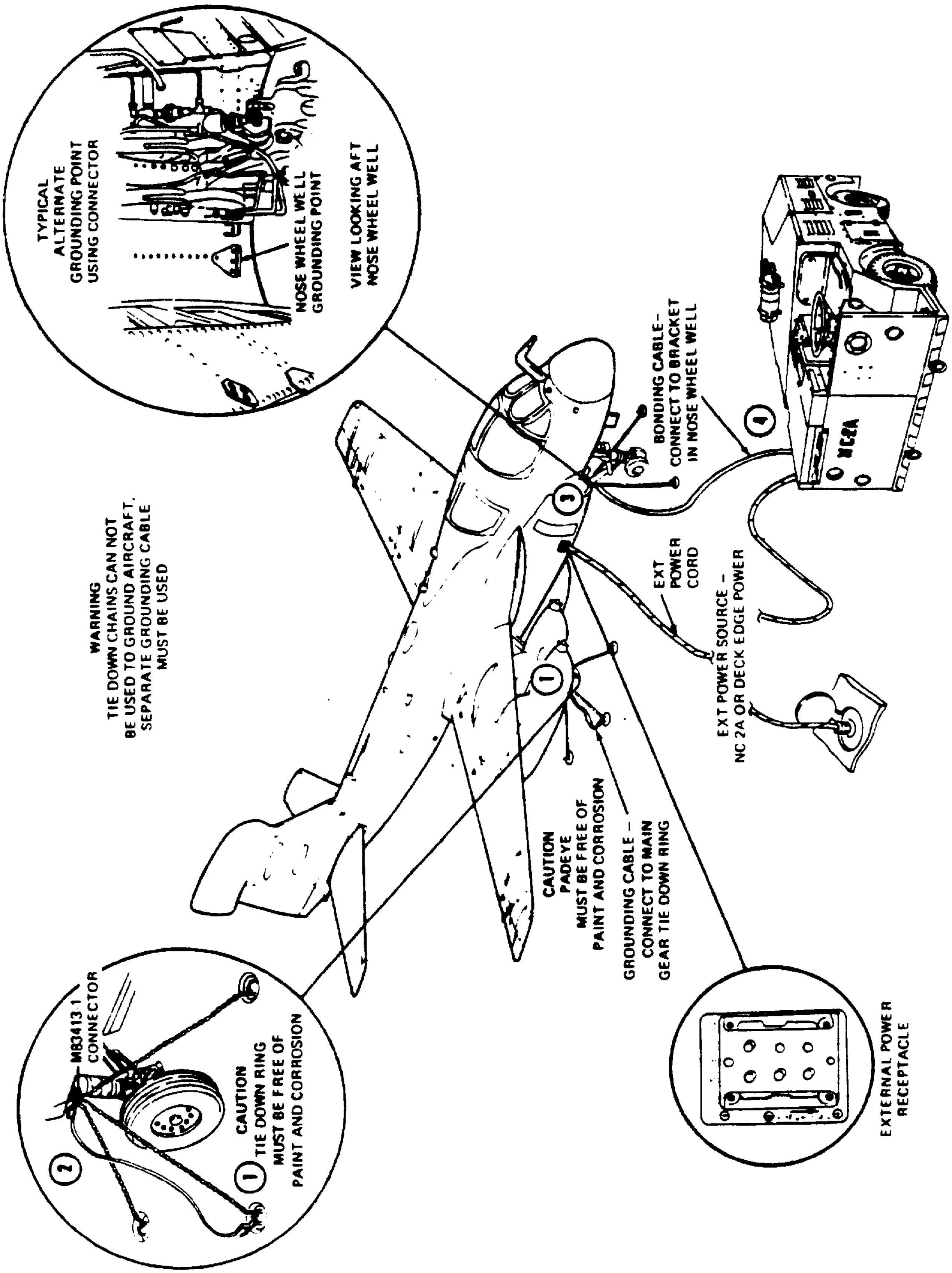


FIGURE 2-131. Carrier-based EA-6 aircraft, maintenance evolution.

b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.23 Carrier-based F-4 fueling/defueling evolution. To ground carrier-based F-4 aircraft when fueling or defueling, proceed as follows (see figure 2-132):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.24 Carrier-based F-4 maintenance evolution. To ground carrier-based F-4 aircraft when in the maintenance evolution, proceed as follows (see figure 2-133):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.25 Carrier-based fighter aircraft (F-4, F-14, F-18) parked evolution and stores loading/unloading evolution. To ground carrier-based fighter (F-4, F-14, F-18) aircraft when in the parked evolution and stores loading/unloading evolution, proceed as follows (see figure 2-134):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).

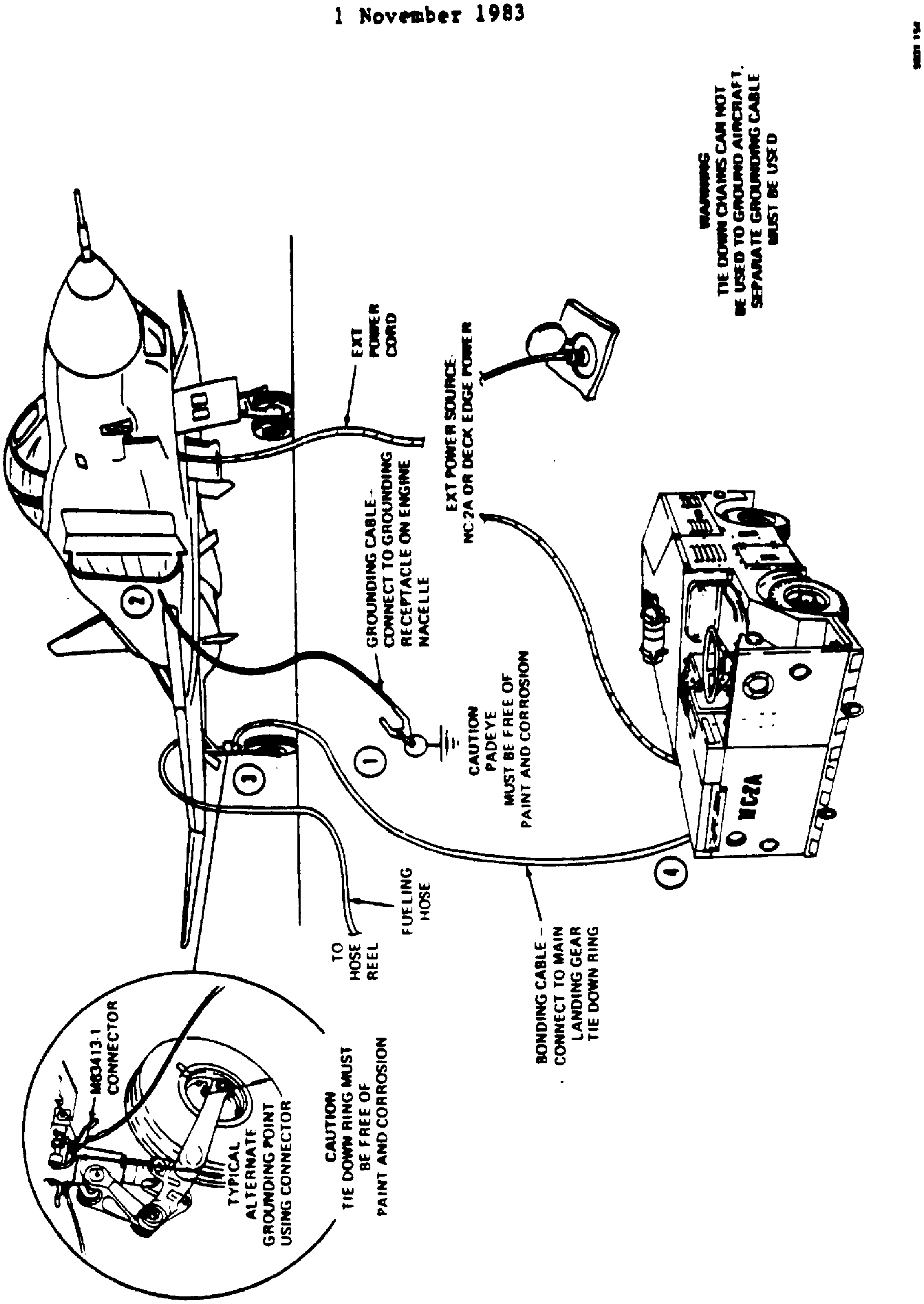


FIGURE 2-132. Carrier-based F-4 aircraft, fueling/defueling evolution.

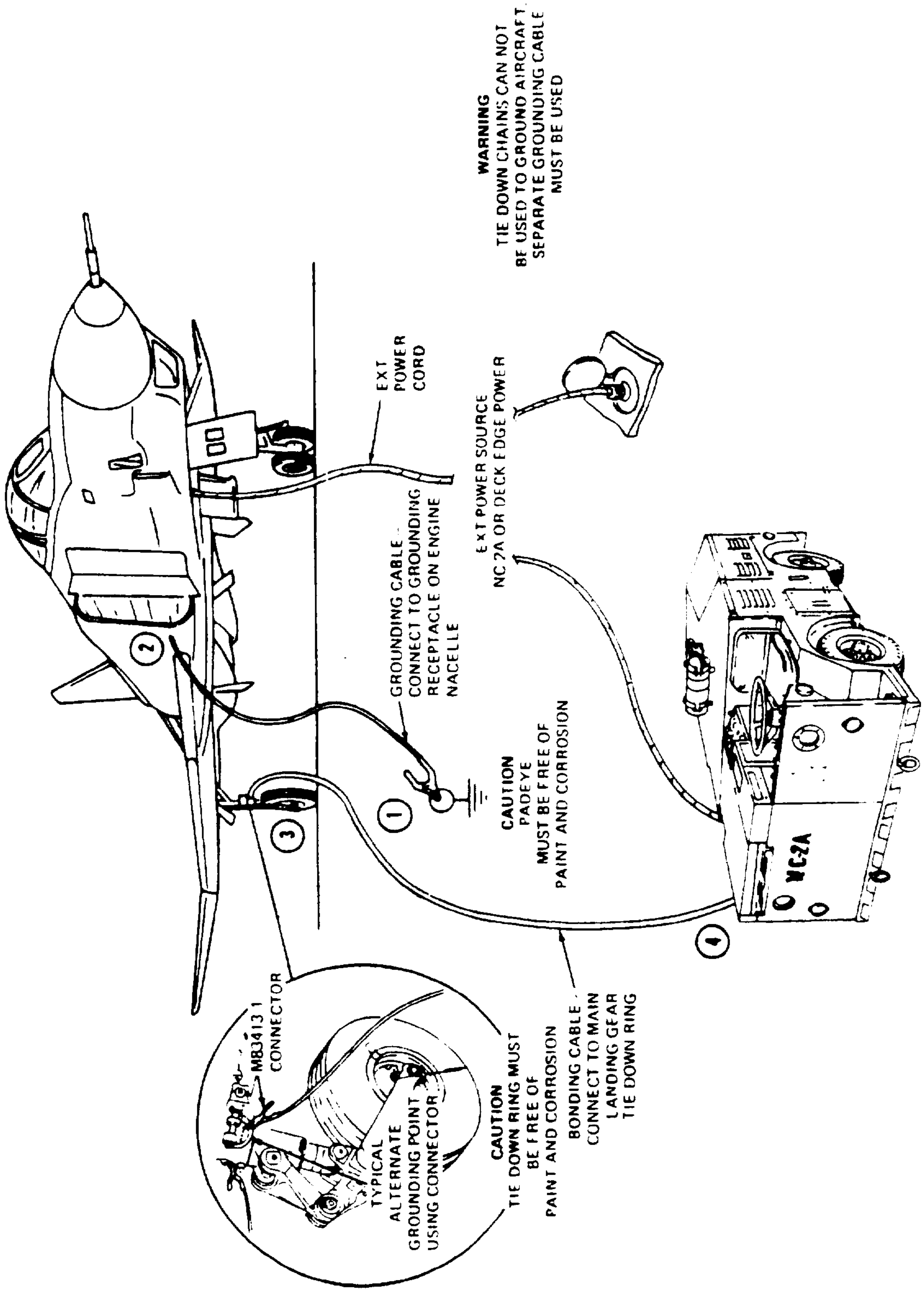


FIGURE 2-133. Carrier-based F-4 aircraft, maintenance evolution.

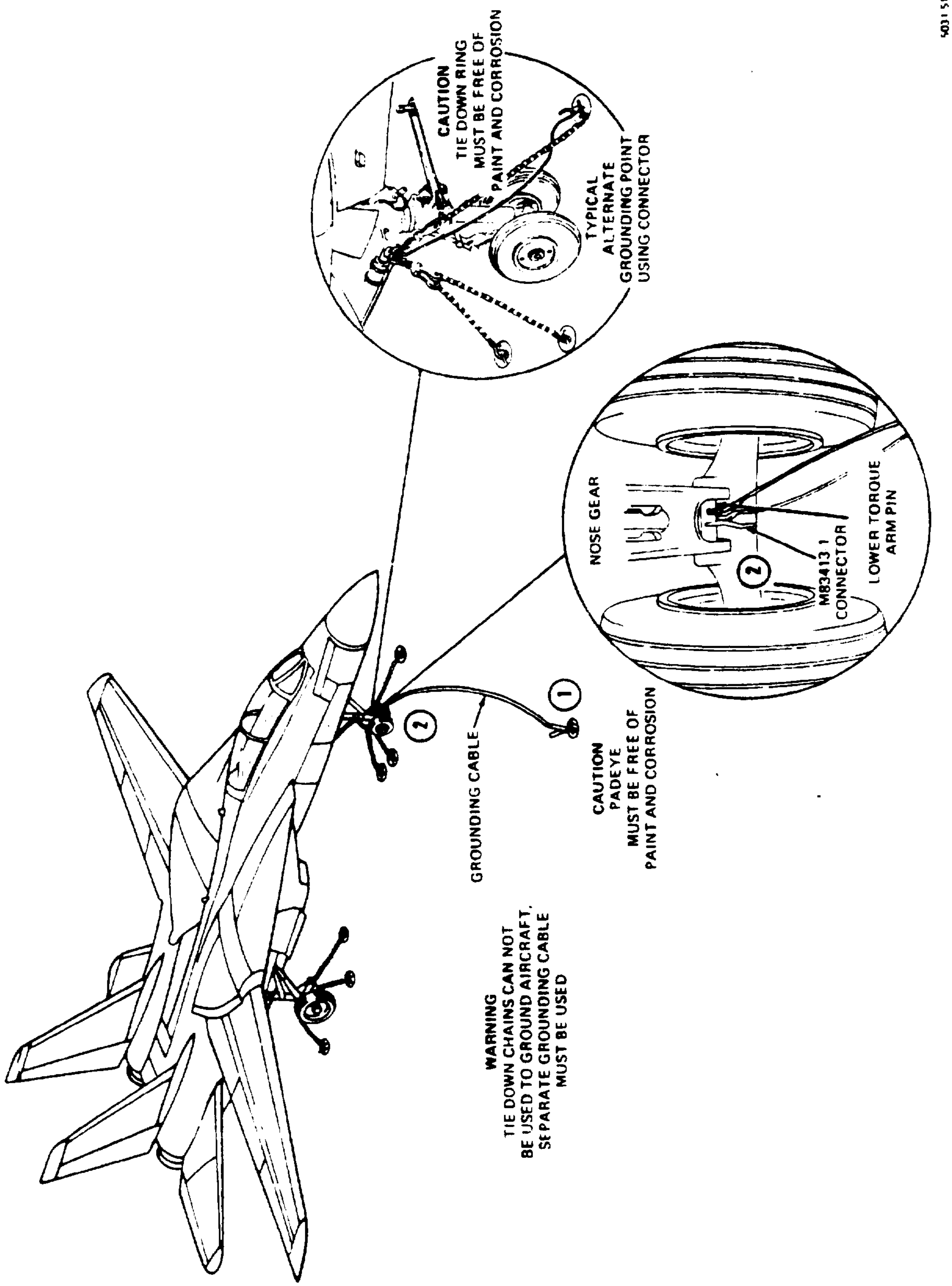


FIGURE 2-134. Carrier-based fighter (F-4, F-14, F-18) aircraft, parked evolution and stores loading/unloading evolution.

b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.2.26 Carrier-based F-14 fueling/defueling evolution. To ground carrier-based F-14 aircraft when fueling or defueling, proceed as follows (see figure 2-135):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to lower torque arm pin (3).
d. Connect free end of bonding cable to bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.27 Carrier-based F-14 maintenance evolution. To ground carrier-based F-14 aircraft when in the maintenance evolution, proceed as follows (see figure 2-136):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to lower torque arm pin (3).
d. Connect free end of bonding cable to bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.28 Carrier-based F-18 fueling/defueling evolution. To ground carrier-based F-18 aircraft when fueling or defueling, proceed as follows (see figure 2-137):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).

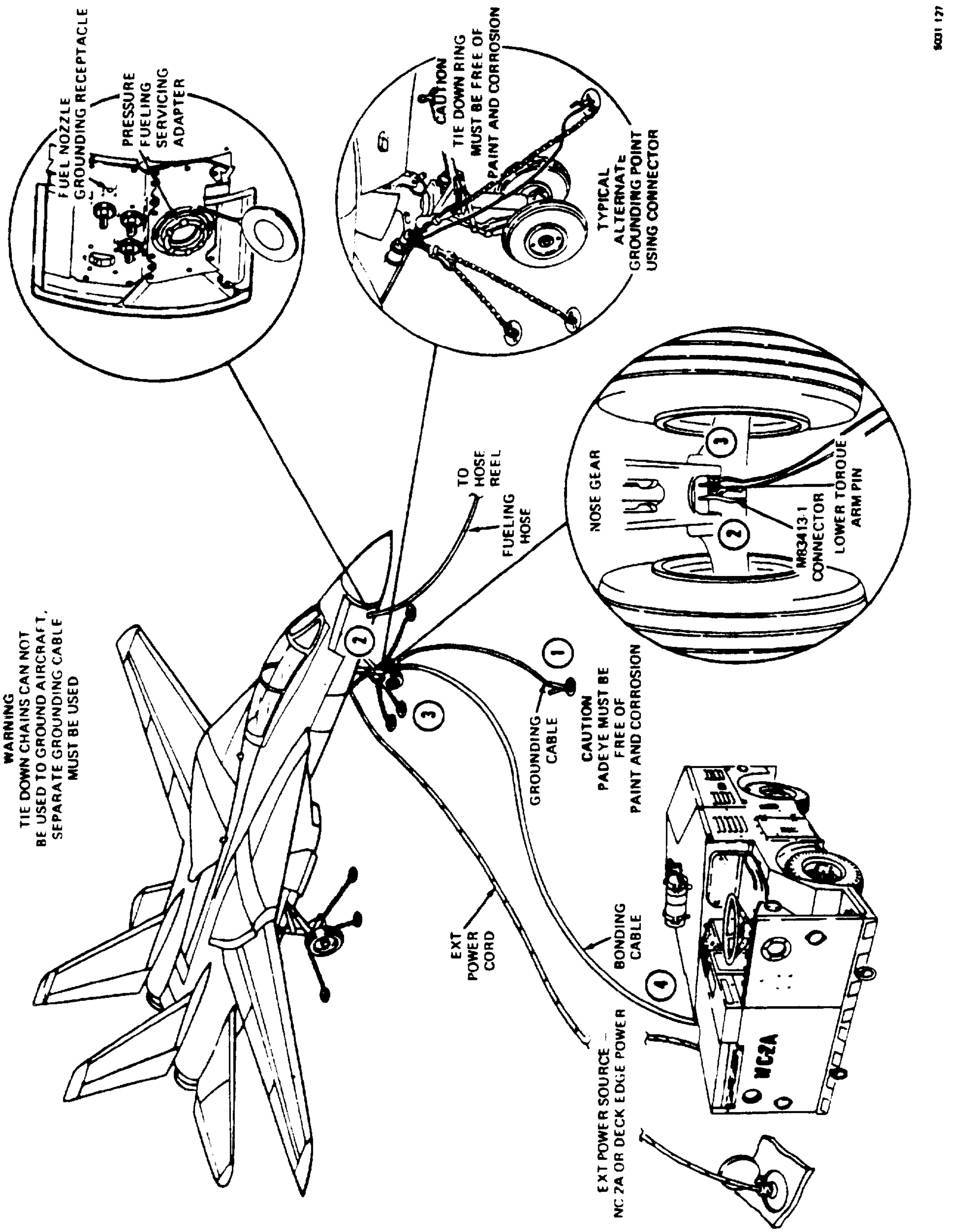


FIGURE 2-135. Carrier-based F-14 aircraft, fueling/defueling evolution.

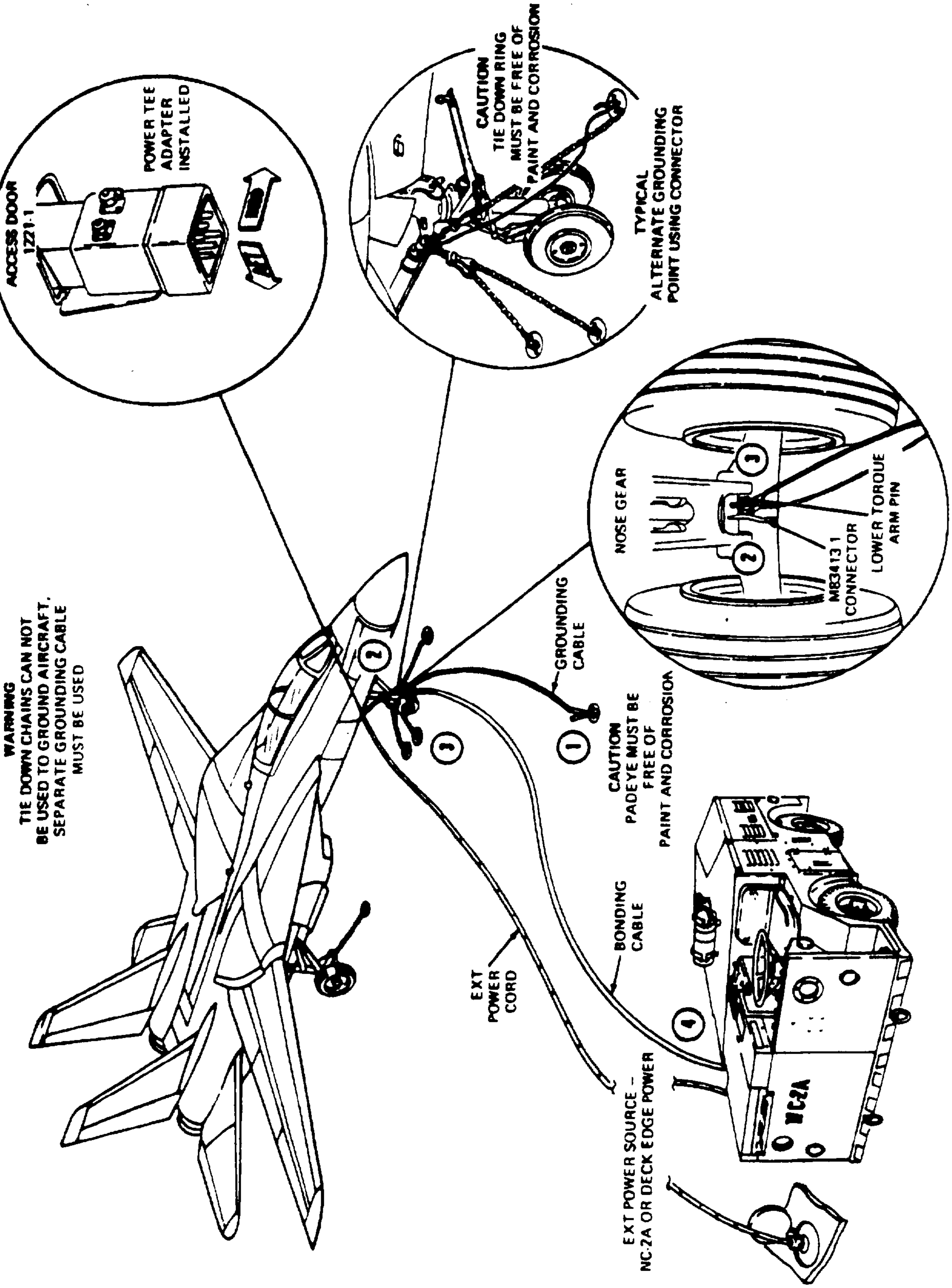


FIGURE 2-136. Carrier-based F-14 aircraft, maintenance evolution.

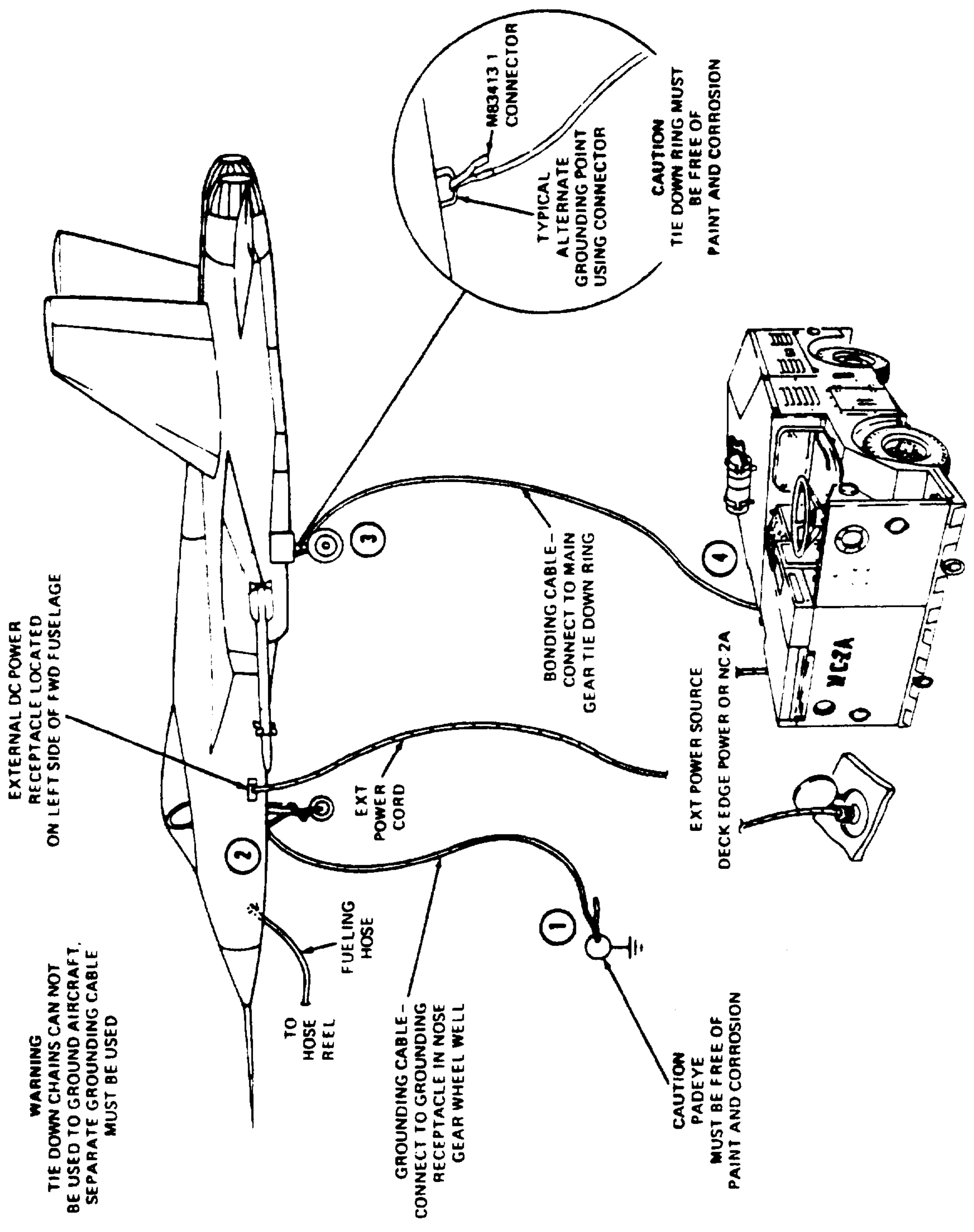


FIGURE 2-137. Carrier-based F-18 aircraft, fueling/defueling evolution.

d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.29 Carrier-based F-18 maintenance evolution. To ground carrier-based F-18 aircraft when in the maintenance evolution, proceed as follows (see figure 2-138):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a. and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.30 Carrier-based H-46 fueling/defueling evolution. To ground carrier-based H-46 aircraft when fueling or defueling, proceed as follows (see figure 2-139):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to left main gear tow fitting point (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.31 Carrier-based H-46 maintenance evolution. To ground carrier-based H-46 aircraft when in the maintenance evolution, proceed as follows (see figure 2-140):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to left main gear tow fitting point (2). If this location is not accessible, then connect grounding cable to right main gear tow fitting point (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to left main gear tow fitting point (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

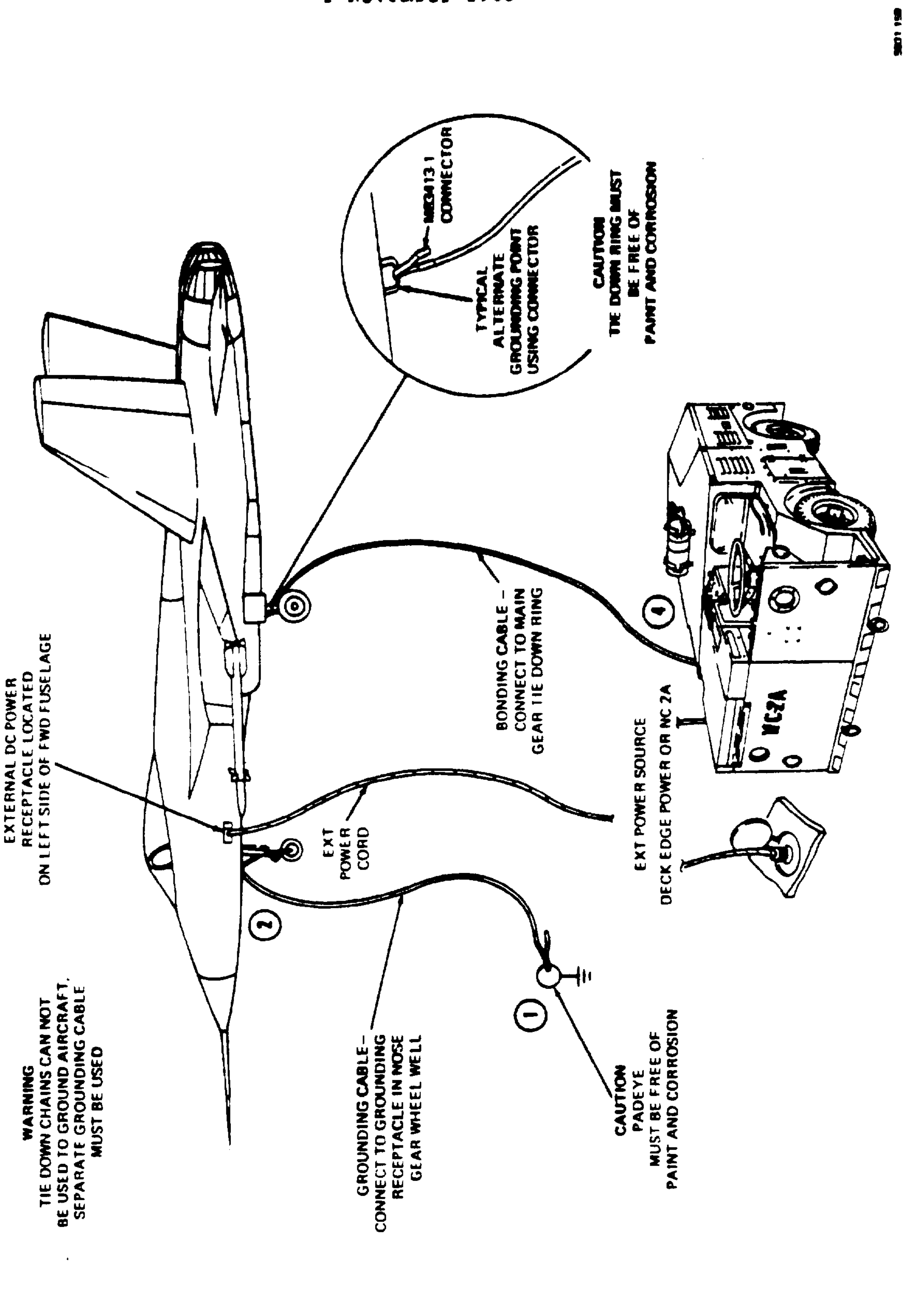


FIGURE 2-138. Carrier-based F-18 aircraft, maintenance evolution.

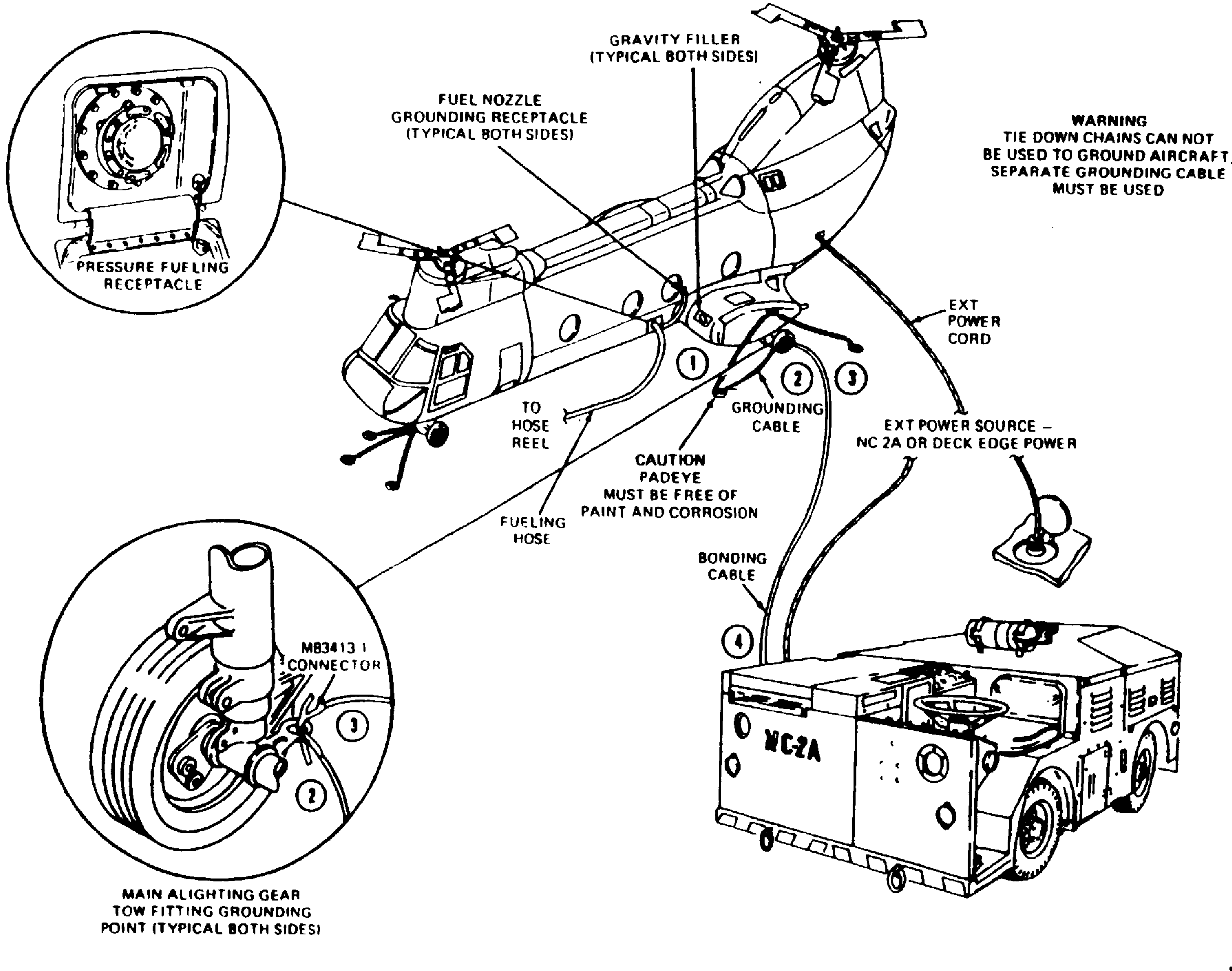


FIGURE 2-139. Carrier-based H-46 aircraft, fueling/defueling evolution.

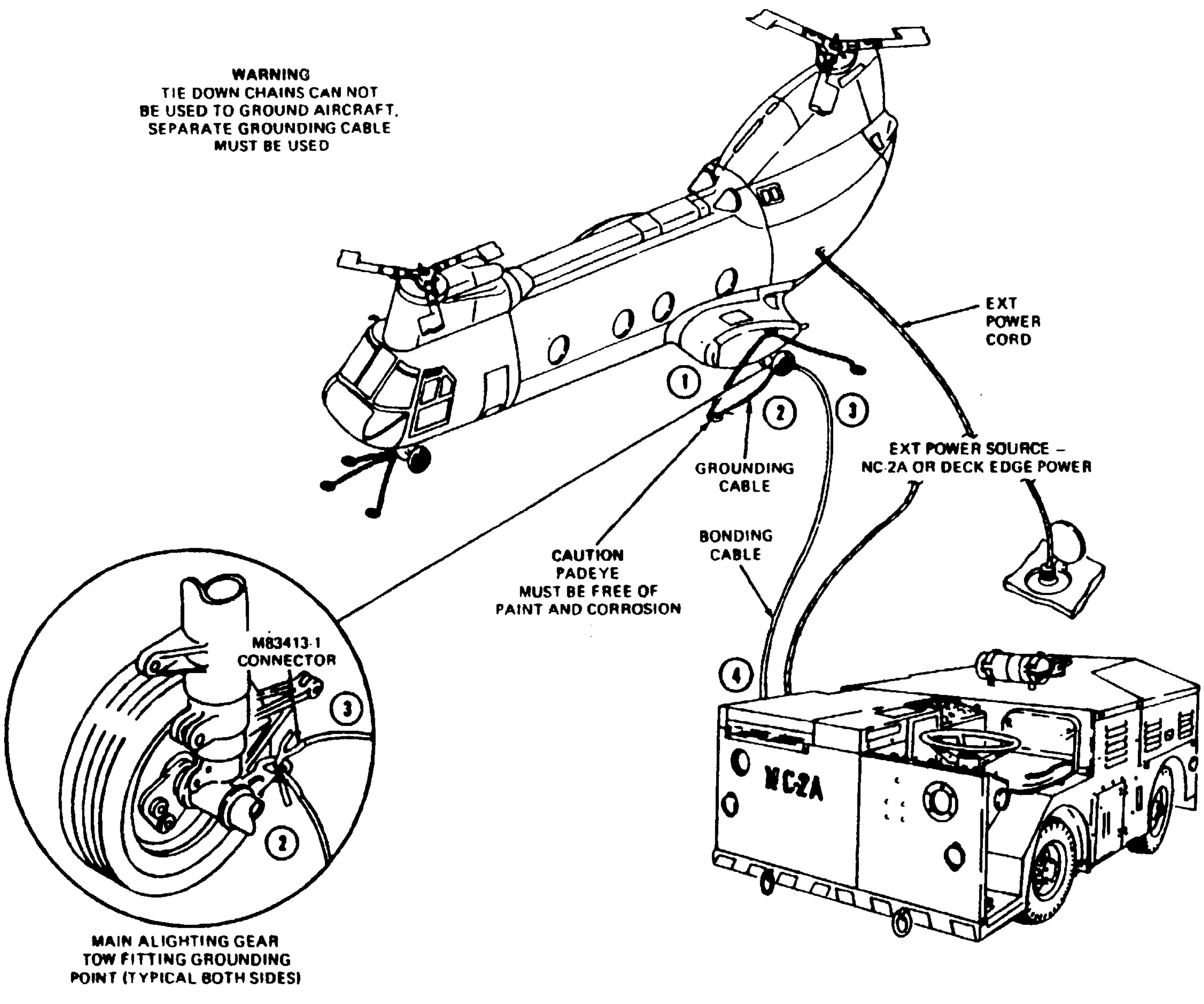


FIGURE 2-140. Carrier-based H-46 aircraft, maintenance evolution.

2.2.32 Carrier-based anti-submarine aircraft (S-3) parked evolution and stores loading/unloading evolution. To ground carrier-based anti-submarine (S-3) aircraft when in the parked evolution and stores loading/unloading evolution, proceed as follows (see figure 2-141):

a. Attach grounding cable with MS3413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with MS3413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.2.33 Carrier-based S-3 fueling/defueling evolution. To ground carrier-based S-3 aircraft when fueling or defueling, proceed as follows (see figure 2-142):

a. Attach grounding cable with MS3413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with MS3413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with MS3413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.34 Carrier-based S-3 maintenance evolution. To ground carrier-based S-3 aircraft when in the maintenance evolution, proceed as follows (see figure 2-143):

a. Attach grounding cable with MS3413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to pylon grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with a MS3413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with MS3413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.35 Carrier-based helicopter aircraft (AH-1, CH-53, H-46, SH-2, SH-3, SH-60) parked evolution and stores loading/unloading evolution. To ground carrier-based

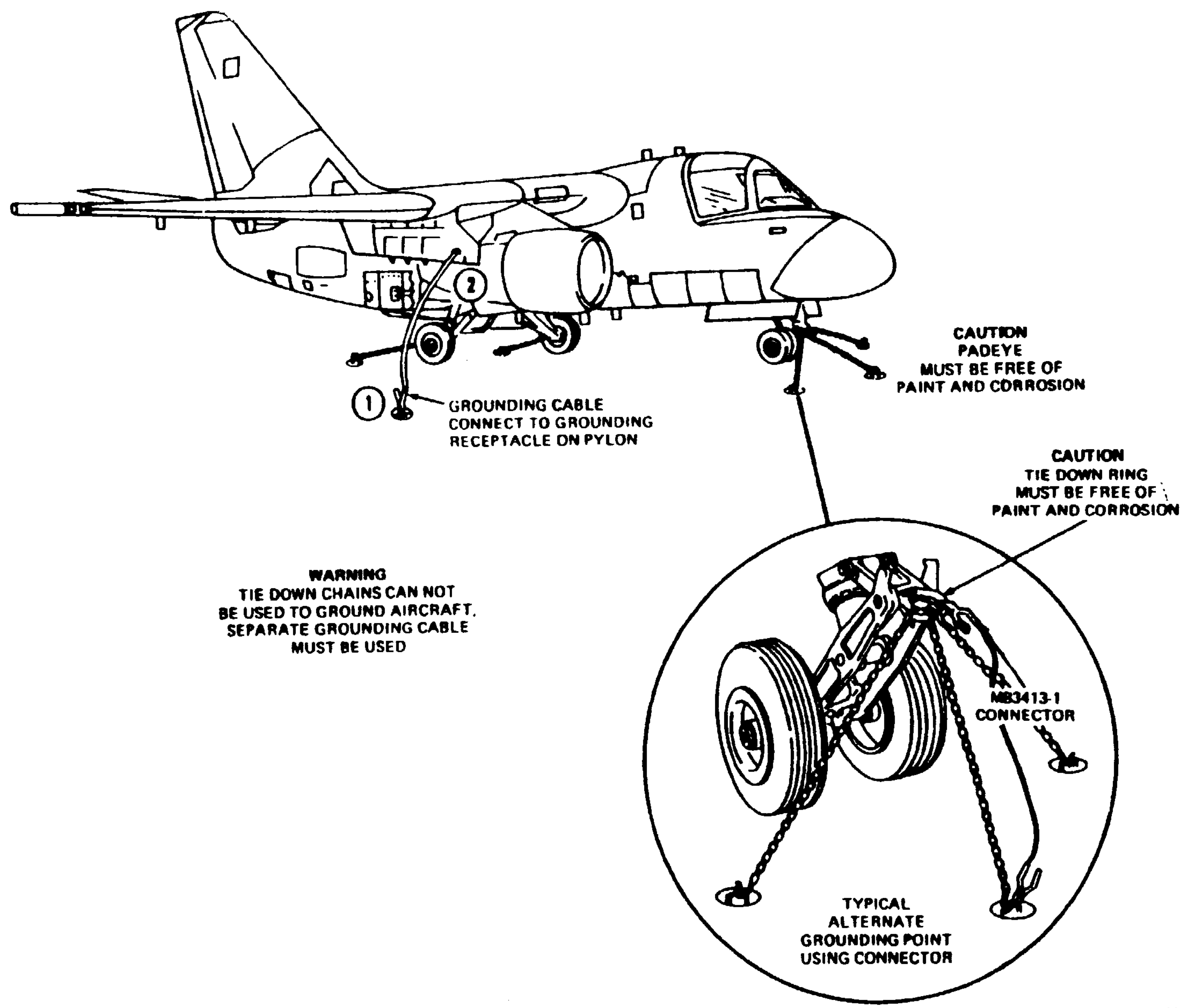


FIGURE 2-141. Carrier-based anti-submarine (S-3) aircraft, parked evolution and stores loading/unloading evolution.

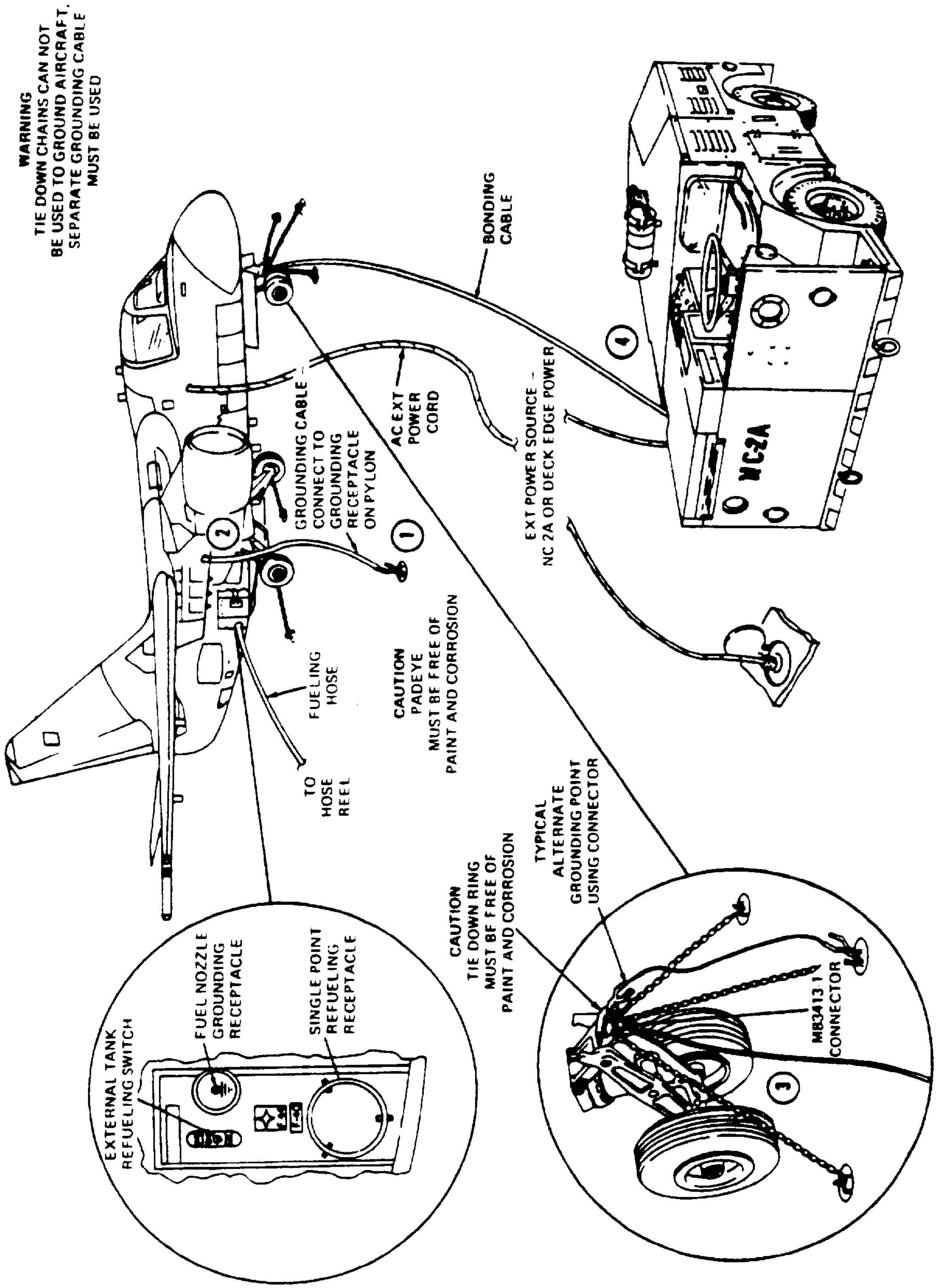


FIGURE 2-142. Carrier-based S-3 aircraft, fueling/defueling evolution.

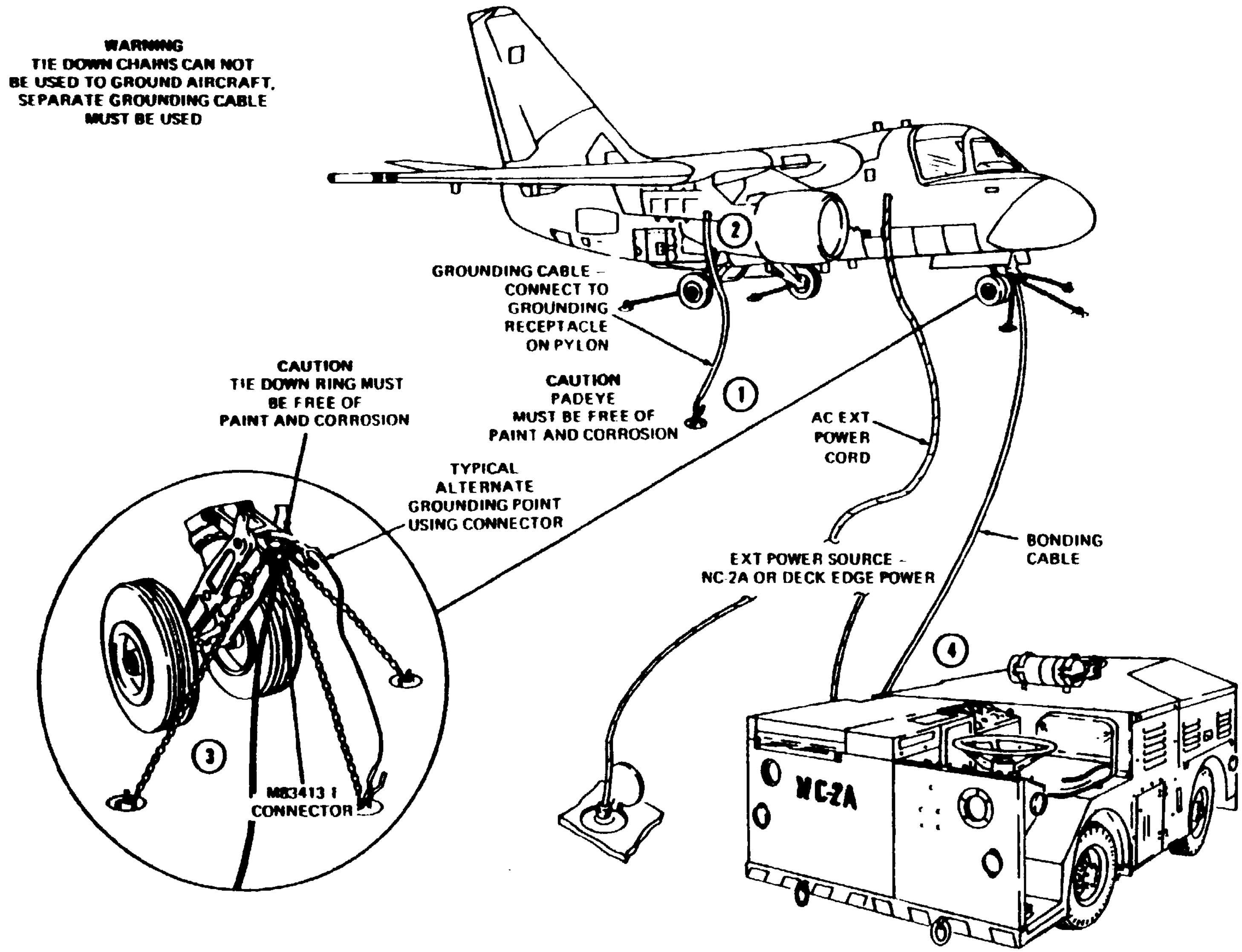


FIGURE 2-143. Carrier-based S-3 aircraft, maintenance evolution.

helicopter aircraft (AH-1, CH-53, H-46, SH-2, SH-3, SH-60) when in the parked evolution and stores loading/unloading evolution, proceed as follows (see figure 2-144):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.2.36 Carrier-based SH-2 fueling/defueling evolution. To ground carrier-based SH-2 aircraft when fueling or defueling, proceed as follows (see figure 2-145):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with a M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.37 Carrier-based SH-2 maintenance evolution. To ground carrier-based SH-2 aircraft when in the maintenance evolution, proceed as follows (see figure 2-146):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to front left fuselage grounding receptacle (2).
c. If grounding receptacle is not accessible, then using a grounding cable with a M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

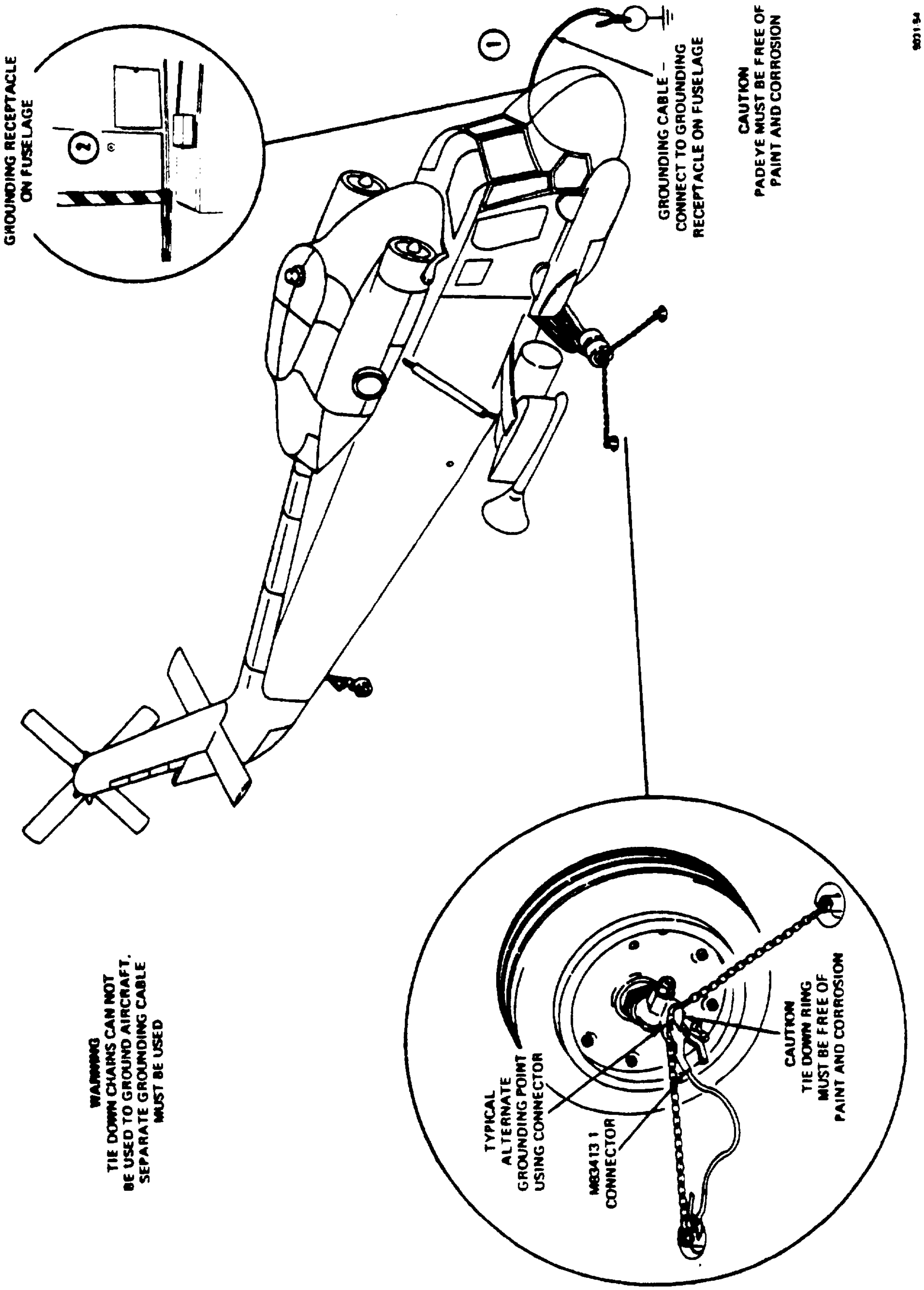


FIGURE 2-144. Carrier-based helicopter (AH-1, CH-53, H-46, SH-2, SH-3, SH-60) aircraft, parked evolution and stores loading/unloading evolution.

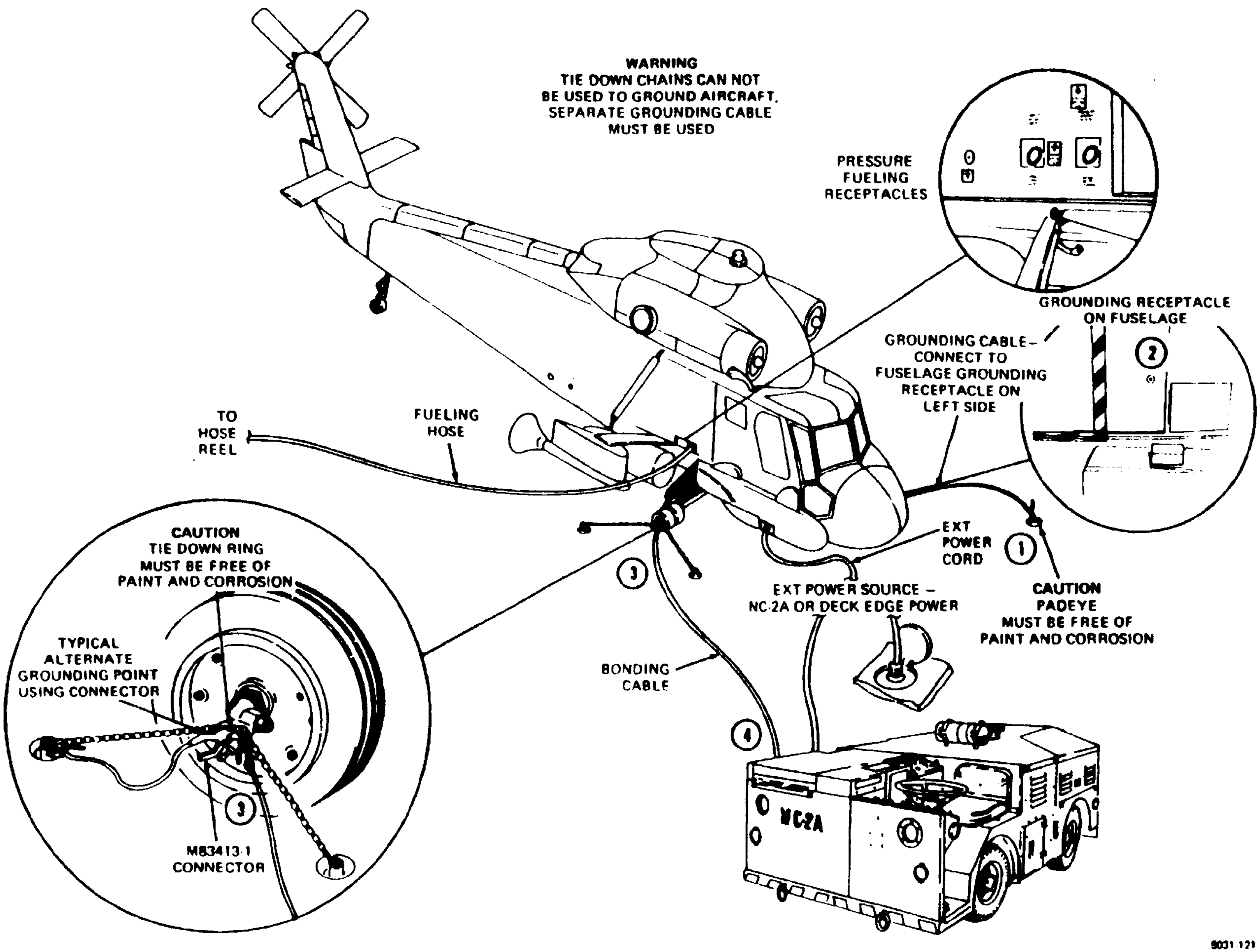


FIGURE 2-145. Carrier-based SH-2 aircraft, fueling/defueling evolution.

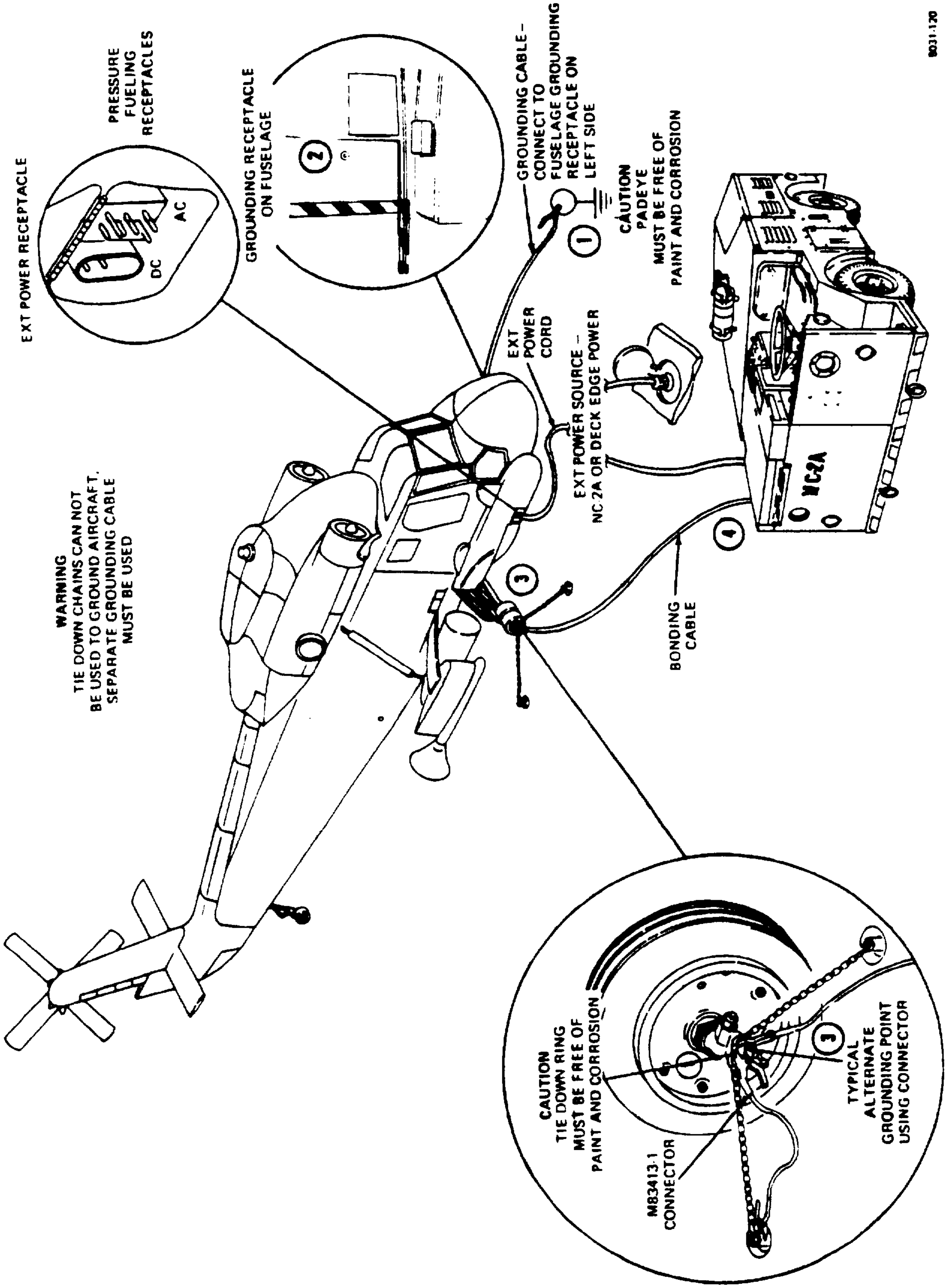


FIGURE 2-146. Carrier-based SH-2 aircraft, maintenance evolution.

2.2.38 Carrier-based SH-3 fueling/defueling evolution. To ground carrier-based SH-3 aircraft when fueling or defueling, proceed as follows (see figure 2-147):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to the static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.39 Carrier-based SH-3 maintenance evolution. To ground carrier-based SH-3 aircraft when in the maintenance evolution, proceed as follows (see figure 2-148):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to the static drag wire bolt (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.40 Carrier-based SH-60 fueling/defueling evolution. To ground carrier-based SH-60 aircraft when fueling or defueling, proceed as follows (see figure 2-149):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.41 Carrier-based SH-60 maintenance evolution. To ground carrier-based SH-60 aircraft when in the maintenance evolution, proceed as follows (see figure 2-150):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).

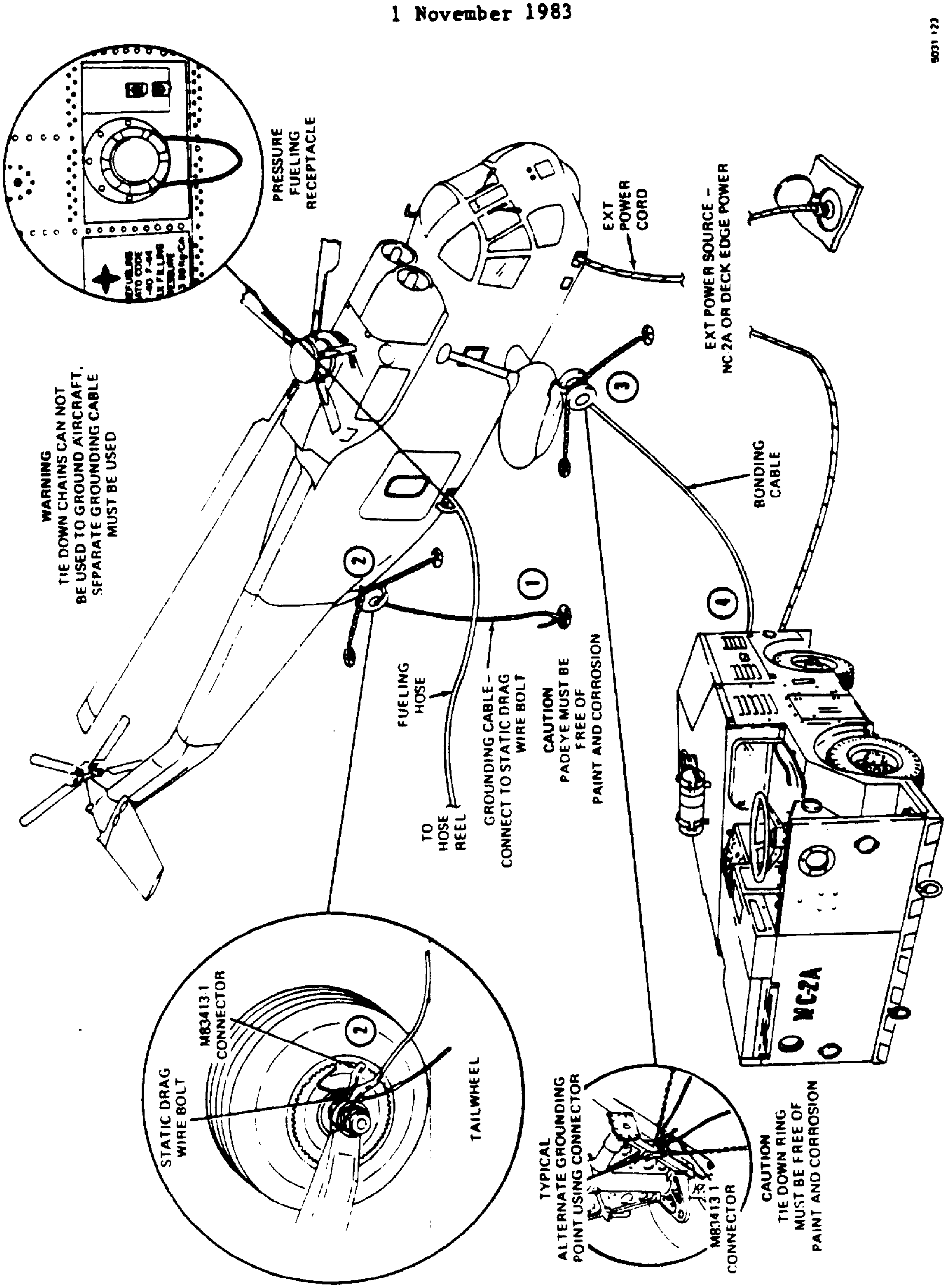


FIGURE 2-147. Carrier-based SH-3 aircraft, fueling/defueling evolution.

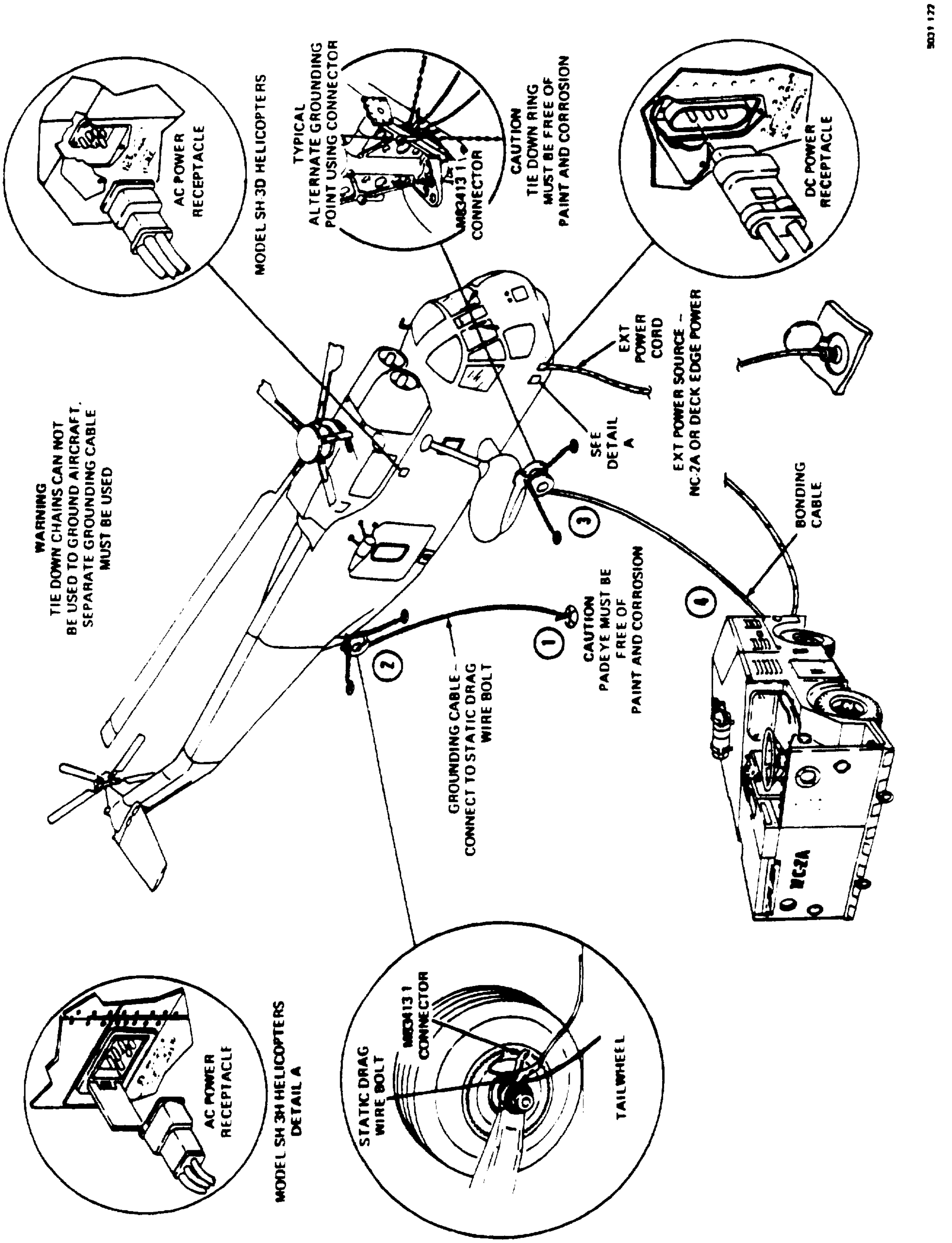


FIGURE 2-148. Carrier-based SH-3 aircraft, maintenance evolution.

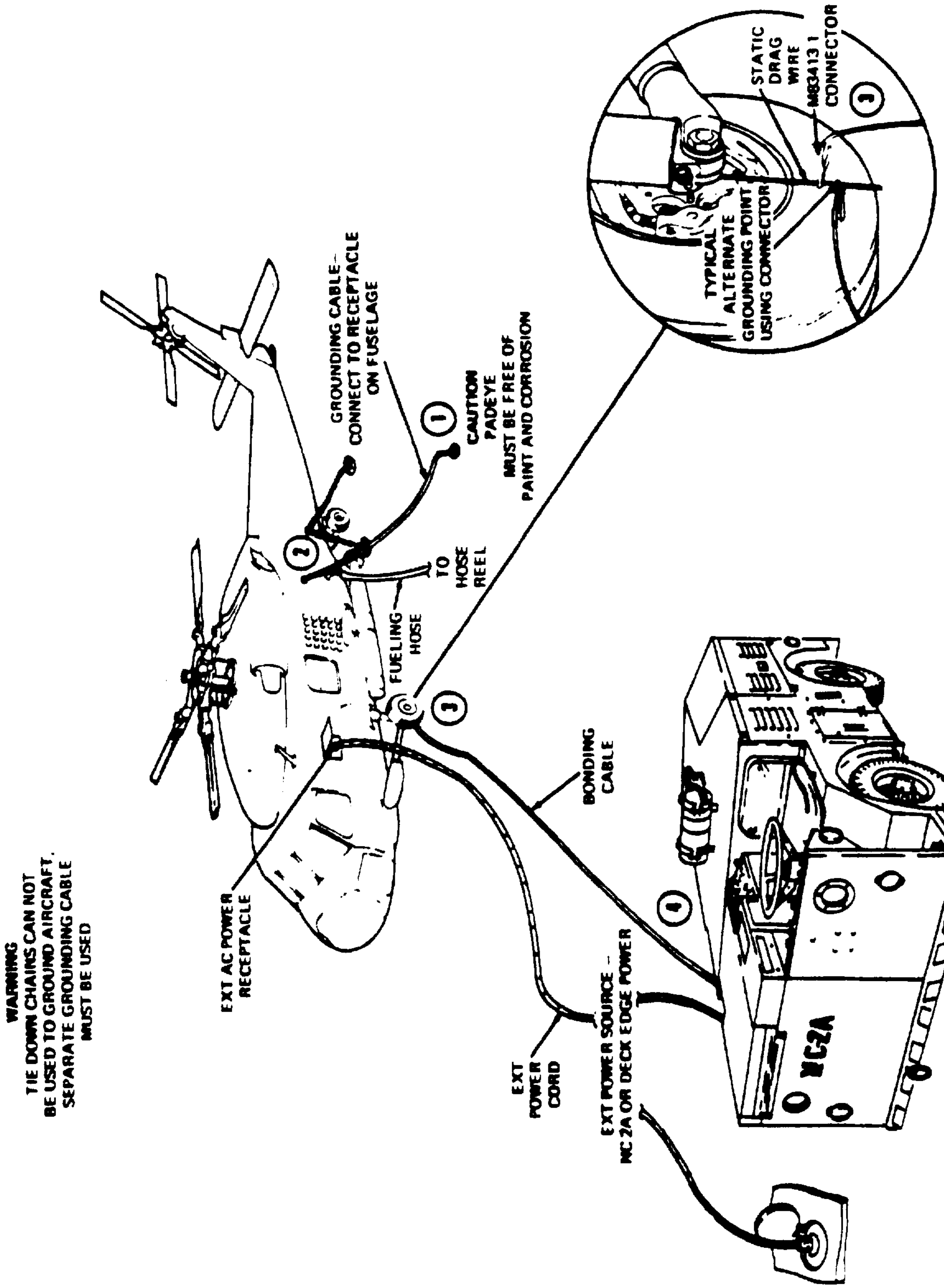


FIGURE 2-149. Carrier-based SH-60 aircraft, fueling/defueling evolution.

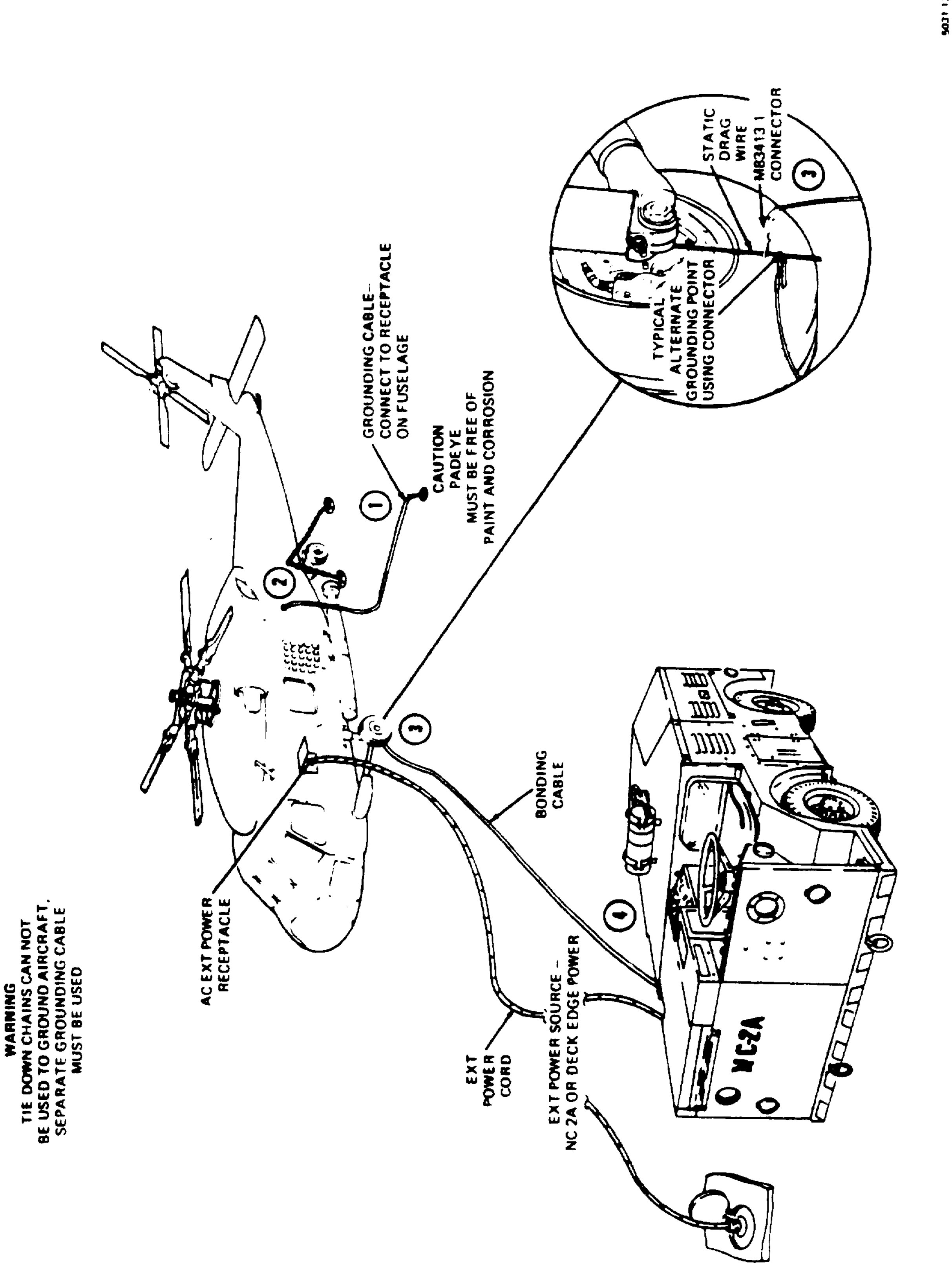


FIGURE 2-150. Carrier-based SH-60 aircraft, maintenance evolution.

b. Connect free end of grounding cable to fuselage grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to static drag wire (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to static drag wire (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.3 Helicopter hovering. The following paragraphs provide step-by-step procedures for static grounding hovering helicopters.

2.3.1 Load transfer evolution. To static ground hovering helicopter during load transfer, proceed as follows (see figure 2-151):

a. Using the helicopter static charge grounding wand, attach M83413-1 connector (clamp) to a certified static ground or padeye (1). If permanent grounds are not available during shore-based operations, drive the grounding wand's associated ground stake 18 inches into the earth and attach connector.
b. Make contact with the helicopter frame or hoist cable using the grounding wand hook (2). This contact must be continuous until hoist cable is ready to be retracted into helicopter.
c. When hoist cable is ready to be retracted, release grounding wand in reverse order of hookup.

2.3.2 Helicopter inflight refueling (HIFR). To ground hovering helicopter during refueling evolution, proceed as follows (see figure 2-152):

a. Using the helicopter static charge grounding wand, attach the M83413-1 connector (clamp) to a certified static ground or padeye (1).
b. Make contact with the helicopter hoist cable using the grounding wand hook (2). This contact must be continuous until hoist cable and fuel hose are connected.
c. Once hoist cable and fuel hose are connected, release grounding wand in reverse order of hookup.

2.3.3 Recovery, assist, secure, and transverse (RAST) system. To ground hovering helicopters (SH-60B) employing the RAST system, proceed as follows (see figure 2-153):

a. Using the helicopter static charge grounding wand, attach the M83413-1 connector (clamp) to a padeye (1).

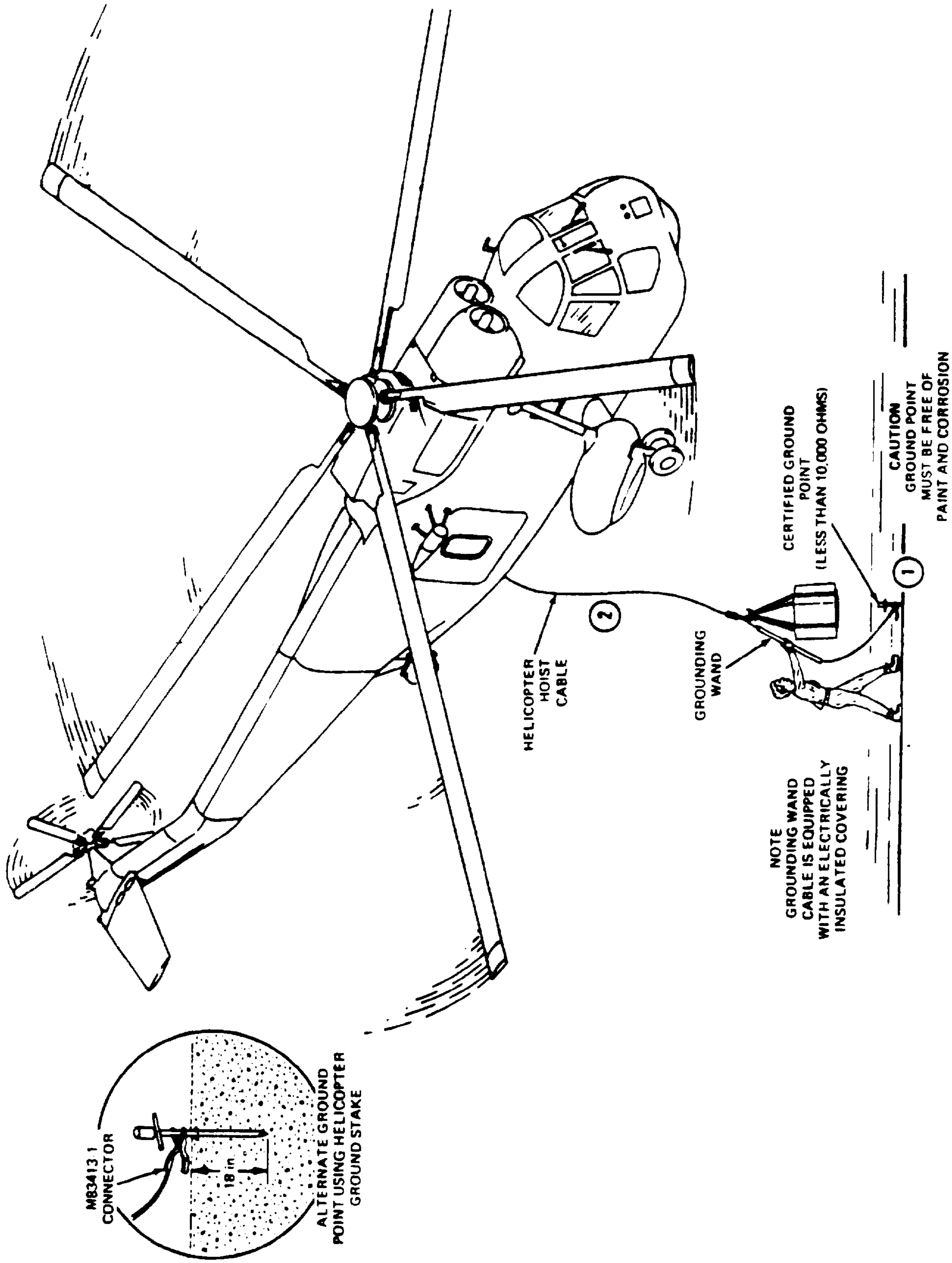


FIGURE 2-151. Static grounding of hovering helicopter during load transfer.

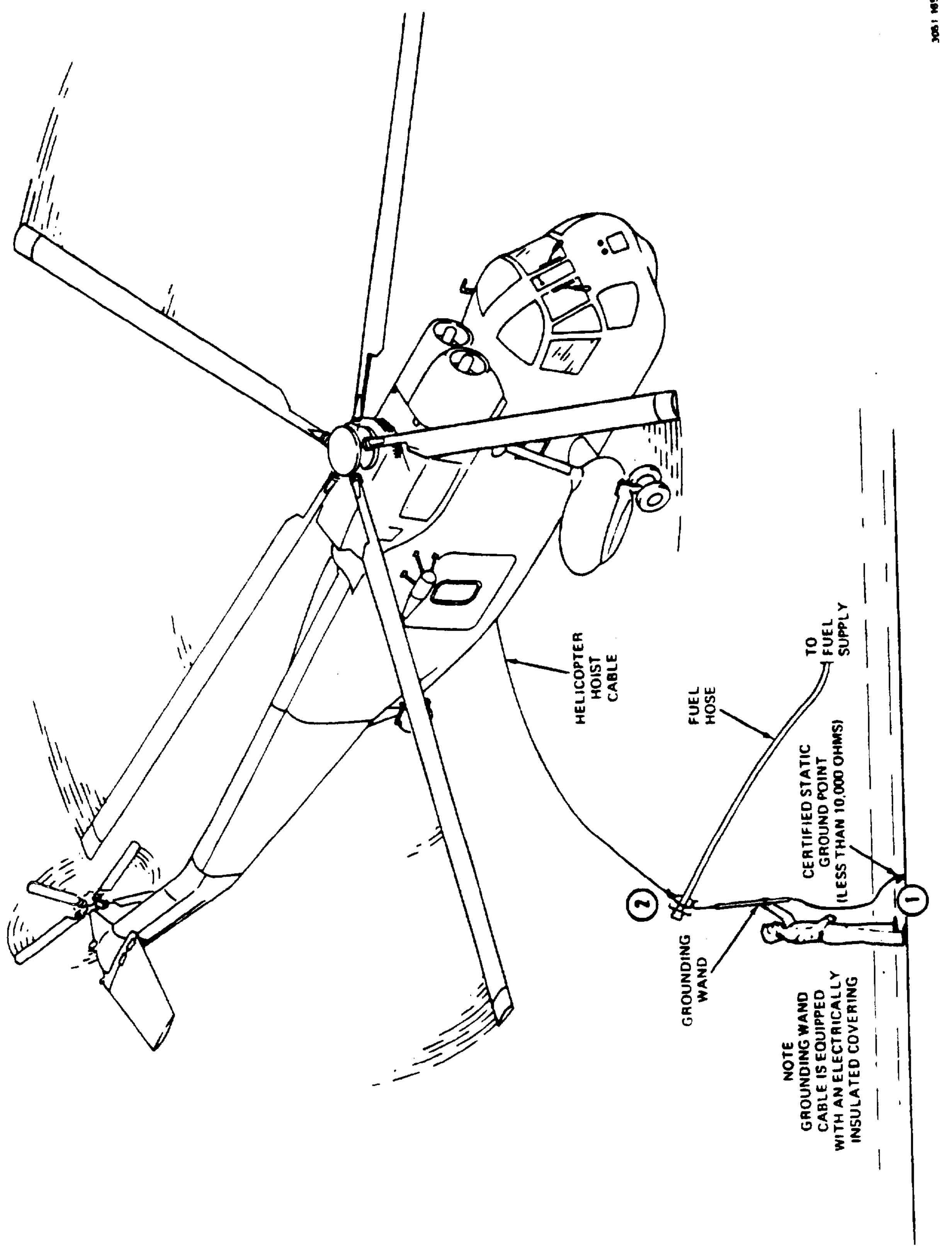


FIGURE 2-152. Static grounding of hovering helicopter during refueling evolution (HIFR).

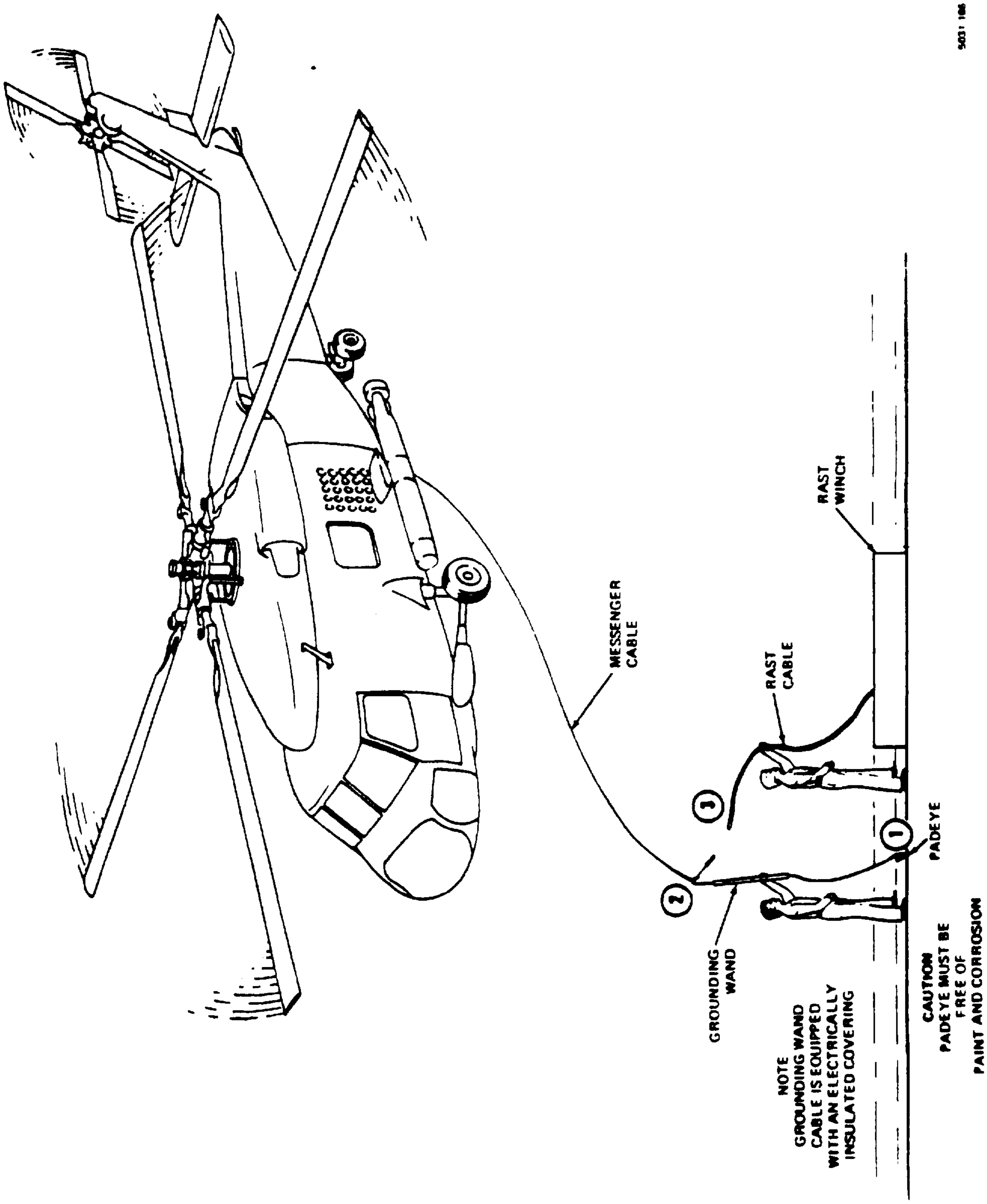


FIGURE 2-153. Grounding hovering helicopters employing RAST system.

b. Make contact with the messenger cable using the grounding wand hook (2). This contact must be continuous until messenger cable probe is secured to the RAST cable (3).
c. Once messenger cable and RAST cable are connected, release grounding wand in reverse order of hookup.

2.4 External electrical power. The following paragraphs provide step-by-step grounding and bonding procedures for a generic type aircraft using various carrier-based and shore-based external electrical power sources. Shipboard deck edge power, FLEDS, and various MEPPS are illustrated. Grounding and bonding procedures for aircraft fueling/defueling operations requiring external electrical power are also included with the A-6 chosen as an example. These procedures are further discussed and amplified in paragraph 3.3. These bonding and grounding procedures must be performed prior to connection of external power cables.

2.4.1 Deck edge power distribution system. To static ground aircraft when using deck edge power, proceed as follows (see figure 2-154):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to an approved grounding point on the aircraft (2).
c. To remove grounding cable, reverse above procedures.

2.4.2 FLEDS. To ground aircraft when powered by FLEDS, proceed as follows (see figure 2-155):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to an approved grounding point on the aircraft (2).
c. Attach cable with M83413-1 connector to an approved grounding or bonding point on the aircraft (3).
d. Connect free end of cable to a bare metal area on the DBA, such as the stud or bolt (4).
e. To remove cables, reverse above procedures.

2.4.3 MMG-1A MEPP. To ground aircraft when using the MMG-1A MEPP, proceed as follows (see figure 2-156):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to an approved grounding point on the aircraft (2).
c. Attach bonding cable with M83413-1 connector to an approved grounding or bonding point on the aircraft (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove cables, reverse above procedures.

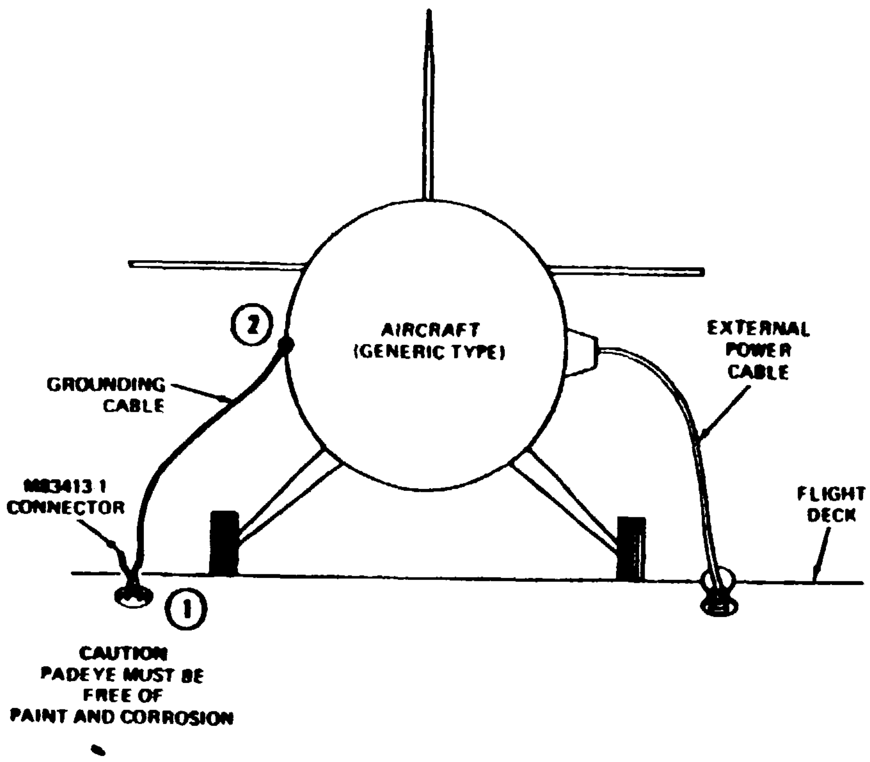


FIGURE 2-154. Carrier-based aircraft grounding when using deck edge power.

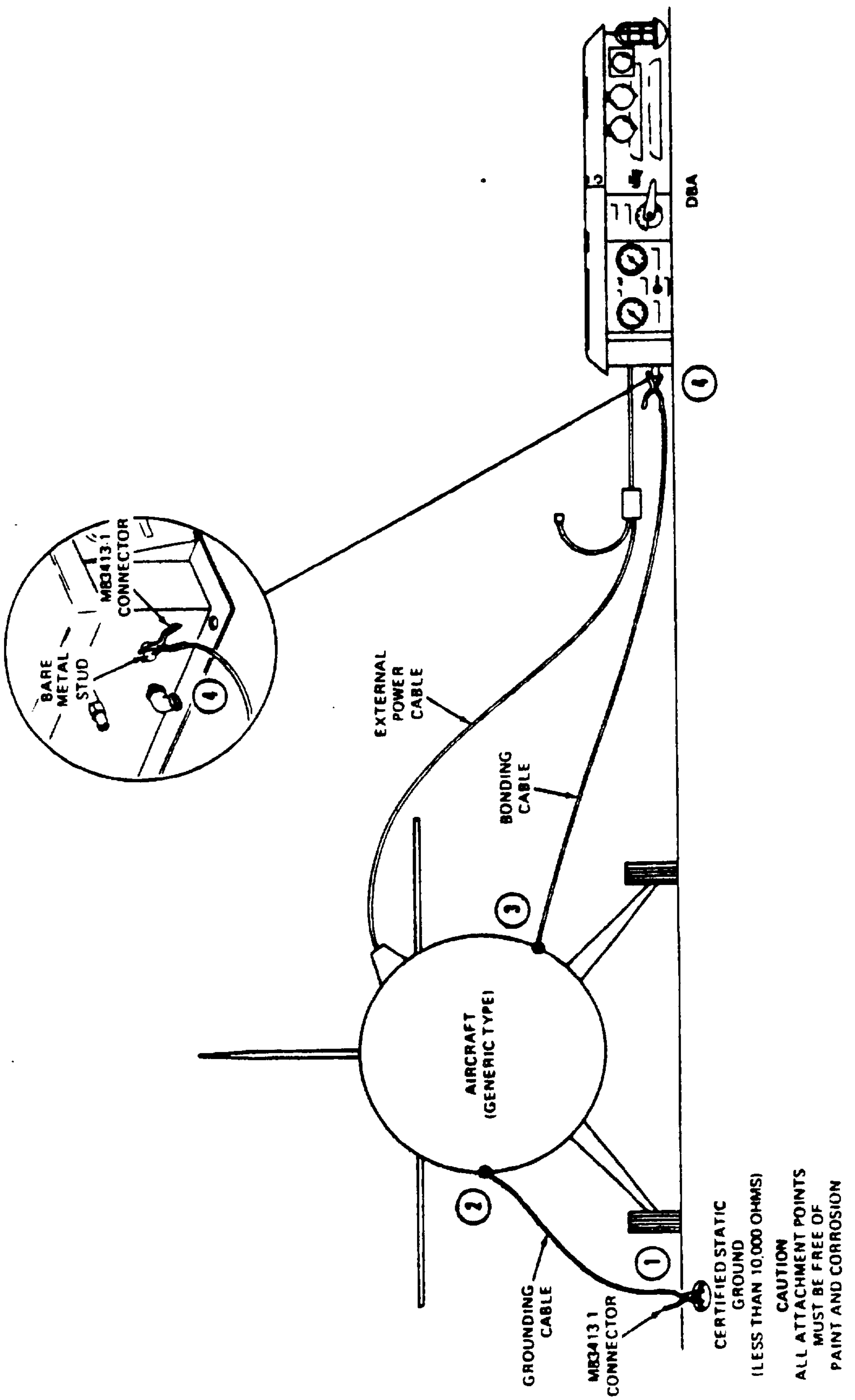


FIGURE 2-155. Apron-based aircraft grounding when using FLEDS.

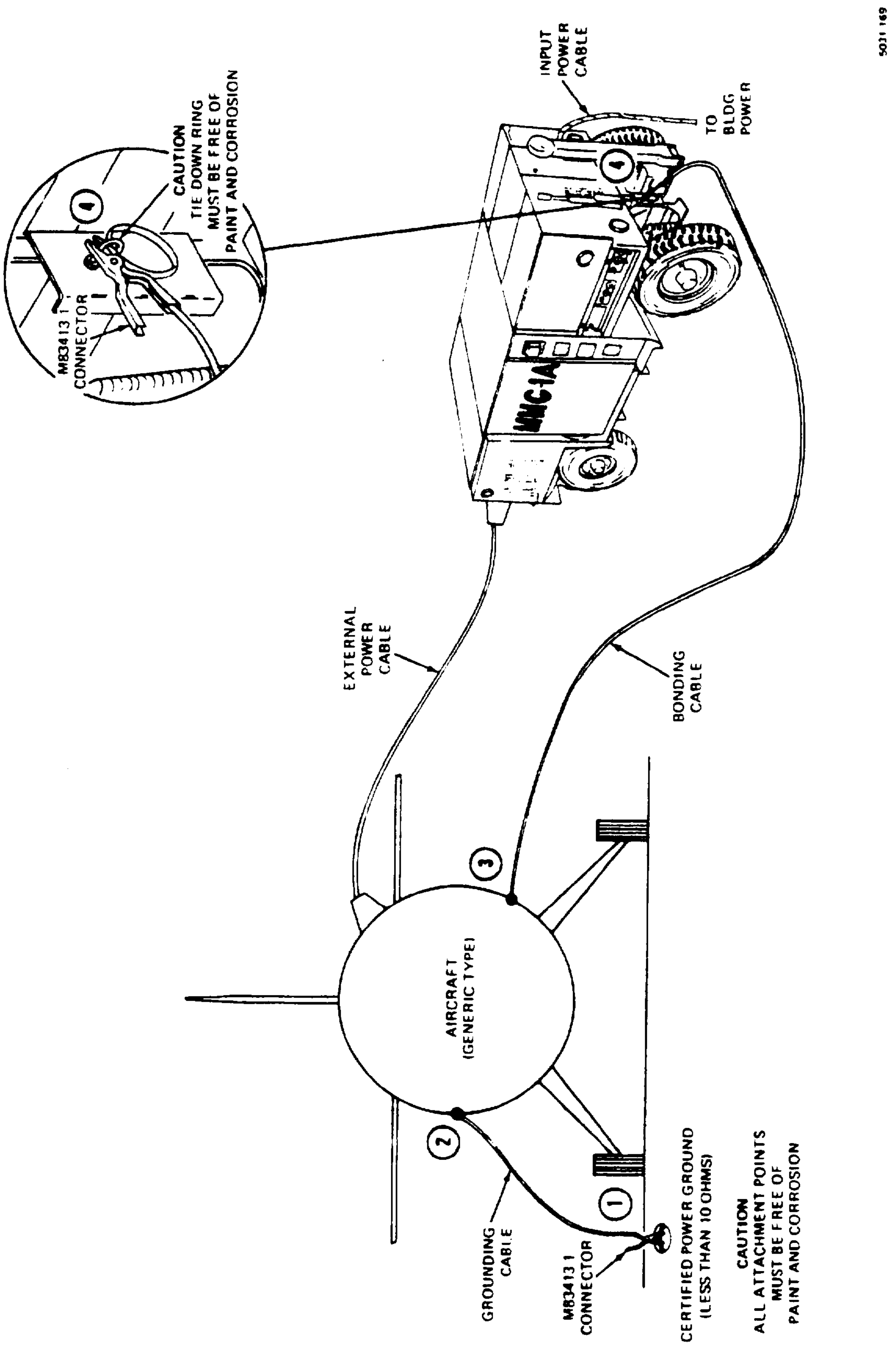


FIGURE 2-156. Hangar-based aircraft grounding when using MMG-1A MEPP.

2.4.4 NC-2A MEPP. To ground aircraft when using the NC-2A MEPP, proceed as follows (see figure 2-157):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to an approved grounding point on the aircraft (2).

NOTE: The following bonding procedure is not required for aircraft that use 28 vdc power only.

c. Attach bonding cable with M83413-1 connector to an approved grounding or bonding point on the aircraft (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove cables, reverse above procedures.

2.4.5 NC-8A MEPP. To ground aircraft when using the NC-8A MEPP, proceed as follows (see figure 2-158):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to an approved grounding point on the aircraft (2).

NOTE: The following bonding procedure is not required for aircraft that use 28 vdc power only.

c. Attach bonding cable with M83413-1 connector to an approved grounding or bonding point on the aircraft (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove cables, reverse above procedures.

2.4.6 NC-10C MEPP. To ground aircraft when using the NC-10C MEPP, proceed as follows (see figure 2-159):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to an approved grounding point on the aircraft (2).

NOTE: The following bonding procedure is not required for aircraft that use 28 vdc power only.

c. Attach bonding cable with M83413-1 connector to an approved grounding or bonding point on the aircraft (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove cables, reverse above procedures.

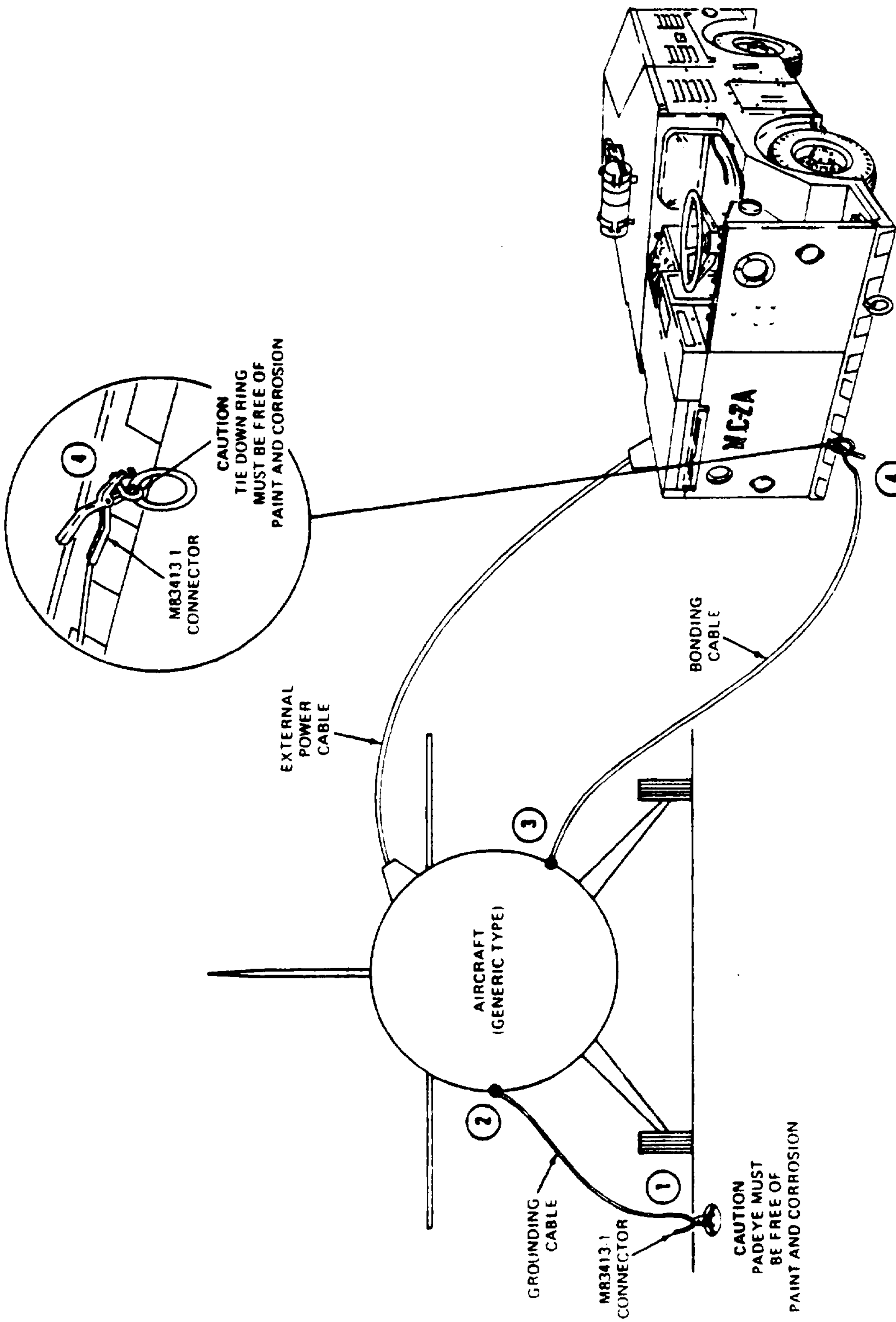


FIGURE 2-157. Carrier-based aircraft grounding when using MC-2A MEPP.

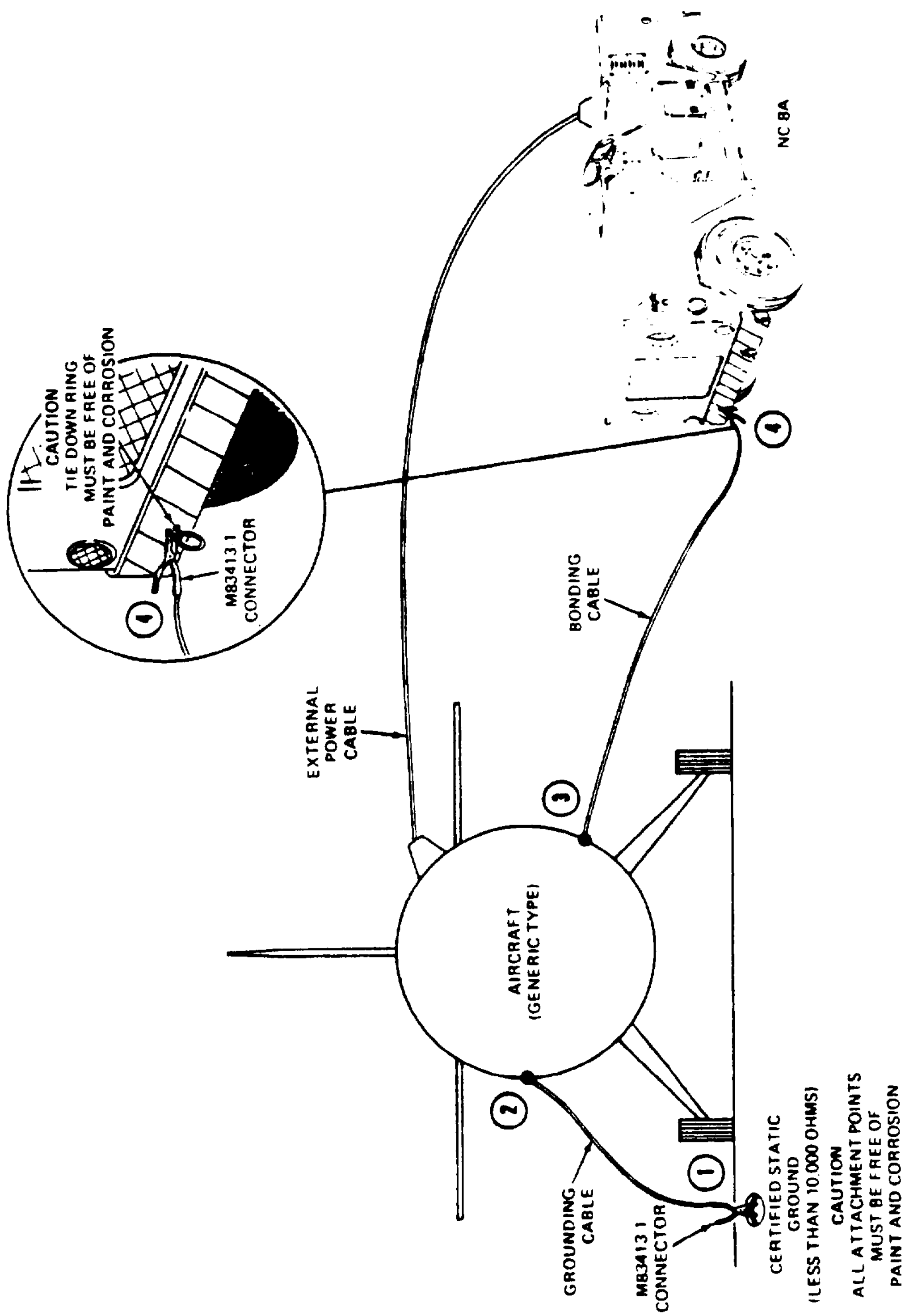


FIGURE 2-158. Apron-based aircraft grounding when using NC-8A MEPP.

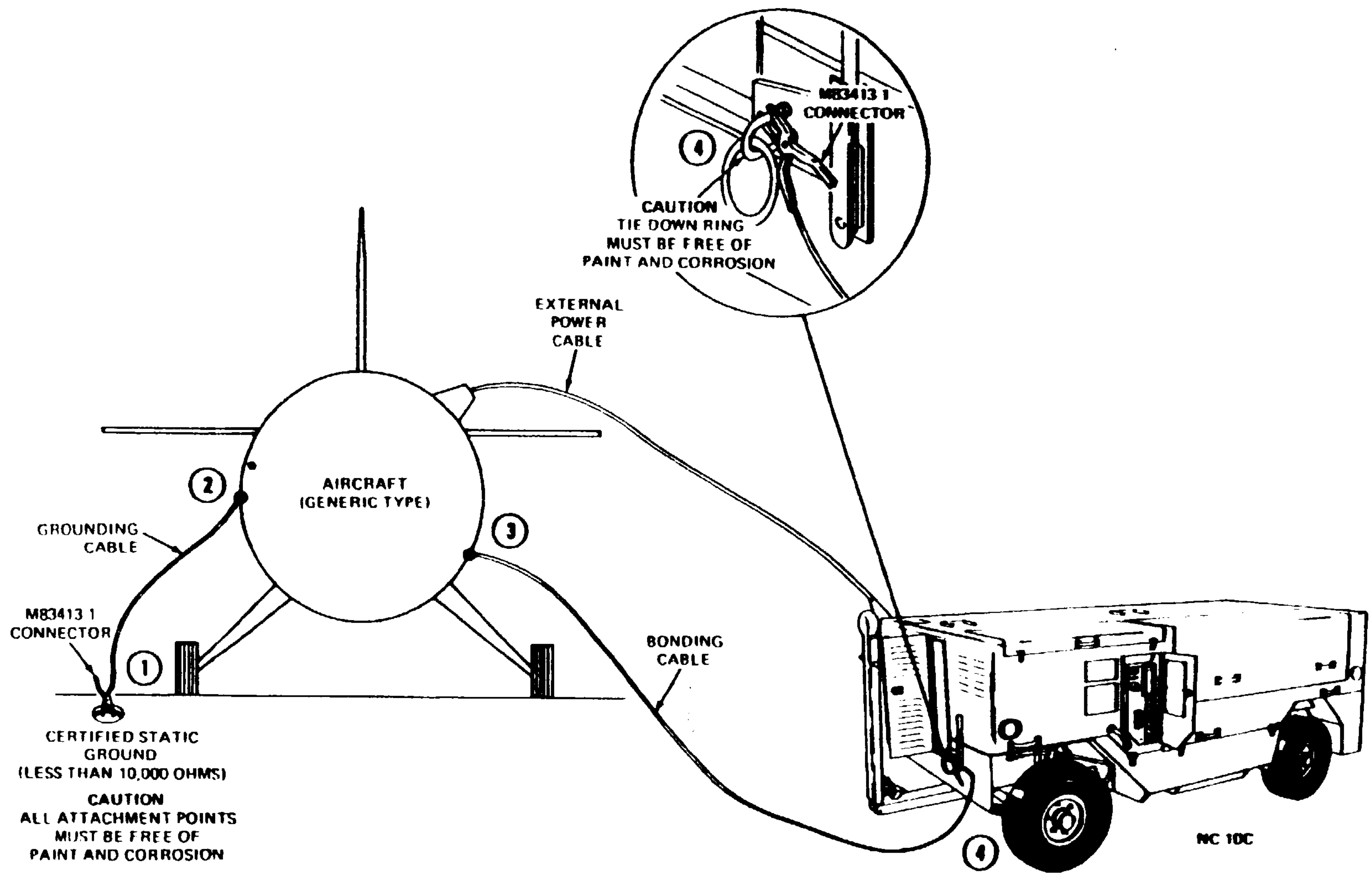


FIGURE 2-159. Apron-based aircraft grounding when using NC-10C MEPP.

2.5 Aircraft fueling when using external electrical power (A-6). The following paragraphs describe the procedures required to ground A-6 aircraft in the fueling evolution using external electrical power.

2.5.1 Aircraft powered by diesel engine driven NC-2A, NC-8A, or NC-10C MEPP sources (see figure 2-160).

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to the main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to nose gear tiedown ring (4).
e. Attach fuel nozzle ground connector to nose gear tiedown ring (5).
f. Attach external power source bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (6).
g. Connect free end of bonding cable to a bare metal area on the external electrical power source (7).
h. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
i. To remove grounding or bonding cable, reverse above procedures.

2.5.2 Aircraft powered by a MMG-1A power source which is powered by 60 Hz ground neutral power (see figure 2-161).

NOTE: Aircraft must be grounded to a certified power ground of less than 10 ohms.

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to the main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a power ground (3).
d. Connect fuel truck bonding cable to nose gear tiedown ring (4).
e. Attach fuel nozzle ground connector to nose gear tiedown ring (5).
f. Attach external power source bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (6).
g. Connect free end of bonding cable to a bare metal area on the external electrical power source (7).
h. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
i. To remove grounding or bonding cable, reverse above procedures.

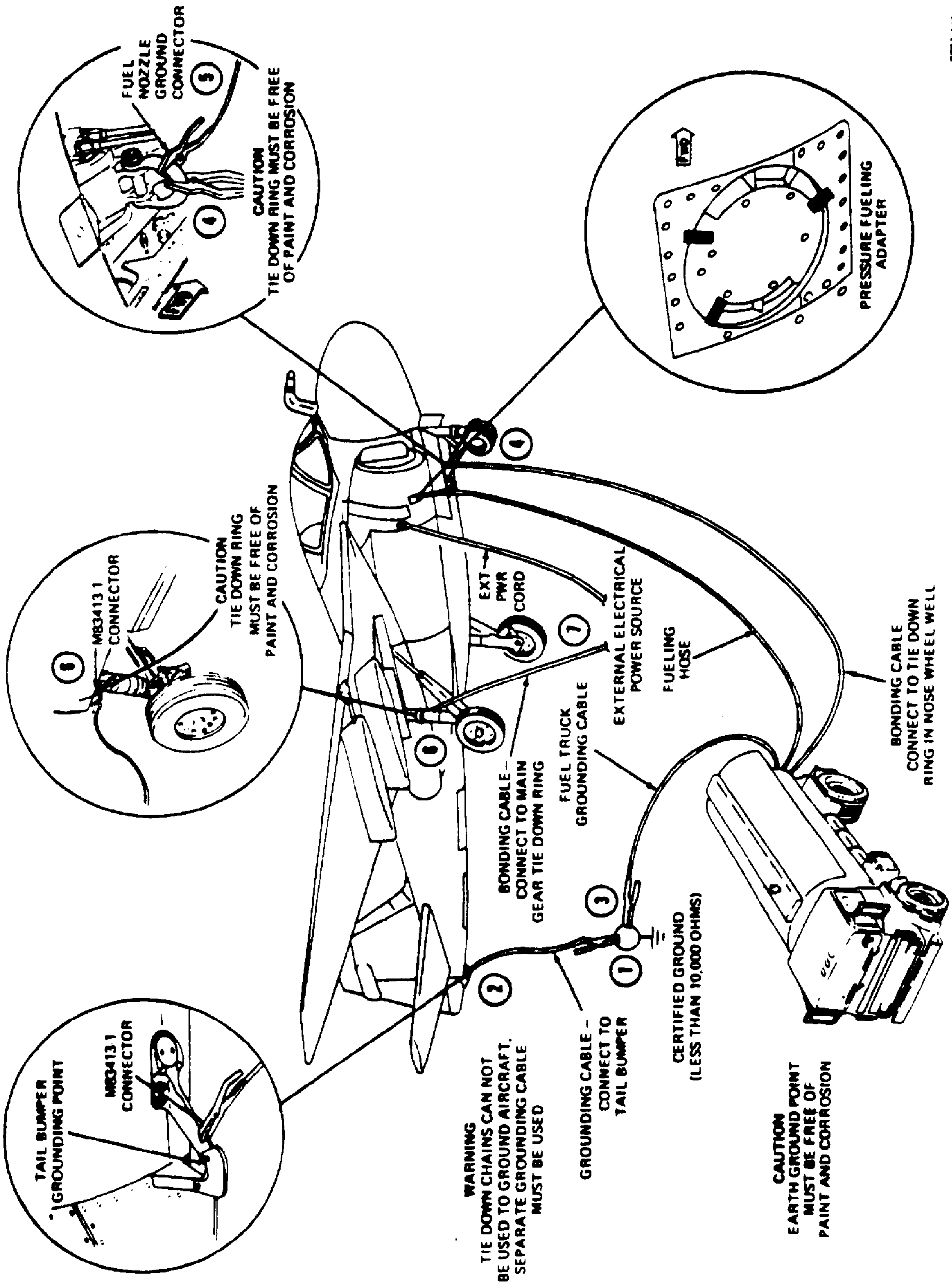


FIGURE 2-160. A-6 aircraft grounding during fueling/defueling with external power supplied by a diesel engine driven MEPP (MC-2A, MC-8A, or MC-10C).

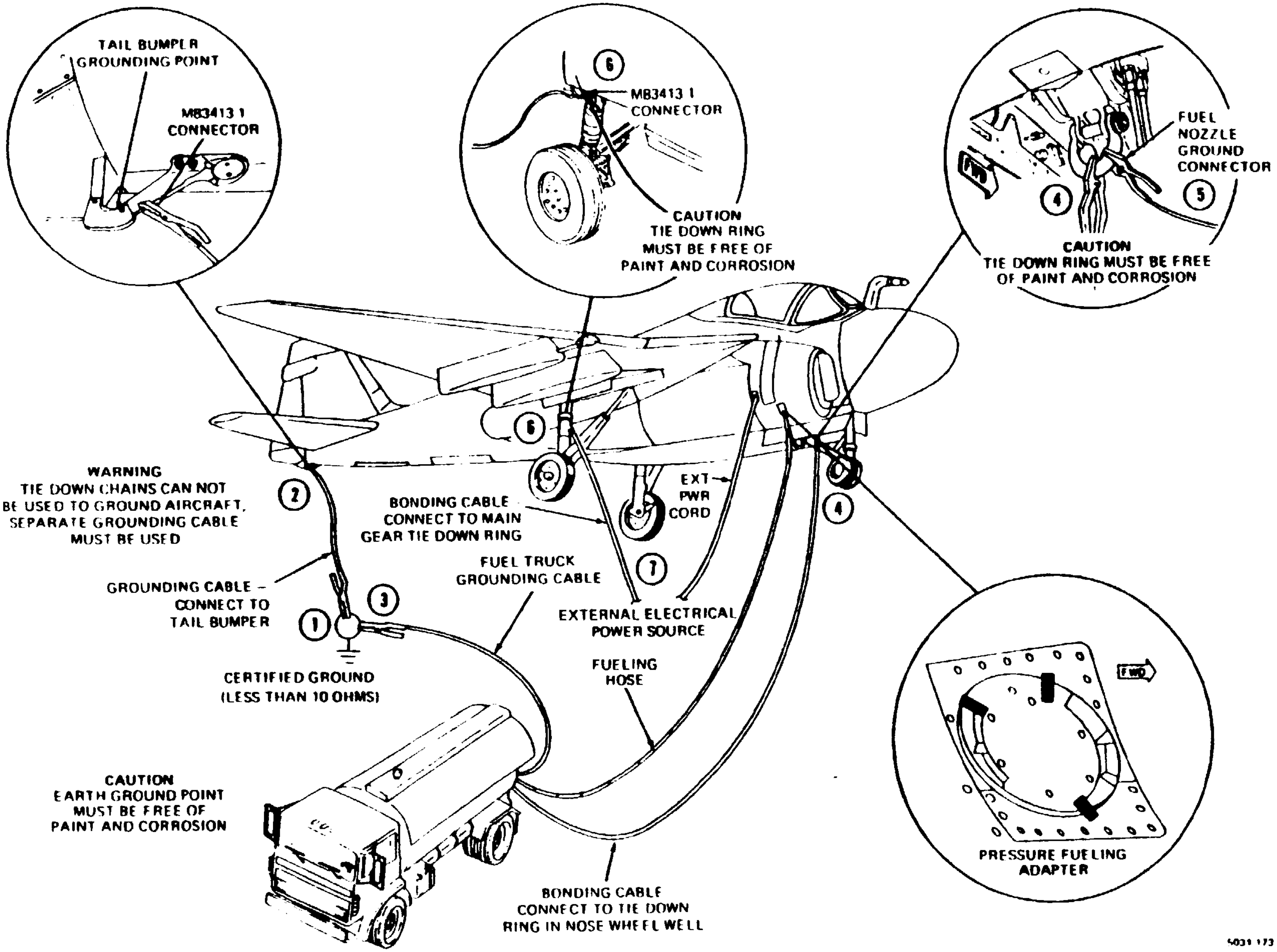


FIGURE 2-161. A-6 aircraft grounding during fueling/defueling with external power supplied by an electric motor driven MEPP (MMG-1A).

2.5.3 Aircraft powered by FLEDS. To ground aircraft in the fueling evolution when using external power, proceed as follows (see figure 2-162):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground (1).
b. Connect free end of grounding cable to aircraft grounding point (2). If this location is not accessible, then connect grounding cable to the main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to nose gear tiedown ring (4).
e. Attach fuel nozzle ground connector to nose gear tiedown ring (5).
f. Attach external power source bonding cable with M83413-1 electrical ground connector to aircraft grounding point (6).
g. Connect free end of bonding cable to a bare metal area on the external electrical power source (DBA) (7).
h. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
i. To remove grounding or bonding cable, reverse above procedures.

2.5.4 Aircraft powered by deck edge power source. For grounding aircraft under deck edge power refer to paragraph 2.2.

2.6 Hot fueling. Since aircraft engines are operating during hot fueling operations, additional external power is not required. The fueling evolutions described in paragraph 2.1 are applicable to hot fueling from trucks. Shipboard hot fueling procedures are similar to those described in paragraph 2.2, except external power sources are not connected.

2.6.1 Hydrant fueling. Fueling from hydrants requires static grounding. If ground points are not available at the hydrant stations, then static grounding must be accomplished by bonding the airframe to the hydrant ground cable. Grounding and bonding procedures and sequences are identical to the fueling evolutions depicted in paragraph 2.1.

2.6.2 Bladder fueling. Fueling from bladders requires static grounding of aircraft. For hot refueling from a bladder, the aircraft must be bonded to the external fuel pump ground stake. Grounding and bonding procedures and sequences are identical to the fueling evolutions depicted in paragraph 2.1.

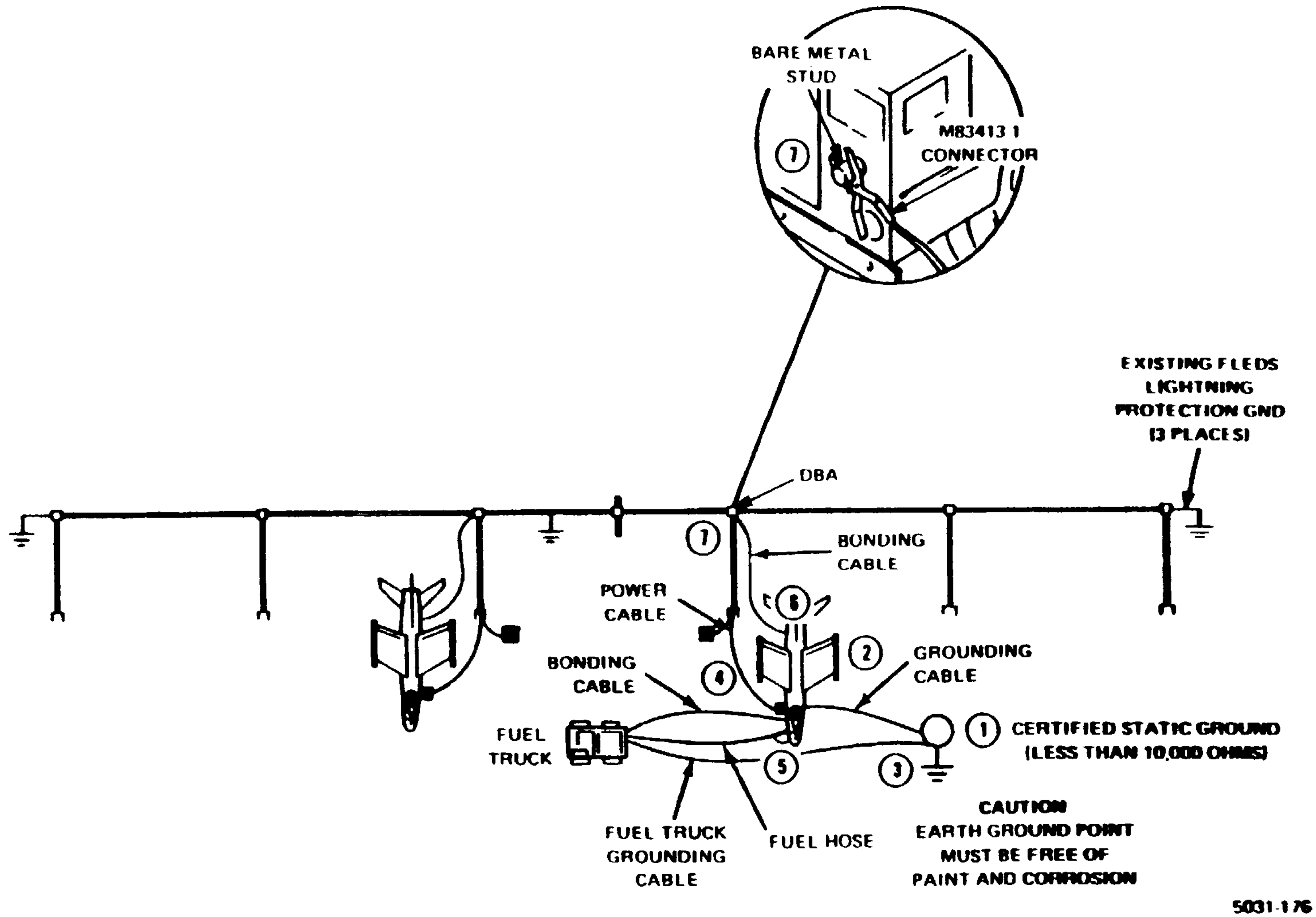


FIGURE 2-162. Aircraft grounding during fueling/defueling with external power supplied by FLEDS.

SECTION 3

3.0 OPERATIONAL GROUNDING CONCERNS

This section provides personnel with the necessary information to understand the need for grounding and bonding. This section discusses the grounding problems and hazards encountered in everyday ground handling of aircraft during flight operations. Descriptions are given of static electricity, energy sources, and grounding effects. Various aircraft scenarios are presented that involve safety-related servicing situations, together with the approved methods of handling such problems.

3.1 Static electricity. This is defined as ''electricity at rest,'' and consists of electrical charges (positive and negative) that are usually kept apart by insulators. Although flow and accumulation are small (in the range of only thousandths of an ampere), voltages may rise to many thousands. A well-known example of static electricity is the discharge (sparking) of an accumulated charge built up on a person who has walked on a carpet in a dry room, and touches a metal door handle or radiator.

3.1.1 Materials are composed of atoms, which include electrons and protons. An electron is a particle of negative charge, and a proton is a particle of positive charge. Normally, in any given material, the electrons and protons are balanced, so that there is no net electrical charge. However, if the material is subjected to some form of friction, some of the electrons will break away from their atoms, leaving the material with a positive charge due to an excess of protons. In other situations, a substance or person may be left with an excess of electrons, and have a negative charge. Either of these unbalanced conditions gives rise to the existence of a static electrical charge in the material or person involved.

3.1.2 The process by which a neutral atom becomes positively or negatively charged through removal or addition of electrons is called ionization. When ionization is completed, the charged atom (called an ion) has an electrostatic field surrounding it. This electrostatic field is comparable to the magnetic field that exists around a magnetic pole. A large accumulation of positive or negative ions creates a strong electrostatic field, an effect that may be seen in a dry room when a comb is passed quickly through a person's hair. The comb accumulates certain charges, leaving the hair depleted of those charges. The electrostatic field created around the strands of hair causes the hair to ''stand on end.''

3.1.3 The accumulation of static electricity creates potentials ranging from a few volts to thousands of volts. If two charged bodies are brought to within a distance shorter than needed for breakdown of the air between them, a discharge will result, similar to what occurs in lightning. In the case of lightning, the clouds become highly charged to the point that there is enough voltage buildup to cause a discharge, either from cloud to ground, or from one cloud to another, whichever is closer.

3.1.4 In the earlier cases of the person walking on the carpet, and the comb passing through hair, emphasis had been placed on a dry atmosphere. Had room humidity been high, the accumulation of water particles would have provided a path for the negative charges to travel to the positively charged material, and thus prevented buildup of excessive electrostatic voltages.

3.1.5 Now that there is some understanding of static electricity and how it comes about, how seriously should it be taken? The following excerpt from NAVSEA OP5, Volume 1 summarizes this matter:

> ''...Failure to take all known precautions to avoid the accumulation of charges of static electricity or to safely dissipate such charges may result in disaster. The generation of static electricity cannot be prevented entirely. Its generation is not in itself a hazard provided it can be dissipated safely. The hazard is encountered when charges accumulate to the extent that a spark discharge occurs to some other object in the presence of hazardous atmospheres, dusts, or exposed sensitive explosives. Elimination of such potential hazards, therefore, requires proper grounding or neutralization of the charges to avoid dangerous accumulations.''

3.2 Energy sources. Evaluation of a situation's potential hazards is based on the source mechanism and the source magnitude of the electrical energy. With operations involving aircraft such as stores handling, maintenance, fueling, and aircraft parking, the following energy sources must be considered:

a. Static
   - Triboelectric
   - Induced
   - Friction

b. Power
   - Ground Fault
   - RF Electromagnetic Energy
   - Lightning

3.2.1 Static energy sources. The static sources listed above are defined and evaluated in the following paragraphs.

3.2.1.1 Triboelectric effects. These are generally associated with buildup of static charges on an aircraft in flight. High static voltages, however, can result from interaction at the contact surfaces of various materials in any type of relative motion, eg, wind-blown snow, or dust particles striking a parked aircraft. A conservative estimate of electrical current in a moderate wind-blown dust situation is 30 microamperes. This type of static electricity is also called precipitation static or p-static. Connecting the aircraft frame to an approved static ground point provides a conductive path back to ground for the static charges as they are generated. A static ground point is defined as a ground point having less than 10,000 ohms impedance to earth.

3.2.1.1.1 A helicopter exemplifies triboelectric effects. Static voltages of up to 1000V are normally generated by a hovering helicopter. In exceptional weather conditions, charges up to 1,000,000V have been recorded.

3.2.1.1.2 Personnel must use extreme care when approaching a hovering aircraft. Strict observance of the prescribed aircraft manual procedure will prevent the serious injury certain to occur if the aircraft is touched prior to grounding.

3.2.1.2 Induced static charges. Paragraph 3.1.2 described the basic manner in which static electricity and electrostatic fields are generated. An example given was that of passing a comb through one's hair, causing the hair to ''stand on end.'' On a much larger scale, during storm activity, clouds become negatively charged and create a powerful electrostatic field. As a highly charged cloud passes over a parked aircraft, the electrostatic field causes the aircraft to become positively charged. The positive charges are conducted from the ground, up through the tires, building up charges of up to 60,000V on the aircraft. These are called induced charges. If the storm cloud loses its negative charge, either by a lightning discharge to another cloud or to some spot on the ground, or even if the storm cloud merely moves on, the electrostatic force of the negative charge holding the positive charge on the aircraft disappears. The positive charge on the aircraft will now return to ground via the tires. Should the tire resistance be high, the discharge time may be long. Should a person touch the aircraft and provide an alternate path to ground, the person will receive a shock which normally may do no more harm than to cause loss of balance, with perhaps a fall to the ground. However, on rare occasions the shock could be serious. If the person has been in contact with the aircraft throughout the charging period, ie, as the charged cloud moves slowly overhead, the person will probably feel no effect. If the cloud above suddenly discharges to another cloud, the charged aircraft immediately discharges back to ground via whatever path is available, which includes the person touching the aircraft. The person will now probably feel a sharp shock, the severity of which depends on the extent to which the aircraft was originally charged. It can be seen that if the aircraft were connected to a static ground point (less than 10,000 ohms), the positive charge would take this path of least resistance back to ground and thus provide protection to personnel working about the aircraft.

3.2.1.3 Friction. Static electricity is generated when certain materials rub together. During such close moving contact between two materials, one of the materials is depleted of electrons, causing a surplus in the second. The magnitude of the static electrical charge thus produced depends on the materials involved and on the amount of humidity present during such friction. With synthetic materials (such as nylon) undergoing friction in a cold dry climate, the effect is greater. Voltages as high as 27,000V have in some instances been recorded. Because of hazards presented by such high charges, personnel subjected to such conditions must bring themselves to the same voltage potential as the aircraft and weapon system. Since the risk of generating static electricity is increased in dry atmosphere, such risk is decreased in a damp, highly humid atmosphere which inhibits the accumulation of static electrical charges. Moisture in the air or on the skin provides a conductive path for the positive and negative charges to be rejoined, neutralizing the static charges. To further protect against the effects of friction, it is essential that the aircraft be grounded.

3.2.1.3.1 Static electrical charges are generated on clothing by friction, especially by the action of removing garments. Since clothing is largely of synthetic material, which amplifies the effects of friction, personnel should exercise extreme caution in areas where hazardous conditions may be present. The removal of clothing therefore, should be prohibited, especially in dry climates, during fueling and ordnance operations. The buildup of static electrical charges can be minimized by use of cotton clothing and antistatic powders.

3.2.1.3.2 The friction generated in fueling an aircraft, with passage of fuel from the supply vehicle through the fueling hose to the aircraft, generates high electrical charges. Charge separation and consequent buildup of electrostatic charges occur between the moving fuel and fuel filter, hose, and other surfaces. Since fuel is normally an excellent insulator, separated charges are easily removed by the flowing fuel to a distant location. If no electrically conductive return path is available, the charge accumulates on metallic surfaces, and is a high potential energy source. With the continued accumulation of charge, sufficient electrical potential is generated to cause an arc across insulating barriers. These voltages build up within the aircraft fuel tank and are a serious danger. Were these voltages to arc over to points of lower potential with the right fuel-air vapor mixture present, an explosion would occur. Bonding the aircraft frame to the fuel supply vehicle provides a means of dissipating these high voltages. Bonding does not prevent generation of high voltages within hose or tank, but provides a return path for the accumulated charges as contact is made with the inside fuel tank surface.

3.2.1.4 Summary. Various sources of static electricity, such as triboelectric, induced charge, and friction have been discussed. In general, direct effects of static electricity are not serious, although such shocks can cause involuntary reflex movements resulting in injury to the affected person or others nearby. On the other hand, sparks generated in the vicinity of a fueling operation can have disastrous results. Catastrophic results can occur from discharge of static electricity into a squib, cartridge, or electroexplosive device (EED). Care in ensuring that aircraft, weapon system, fueling system, and personnel are kept at ground potential will minimize the dangerous effects of static electricity. A ground of up to 10,000 ohms is considered an adequate safety measure.

3.2.2 Power. Various types of electrical power, such as 115V ac, 28V dc, lightning, and radio frequency (rf) are discussed in the following paragraphs. The term power used in this context assumes electric current flow measurable in amps, in contrast to static electricity whose current flow, typically, is in the range of thousandths of an ampere.

3.2.2.1 Operational power. During aircraft flight, all electric power required by onboard equipment is supplied by generators driven by the aircraft engines. Two basic types of electrical voltage are used: 28 volts, direct current (dc) and 115 volts alternating current (ac), at 400 Hertz. The 28V dc system is a two-wire system, positive and negative, with the negative side of the system connected to the aircraft structure. The 115V ac is a four-wire system consisting of phases A, B, C, and neutral (N), with the neutral wire connected to the aircraft structure. Equipment using ac power may use either single phase power consisting of neutral and phase A, B, or C, or 3-phase power which requires phases A, B, C, and N.

3.2.2.1.1 When the aircraft is on the ground, it is not practical to run the engines for electrical power, so the required ac and dc power is supplied by generators external to the aircraft. These sources may be mobile or fixed. The mobile sources are called Mobile Electric Power Plants (MEPP). Following are a few examples.

Use	Model	Type	Outputs
Ship	NC-2A	Engine-driven, self-propelled	115/200V ac, 400 Hz 30 kVA, 28V dc, 500A
Flight Line	NC-8A	Engine-driven, self-propelled	115/200V ac, 400 Hz, 60 kVA, 28V dc, 500A
Flight Line	NC-10C	Engine-driven, self-propelled	115/200V ac, 400 Hz, 90 kVA, 28V dc, 750A
Hangar	MMG-1A	Electric motor-driven trailer-mounted	115/200V ac, 400 Hz, 60 kVA, 28V dc, 500A

A complete listing of MEPPs, together with a description of each model, is given in NAVAIR publication 19-45-1.

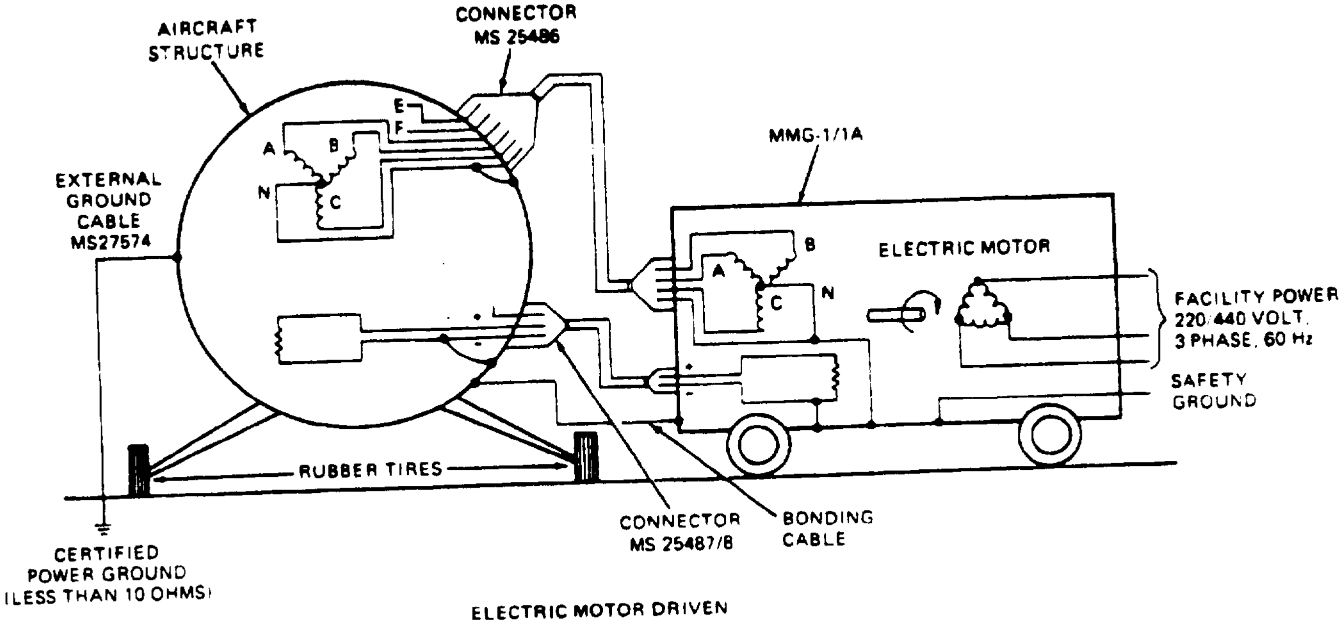
3.2.2.1.2 Figure 3-1 shows a typical example of an aircraft supplied with external power in a shore base flight line configuration. The ac and dc generators are diesel engine-driven and are mounted on a self-propelled chassis on rubber tires. The ac neutral (N) and dc negative wires are both connected to the chassis. In this configuration, the supply cables provided with the MEPP are about 30 ft long. The ac and dc connector plugs are standard MS fittings which mate with most aircraft. Alternative equipment used to provide external electric power is:

a. MMG-1. This is an electric motor-driven MEPP, normally used inside hangars. The electric motor input is 220/440V ac, 3 phase, 60 Hz. The input power includes a safety ground line which is connected to the MEPP chassis. The generator output neutral is also connected to the MEPP chassis. Both engine-driven and motor-driven MEPPS are bonded to the aircraft, independent of the power cable neutral or negative. Neither MEPP is independently grounded.

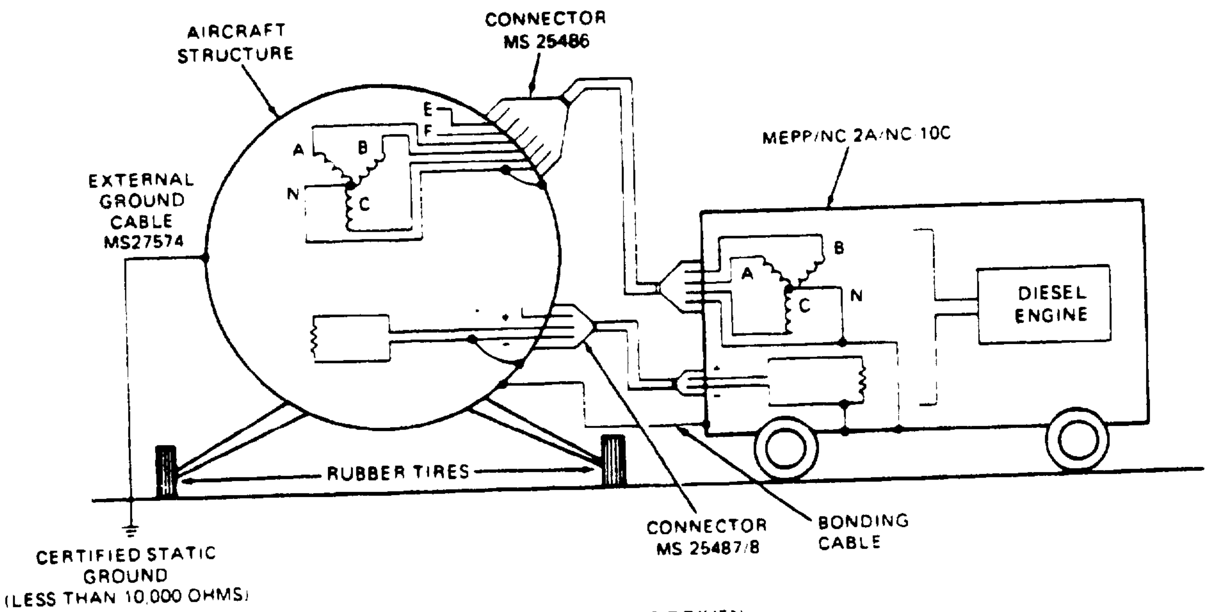
b. Flight Line Electrical Distribution System (FLEDS). This system is installed on shore station aprons. Figure 3-2 shows a typical FLED layout. AC power is provided to the system by a MEPP located at a central location. The ac neutral line is connected to ground at the point of entry to the FLEDS and at the remote ends. Distribution boxes (DBA) are provided at intervals throughout the system, each containing circuit breakers, overload relays, and service cables to supply two aircraft. The distribution cables are protected from taxiing aircraft by metal ramp.

c. Deck Edge Power. This is a similar system to the FLEDS except for being installed aboard an aircraft carrier. The 115V ac, 400-Hz generator is driven by an electric motor fed from the 220/440 Vac, 3-phase, 60-Hz, three-wire delta system. Aboard ship, the 3-phase, 60-Hz system is not grounded.

3.2.2.1.3 The 115V ac, 3-phase, 400-Hz power is fed to the aircraft via a standard connector. This connector (MS 25486) has six connections, A, B, C, and N for the 3-phase ac; and E and F for control purposes only. The manner in which E and F are connected varies from aircraft to aircraft. The 28V dc supply is fed to



ELECTRIC MOTOR DRIVEN



DIESEL ENGINE DRIVEN

FIGURE 3-1. Aircraft supplied with external power.

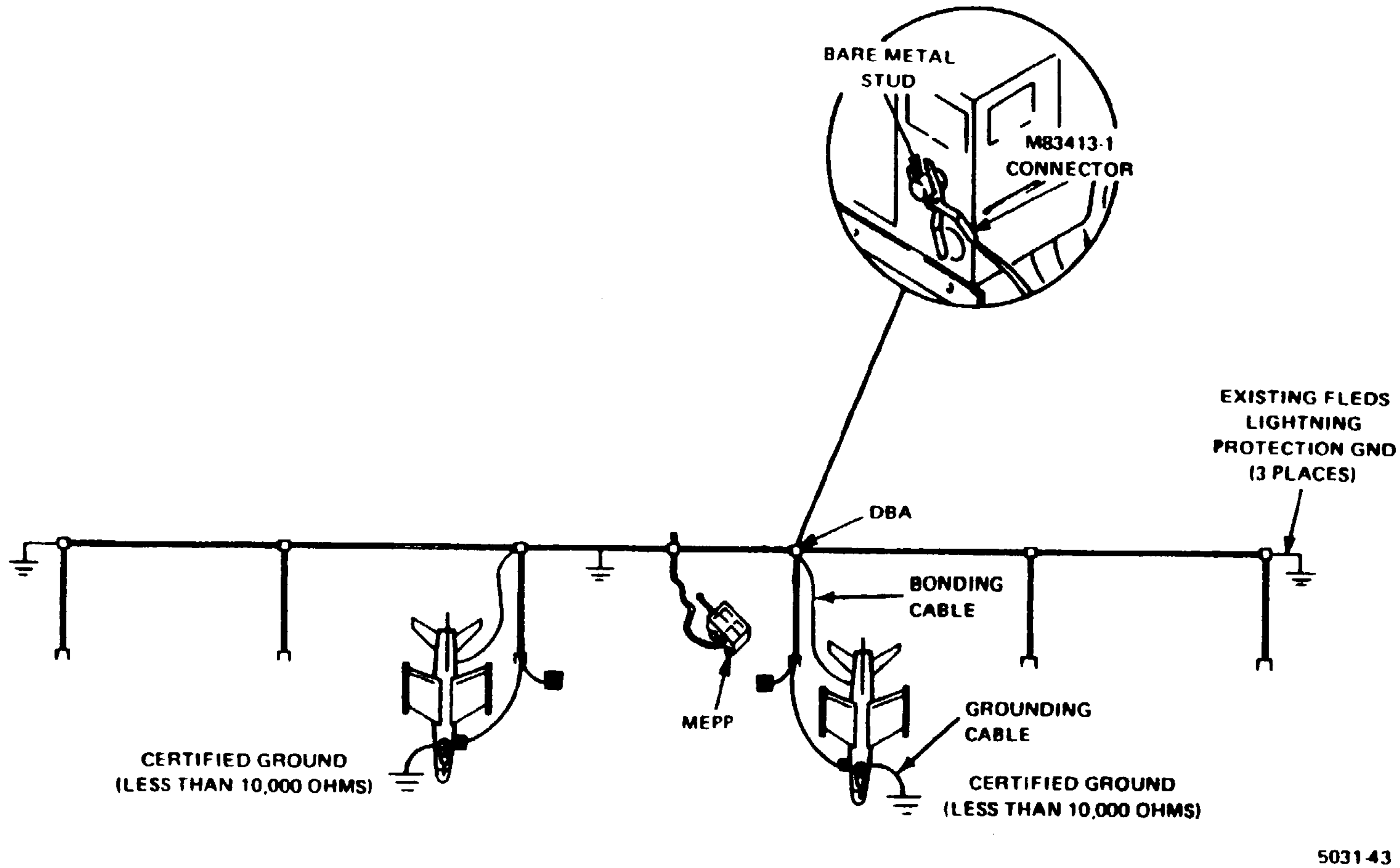


FIGURE 3-2. Typical flight line electrical distribution (FLED) system.

the aircraft by a separate 3-pin connector. The connector is designed in accordance with MS 25487 or MS 25488. In each case, two pins are for 28V dc positive and negative, with the third pin for aircraft control purposes.

3.2.2.1.4 Prior to mating the power connectors to the aircraft, be sure that the aircraft is connected to a power ground (see paragraph 3.3). The purpose of this is to provide protection against ground power fault for all personnel working on or about the aircraft. Occasionally, a fault may occur in the electrical supply system, probably at the supply connector, that results in the neutral line becoming disconnected from the aircraft and a phase line contacting the aircraft structure. In this condition, the aircraft skin is said to become ''hot,'' ie, with about 115V ac potential with respect to ground. If the aircraft is not connected to ground, a person standing on the ground who touches the aircraft could receive a lethal shock. It is accepted that electrical voltages in excess of 45V dc or 30V ac can give lethal shocks to humans. This is based on a body resistance of 1500 ohms and lethal current levels of 20mA ac and 30mA dc .

3.2.2.1.5 Since the predominant fault mode concerns the external power supply connector, one cannot rely on the neutral connection to the aircraft to provide a fault return circuit to activate the overload trip. For that reason, it is necessary to bond the aircraft to the external electrical power source, ie, the MEPP or FLED distribution box (DBA). In the case of deck edge power, this has already been done when the aircraft is grounded to the ship's deck. Usually, the power required to activate the overload circuit is very high, well in excess of 100 amps. It is possible that the total resistance in the bond circuit will be high enough to restrict the current flow and thus prevent activation of the overload circuit. In this case, the bond strap between aircraft and the MEPP might become hot and cause the wire to overheat. A ''smoking'' ground or bond wire is often the first indication of an electrical circuit problem, and requires that external electrical power be shut off immediately.

3.2.2.1.6 In the case of the engine-driven MEPP, the aircraft is grounded to an approved static ground. This ground also serves to ground the MEPP via the external bond wire and, under normal circumstances, the ac neutral wire. It is then not necessary to independently ground the engine-driven MEPP.

3.2.2.1.7 The motor-driven MEPP provides a different problem. The MEPP motor is connected to the 220/440V ac, 60-Hz main system. A 60-Hz supply cable includes a safety ground wire connected directly to the MEPP chassis. When an aircraft is connected to a motor-driven MEPP, it is not uncommon for 115V ac, 60-Hz powered equipment to be used on or about the aircraft. It then becomes essential that should a fault occur in any of the 60-Hz powered equipment, including the MEPP motor, that the aircraft be grounded to a low resistance point of less than 10 ohms in value which shall be connected to the 60-Hz power source ground system.

3.2.2.1.8 For aircraft being serviced inside a hangar this presents no problem, as all aircraft are routinely connected to low resistance points connected to the 60-Hz power ground. For aircraft parked on an apron and fed by a motor-driven generator, it may be difficult to locate a power ground of less than 10 ohms, but every effort should be made to meet this requirement. It should be noted that 10 ohms is not a low enough impedance to provide adequate short circuit protection at all times against power ground faults, when the airframe may be at a 115V ac potential. The 10-ohm value was chosen as a practical obtainable value to provide some degree of safety and, at the same time, an adequate airframe system ground. A 10-ohm ground resistance will not provide enough fault current to trip a 50-amp circuit breaker, nor will it cause a grounding cable to burn; in fact, there may be no indication of a fault. The wire may get too warm to touch if a ground fault exists.

3.2.2.1.9 Since many electrical problems are caused by defective cable plugs, it is imperative that cable plugs be carefully and frequently examined for bare or broken wires or other damage prior to connection to the aircraft. It is also extremely important that the cable and connector be thoroughly checked and tested after repair and before being returned to service. The U.S. Navy Support Equipment, Basic Handling and Safety Manual, NAVAIR 00-80T-96, paragraph 3-320, addresses the hazards of electric shock associated with defective electrical cables and connectors.

3.2.2.1.10 The deck edge power supplied by the ship's supply is not grounded to the ship's structure. The neutral of the 3-phase power is not tied to the ship's structure and therefore the system represents a floating neutral power source. Deck edge configurations depicted in this handbook actually indicate aircraft static bonding to the deck.

3.2.2.2 Lightning. Paragraph 3.1.3 provides a simple explanation of the lightning phenomena. When a charge of sufficient magnitude builds up in a cloud, preliminary breakdown occurs and a stepped leader is initiated. As the stepped leader nears the earth, upward-moving discharges may be produced from local high points that are at or near ground potential. For this reason, the tail of an exposed aircraft often provides the primary attachment point for a stepped leader (see figure 3-3). As the leader completes its path to earth, a return stroke is generated. The currents in return strokes typically reach levels of 20,000 amperes, with peaks of up to 200 kiloamperes (KA) recorded. During the life of an aircraft, it may be struck many times by lightning, but only on rare occasions is damage sustained. Little can be done to prevent a lightning strike to an aircraft parked on a concrete/asphalt apron outside a hangar. A low impedance ground will reduce the amount of time required to bleed-off induced charge due to ''nearby''

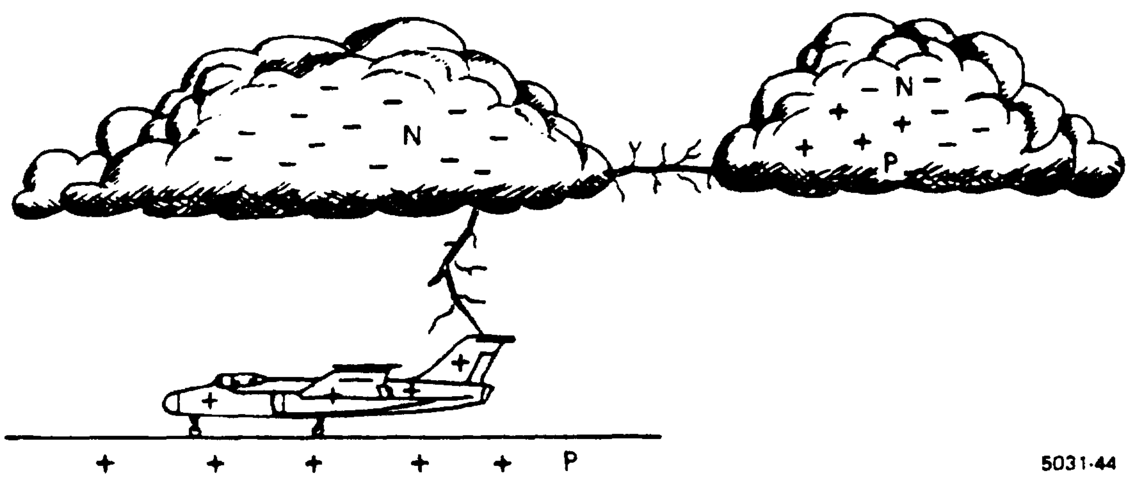


FIGURE 3-3. Lightning discharge.

lightning, and reduce the chance of sideflashes. Of course, no ground will totally protect personnel working on the exterior of an aircraft in the vicinity of an electrical storm. If weather conditions are such that lightning strikes are imminent, all operations involving refueling, ordnance loading, or maintenance must be suspended.

3.2.2.3 RF electromagnetic energy. Today's environment has many unintended side effects caused by radio frequency (rf) transmitting devices used in conjunction with naval flight operations. Of concern are those high power communication and radar transmitters which may be located near parked aircraft. The best example of this situation is the carrier flight deck, which probably contains the highest concentration of transmitted rf energy to be found on any base from which aircraft operate. Although high power communication and radar transmitters may be found at greater distances from parked aircraft at a shore station, an aircraft may be affected by an adjacent aircraft whose onboard communication system or radar transmitters are being tested. Aircraft aboard ship could be similarly affected.

3.2.2.3.1 The principal problem is the amount of rf energy induced into the aircraft frame and circulating on the aircraft skin. This quantity or level of rf energy is greatly affected by the position of the aircraft relative to a particular rf transmitter, the power output of that transmitter, and the actual frequency of the rf energy being transmitted. It is further affected by the actual location of any connections between aircraft and ground (deck). Where position of one ground may have a significant effect on induced current, other ground connections from different locations on the aircraft to other locations on the deck may not have the same effect. Any existing aircraft grounding scheme should not be altered in an effort to provide the aircraft with additional protection against rf energy. If the ground connection is broken while the rf transmission is in progress, an electric arc may be drawn out. This is an important fact to note. If an arc is produced while disconnecting a ground, the source may be rf energy, caused by a local transmitter and the current flow can be high. (A power line short circuit to ground may also produce an arc when the ground is disconnected.) If, on the other hand, an arc is drawn while a ground is being attached to the aircraft, the source is static electricity and the current flow will be light.

3.2.2.3.2 Since there is no protection from transmitted rf energy, it is necessary that personnel ensure that no operations are conducted without observation of all recommended procedures. For instance, a fuel hose nozzle should always be bonded to the aircraft before the filling cap is removed and the hose nozzle inserted into the fuel tank. Conversely, the filling cap should be replaced before the hose nozzle bond is disconnected from the aircraft. These procedures will ensure that no rf arcs are inadvertently produced in a hazardous atmosphere while the fuel tank cap is removed.

3.3 Operational procedures. The following paragraphs summarize grounding and bonding procedures performed during maintenance, fueling/refueling, and ordnance handling evolutions. Note: Any area that the M83413-1 electrical ground connector (clamp type) is clamped to should be free of paint, corrosion, dirt, grease and not made of a composite material. The clamp should be twisted to ensure that a good electrical path is established.

3.3.1 Maintenance grounding procedures. When performing maintenance evolutions, the following items must be considered.

3.3.1.1 Parked aircraft must be grounded to an approved static ground (less than 10,000 ohms).

3.3.1.2 When performing hangar maintenance, the aircraft must be grounded to an approved power ground (less than 10 ohms).

3.3.1.3 When performing maintenance requiring external electric power, the aircraft must be grounded to an appropriate ground. An approved static ground must be used if the external source is an engine-driven generator or FLEDS. A power ground must be used when the external source is a motor-driven (60-Hz) generator even if 28V dc only is connected to the aircraft. In addition to the required static or power grounding, aircraft must be bonded directly to the power source as follows:

a. Bonded to the MEPP chassis (engine-driven or motor-driven).
b. Bonded to the DBA, if FLEDS is the power source.

NOTE: Exceptions to the above are: (1) when the aircraft is powered from deck-edge power on a ship, grounding to the deck only is required; (2) where the aircraft will be fed from hangar bulkhead outlets, grounding only to power ground is required; and (3), aircraft using 28V dc diesel generated power only.

3.3.1.4 If the external power source is an engine-driven MEPP, the MEPP shall not be independently grounded. Consequently, a motor-driven generator is independently grounded through its own power supply cable, in accordance with the National Electric Code with no additional ground required.

3.3.2 Fueling/refueling grounding procedures. The following paragraphs provide grounding and bonding procedures to be followed while performing various fueling/refueling scenarios.

3.3.2.1 The grounding procedures to be observed when refueling a parked aircraft with no external power required is as follows:

a. Ground aircraft by connecting ground cable (type MS27574) from any approved static grounding point to a grounding receptacle on the aircraft.
b. Ground refueler to an approved static ground point (use same point as used by aircraft).
c. Bond refueler to aircraft using:
   - 1st choice - approved grounding receptacle
   - 2nd choice - grounding connector (Type MIL-C-83413), to be attached to a clean, unpainted metallic surface.
d. Attach fuel delivery nozzle bonding cable to aircraft before removing filler cap.
e. On completion of refueling operation, secure in reverse order to above. Ensure filler cap is replaced before removing nozzle bonding cable.

3.3.2.2 The grounding procedure to be observed when refueling a parked aircraft with external power required is as follows:

a. Ground aircraft by connecting ground cable (type MS27574) from any approved static grounding point to a grounding receptacle on the aircraft. When powered by a diesel-driven generator, connect aircraft to a static ground. When powered by an electrically-driven generator (MMG-1A), connect aircraft to a power ground.
b. Bond aircraft to ground power unit (GPU) using a suitable grounding cable (Type MS 27574). The cable will be attached to the aircraft by:
   - An approved grounding receptacle, if available.
   - If not available, attach to a clean, unpainted metallic surface using a grounding connector (Type MIL-C-83413).

   The other end of the grounding cable will be connected to the Mobile Electric Power Plant (MEPP) by attaching the grounding connector (Type MIL-C-83413) to a clean, unpainted metallic surface.
c. Attach electrical power cable(s) from MEPP to aircraft. Carefully examine the 115V ac and/or 28V dc connectors for any evidence of damage prior to connecting to the aircraft receptacles.
d. Ground refueler by attaching grounding cable from refueler to an approved static ground point. It is necessary to use the same ground as used by aircraft.
e. Bond refueler to aircraft using:
   - An approved grounding receptacle.
   - If grounding receptacle is not available, attach to a clean, unpainted metallic surface using a grounding connector (Type MIL-C-83413).
f. Attach fuel delivery nozzle bonding cable to aircraft before removing filler cap.
g. On completion of refueling operation, secure in reverse order to above. Ensure filler cap is replaced before removing nozzle bonding cable. Remove aircraft/truck bond.

NOTE: The above procedure will apply regardless of whether the MEPP is driven by a diesel engine or an electric motor. It is not necessary to separately ground the MEPP.

The above procedure will apply when aircraft is powered by FLEDS or ship's deck edge power. In the case of FLEDS, the aircraft will be bonded to the distribution box assembly (DBA). On board the carrier, the aircraft need only be grounded to the deck. It should be further noted that tiedown chains do not provide satisfactory grounding paths.

3.3.2.3 When the fueling operation is being conducted on an icy, sandy, or rocky terrain or where it may be impossible to adequately ground the aircraft, precaution must be taken to ensure that the bonding connections are solid and reliable. During carrier operations, grounding to the carrier deck may be frustrated by the use of padeyes which have been coated with nonskid epoxy. The NAVAIR Airframe Electrical Grounding Report (AIR-5181-1000) cites the case of an F-14 aircraft, secured by 12 tiedown chains, which had a combined resistance to ground (deck) of 40,000 ohms. One chain alone measured 5 megohms from end to end. These conditions emphasize the need for extreme care, especially when the system safety must rely solely on good bonding. Aircraft tires may be expected to provide some resistance to ground; however, field measurements have indicated a wide variation in resistance, from 2,000 ohms to a high as 600,000 megohms. In addition, the surface on which the aircraft is standing adds considerable resistance to that offered by the tires. The carrier deck nonskid surface and black asphalt both offer very high resistance to ground. It is a normal procedure to routinely inspect the carrier deck padeyes and clean them of paint or nonskid material. Similarly the ''approved'' grounding points at shore facilities are routinely inspected and the ground resistance is measured and recorded.

3.3.2.4 It is mandatory during a fueling operation that an aircraft frame be connected to ground using a good ground cable, with each end of the cable mated using clean well-maintained connectors. Grounding the aircraft, however, will not stop the generation of electrostatic charges, but will help bleed the charges away before they build up high enough potentials to damage equipment or injure personnel. Additives have been devised which, when added to the fuel, increase the conductivity of the fuel. This means that the generated electrostatic charges find an easier path to ground and thus are prevented from building up to such high values. The use of these additives is presently under study.

3.3.3 Ordnance handling grounding procedures. The following paragraphs provide grounding considerations and procedures during ordnance handling operations.

3.3.3.1 During the loading or unloading of ordnance, the aircraft must be appropriately grounded. Generally, external power is removed from the aircraft during these operations, in which case grounding to an approved static ground is adequate.

3.3.3.2 Various aircraft loading and unloading manuals have cited the adequacy of aircraft tiedown chains in providing suitable grounding. Unfortunately, experience has shown that this is not so and, whereas a new chain will have a resistance of less than 0.5 ohm, a used chain has been measured at 5,000,000 ohms. This is due to excessive corrosion, and this condition is not improved when the installed chain is being subjected to continuous movement when the ship is rolling and the weight of the aircraft is continuously transferring from one chain to another.

3.3.3.3 In accordance with NAVSEA OP4, Volume 2, Fifth Revision, ''The termination of a static ground path at any of the following points is specifically prohibited.

a. Electrical conduits or wire coverings
b. Gas or steam pipes or tubing
c. Sprinkler systems
d. Air terminals for lightning protection
e. Power line neutral points
f. Hydraulic, fuel, or lubricating lines
g. Electronic transmitter cables, wave guides, or ground leads
h. Signal system conduits.''

3.3.3.4 Additionally, all personnel involved in handling ordnance should ground themselves immediately prior to touching any electrical connector, wire, or plug connected to a weapon. Personnel should ground themselves by making momentary bare skin-to-metal contact with a grounded object or the metallic skin of the weapon. In some locations, due to an extremely dry climate, local rules require that personnel handling ordnance shall wear grounding straps or stirrups which extend from under the shoe to the upper calf.

3.3.3.5 Due to the obvious hazards in handling ordnance, all personnel should be aware of the unique characteristics of individual weapons by reviewing the technical manual or OP for that weapon. Familiarization with the contents of NAVSEA OP4, Volume 2, Fifth Revision, especially paragraphs 2-36 through 2-45, is advised. The following excerpt from NAVSEA OP4, Volume 2, Fifth Revision summarizes primary concerns:

> ''Special static protective grounding procedures are required aboard ship only during assembly/disassembly, checkout, and servicing of weapons. In loading of weapons aboard aircraft, static protection is considered adequate if immediately prior to removal of the shorting plugs or dust covers and racking, the aircraft, weapon, and personnel are at the same potential. Prior to unloading, personnel must be at the same potential as the weapon and must replace shorting plugs or dust covers over contacts prior to removal of weapon. In all phases of stowage and operation, static protection is considered adequate provided all firing circuit contacts are protected by shorting plugs or dust covers, or firing circuits are electrically out of line with the electro-explosive devices (EEDs) and the EED leads are shorted to the EED case (eg. EED leads and case are grounded to the weapon skin), or the EED can safely withstand 25 kV between case and bridge wire. Unless it is stated otherwise in the technical manual or OP for the individual weapon, it may be assumed that a weapon incorporates one of these features and therefore needs no grounding during shipboard stowage.''

3.4 Special considerations. Various circumstances will arise that will not allow conformity with the situations that have been previously described. An obvious case is that which arises during winter weather when it may not be possible, because of ice or snow, to ground aircraft in the normal manner. In these circumstances it becomes even more important to ensure that bonding requirements between aircraft and refueler, or aircraft and MEPP are met with even more care. It should be remembered that during the fueling process, static voltages are being generated and accumulated continuously, and only the bonding cable provides a means of keeping this static voltage buildup under control. If the bonding wire is attached to a painted surface on the aircraft, the accumulated static voltage being built up within the fuel tank eventually finds some point to arc over. Hopefully, other factors which would contribute to an explosion are not present. It is important to remember that during the refueling operation, fuel vapors are being forced out of the fuel tank by the incoming fuel. The position and concentration of the fuel vapors depend entirely on the wind circulation around the aircraft which is completely unpredictable.

3.4.1 Refueling from drums. Should refueling be accomplished from drums, bladders, containers, or other sources, the same grounding and bonding precautions are required. This may happen in an area where snow and ice make it impossible to ground, and it is imperative that the drums or containers be adequately bonded to the aircraft. Any hose nozzle that is inserted into a drum must be bonded to the drum before removing the drum cap. Any portable pumps that are used must be bonded securely to the system and grounded if possible. Similar grounding and bonding precautions must be observed during any defueling operation into drums.

3.4.2 Hovering helicopter. Static charges are bled off a hovering helicopter by use of a static charge grounding wand, commonly known as a shepherd's crook. In order to be effective, the wand must maintain constant contact with an electrically conductive portion of the airframe and ground. Should contact be broken even for a short time (ie, a few seconds), dangerously high voltages (in the thousands of volts) can build up.

3.4.2.1 The wand must be electrically conductive and be able to ''break away'' if required without injury to the operator. In addition, the device must be electrically insulated to protect the operator from shock. The wand recommended for use is shown on Naval Air Test Center Patuxent River drawing no. 2754, and its associated ground stake on drawing no. 2752. These devices are shown in figure 3-4. The ground stake is intended for use on portable landing fields where no permanent grounds are available. The stake is driven into the earth and the clamp attached firmly to it. For shipboard use the clamp is affixed to a bare metal mooring eye. A similar procedure is used at land-based fields equipped with certified ground and padeye. This system has proven successful in trials and will replace the makeshift systems now being used.

3.4.2.2 Helicopter inflight refueling (HIFR). This procedure is used for quick refueling of helicopters. The grounding wand must be used to make contact with the aircraft to provide a bleed-off path for the electrostatic charges. The clamp end of the wand must be attached to a certified static ground point. The wand must be in continuous contact with the airframe until the refueling hose is attached and all ground/bond wires are in place. The procedure is as follows:

a. Attach wand's clamp to certified static ground.
b. Make contact with helicopter frame or cable using grounding wand hook.
c. Attach fuel hose to helicopter cable.

3.4.2.3 Recovery assist secure and traverse (RAST). The RAST system is presently used only for the SH-60B (LAMPS MKIII) helicopter system. The grounding wand (shepherd's crook) must be used to maintain continuous contact between the deck and the aircraft until the RAST cable is secured to the aircraft. At that time, the cable will provide the required conductive path to maintain the static charge at a safe level.

3.4.3 Hot refueling of aircraft. In order to reduce turnaround time, a refueling procedure may be undertaken while engines are operating. Here again, it is mandatory that the aircraft be grounded and bonded as required for normal servicing.

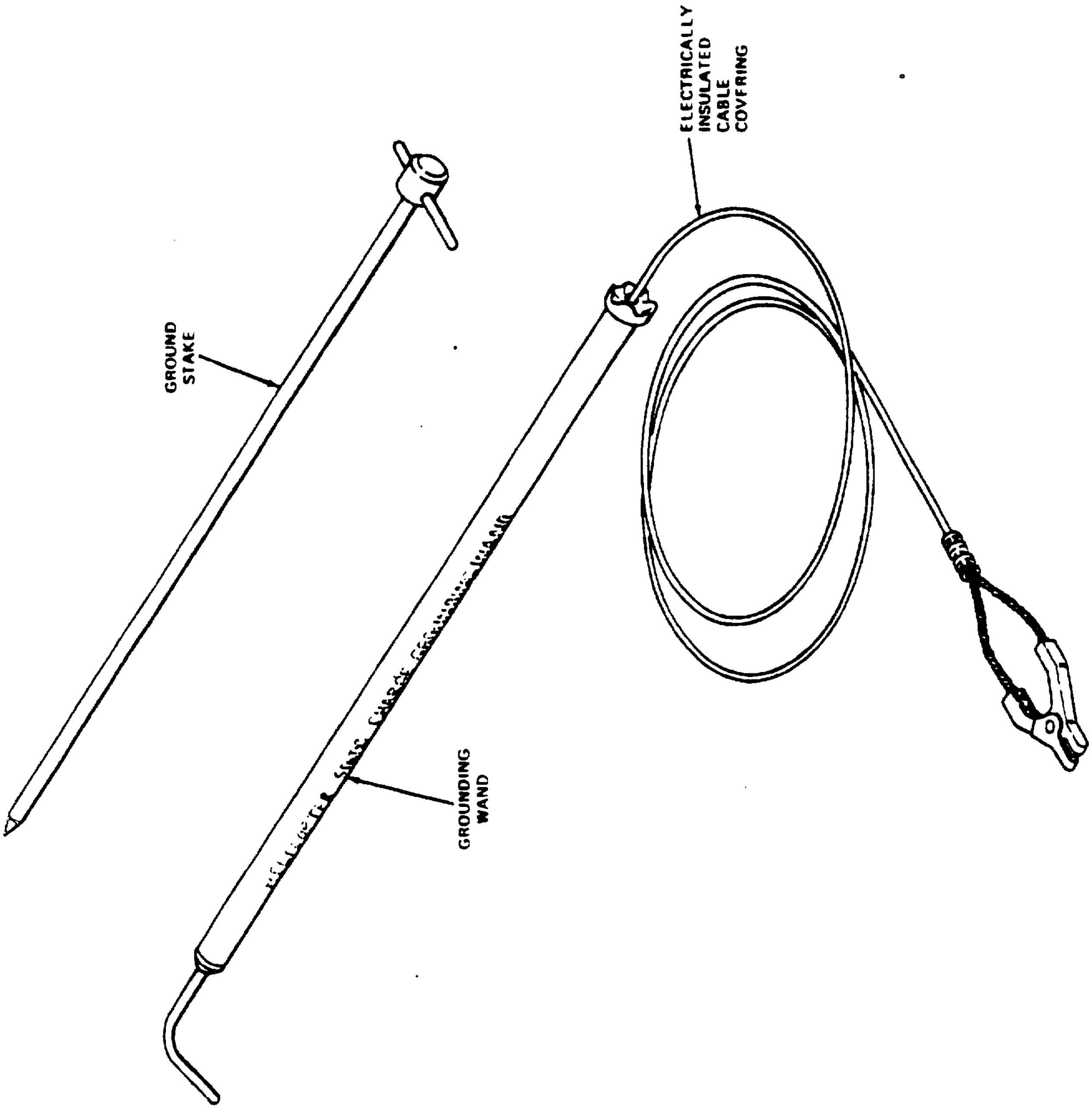


FIGURE 3-4. Helicopter grounding wand.

3.4.4 Servicing aircraft with water, oxygen, and hydraulic carts. Similar precautions are required to ground and bond the aircraft during water, oxygen, and hydraulic services. Where metal hoses are used between oxygen or nitrogen cart and aircraft, bonding is unnecessary.

3.4.5 Temporary grounding. In areas where no approved static or power grounds exist, metal rods may be driven into the ground at suitable points adjacent to the proposed aircraft parking position. For temporary grounds that may be used for some period of time, these rods should be approximately 8 ft. long and 0.875 in. in diameter. Care must be taken that the rod is not driven into a place where it will damage underground services.

3.4.5.1 For aircraft operating in the field, a temporary ground may be obtained by driving a metal rod approximately 3 to 4 ft long and 0.5 in. in diameter into the ground adjacent to the parked aircraft. This usually provides an adequate static ground. The quality of the ground depends on the type of soil and the amount of moisture available. The ground resistance can be improved by saturating the area with water.

3.4.5.2 A temporary ground rod that is in use for some time should have its ground resistance measured on a frequent basis. The resistance should be less than 10,000 ohms. If it is not, consideration should be given to driving additional or longer rods in order to reduce ground resistance.

3.5 Actual grounding problems. The following are excerpts from the Naval Safety Center files. These narrative sections are reproduced here only to demostrate the actual types of problems that are encountered in daily fleet operations.

3.5.1 Narrative: ''WHEN A.C. AND D.C. POWER WAS APPLIED TO ACFT, THE MAINT PERS RECEIVED A SHOCK FROM THE SKIN OF THE ACFT. TROUBLESHOOTING OF THE ELECT SYS REVLD THAT EXTERNAL A.C. D.C. POWER RECEPTACLE COMMON GROUND WIRE NR P 49AON HAD MELTED INSULATION. OXIDIZATION AND CORROSION VISIBLE AT THE TERMINAL ON THE ACFT SKIN WAS THE ONLY APPARENT REASON FOR OVERHEATING. ALL CONNECTIONS WERE SECURE.''

Comment: Prior to any maintenance action, aircraft must be appropriately grounded.

3.5.2 Narrative: ''DURING TURN AROUND INSP PLANE CAPTAIN APPLIED ELECT POWER UTILIZING THE FLIGHT LINE ELECT DISTRIBUTION SYSTEM. UPON CONTACTING AIRCRAFT, PLANE CAPTAIN RECEIVED MILD BUT DEFINITE ELECT SHOCK. ELECT POWER WAS SECURED. WATER WAS STANDING ON RAMP AS A RESULT OF WEATHER CONDITIONS CONSISTING OF LOW OVERCAST AND RAIN. INVEST BY PUBLIC WORKS ELECT SHOP PERS REVEALED BROKEN GROUNDING PLUG WHICH PREVENTED THE CABLE FROM ACHIEVING PROPER GROUND. THIS INCIDENT REEMPHASIZED THE NECESSITY FOR PROPER HANDLING AND MAINTENANCE OF FLIGHT LINE ELECT POWER DISTRIBUTION SYSTEM IN ORDER TO AVOID SERIOUS PERSONNEL INJURY, ESPECIALLY UNDER ADVERSE RAMP CONDITIONS.''

Comment: Emphasizes need to inspect grounding hardware.

3.5.3 Narrative: ''AFTER SHUTDOWN FM FLT, ORD MAN BEGAN PROCED FOR LOADING MK82 PRACTICE BOMBS ON UTBD RACKS. AFTER COMPLETION OF JETTISON REL CKS, JETTISON CART WAS BEING INSTLD IN PORT OUTBD STA. AS CAP AND CART WERE BEING INSERTED INTO BREECH, CART EXPLODED. INJURY TO ORD MAN INVOLVED WAS SUPERFICIAL AND THERE WAS NO DAM TO ACFT. IMMED AFET INCDT, ORD INVOLVED CKED BOTH CKPTS TO ASCERTAIN JETTISON SW POSITION, AND STATED BOTH WERE IN THE OFF/SAFE POSIT. HOWEVER, ACFT WAS UNGROUNDED. THE MOST LIKELY CAUSE OF INCDT WAS THE FAIL OF ORDNANCEMAN TO GROUND ACFT PRIOR TO EXECUTING LOADING PROCEDURES.''

Comment: The next ordnance man may not be so lucky.

3.5.4 Narrative: ''ACFT WOULD NOT ACCEPT EXT DC POWER FOR START. UPON REMOVAL OF DECKING PLT SIDE, DISCOVERED DC EXT POWER RECEPTACLE GROUND LEAD WAS NOT ATTACHED. FURTHER INVEST REVLD GROUND LEAD HAD BURNED A HOLE IN MOUNTING AREA, THUS FREEING THE LEAD. BELIEVE ATTACHING BOLT WORKED LOOSE OVER A PERIOD OF TIME AND CAUSED POOR CONNECTION. ANY LOOSENESS COUPLED WITH EXCESSIVE HEAT GEN BY HIGH CURRENT CAN RESULT IN THIS SIT.''

3.5.5 Narrative: ''WHILE PERFORMING BEFORE START CHECKLIST WITH EXT D.C. PWR APPLIED, CREW NOTICED SMOKE COMING FROM BENEATH PLTS DECKING. EXTERNAL PWR IMMED SECURED. T/S REVLD LOOSE GROND WIRE FOR DC EXT PWR RECEPTACLE. REPLACED GROUNDING WIRE.''

3.5.6 Narrative: ''JUST BEFORE LIGHT OFF, ON START OF NO. 2 ENG, PLT SMELLED ELECTRICAL FUMES AND NOTICED SMOKE COMING FROM UNDER HIS DECKING. HE SHUTDOWN BOTH ENG AND SECURED ACFT. TROUBLESHOOTING REVLD DC EXT PWR RECPT GROUND WIRE LOOSE, BURNING THRUGH ATTACHING STRINGER.''

Comment: Para 3.5.4, 3.5.5 and 3.5.6 are typical of many reports and illustrate not only the need for constant vigilance but the serious consequences that poor maintenance will cause. Any aircraft fire, especially onboard a carrier, can be disastrous.

3.5.7 Narrative: ''WHILE DEFUELING, VAPOR WAS OBSERVED IN THE STBD WHEEL WELL. INVEST REVLD ALL FOUR ENG HRD BOTTLES HAD DISCHARGED. THE FOUR PRIMARY CARTRIDGES WERE EXPENDED. STATIC ELECTRICITY BUILD-UP CAUSED BY IMPROPER GRND OF FUEL TRUCK TO ACFT. THE FUEL TRUCK TO ACFT GROUNDING WIRE WAS CONNECTED TO THE LANDING GEAR SCISSORS STRUT, VICE THE GROUNDING KNOBS PROVIDED ON THE FORWARD SIDE OF THE LANDING GEAR. THIS SCISSORS STRUT IS PAINTED AND POSSIBLY COULD HAVE CAUSED AN INPROPER GRND. PROPER GROUNDING PROCEDURES HAVE BEEN STRESSED IN THE CMD. MAINT ERROR SQD.''

Comment: This illustrates not only the need to make sure that the bonding cable is attached to a clean metallic surface but the need to do an even better job of stressing these important requirements.

3.5.8 Narrative: ''WHILE TROUBLESHOOTING A FUEL QUANTITY DISCREP, ELECTRICIAN, AE2 SOUCHAK, RECEIVED AN ELECTRICAL SHOCK WHILE HANDLING A CANNON PLUG IN FLAP WELL. INVESTIGATION REVLD THAT ACFT WAS NOT GROUNDED (NOR REQUIRED TO BE).''

Comment: Cannot agree with the comment ''(nor required to be).'' The local requirements should be rewritten.

3.5.9 Narrative: ''WHILE FUELING FOR TRAINING FLIGHT, LIGHTNING STRUCK IN CLOSE PROXIMITY TO AIRCRAFT AND FUEL TRUCK. OF THE TWO CREWMEMBERS FUELING THE AIRCRAFT, ONE WAS KNOCKED TO THE GROUND AND THE OTHER LEFT DAZED BUT STILL ON HIS FEET. THE DRIVER OF THE FUEL TRUCK WAS APPARENTLY UNAFFECTED. THE FUELING OPERATION WAS SECURED AND THE CREWMEMBERS WERE TAKEN TO THE HANGAR AREA WHERE CORPSMEN CONDUCTED AND INITIAL EXAMINATION. THE CREWMEMBERS WERE SUBSEQUENTLY TRANSPORTED TO THE MEDICAL CENTER AND LATER RELEASED WITH NO APPARENT INJURIES. BECAUSE ACCEPTED AND PROVEN SAFETY PROCEDURES WERE FOLLOWED, A TRAGEDY OF IMMENSE PROPORTIONS WAS UNDOUBTEDLY AVERTED. ALTHOUGH THE SKY WAS OVERCAST WITH SOME CUMULUS CLOUDS IN THE AREAS, THERE WAS NO RAIN OR LIGHTNING ACTIVITY IN THE AREA. AS A RESULT, THE DRIVER AND CREWMEMBERS ALL WERE SATISFIED THAT CONDITIONS WERE SAFE FOR REFUELING. AT FIRST, IT WAS BELIEVED THAT THE AIRCRAFT HAD BEEN STRUCK BY THE LIGHTNING; HOWEVER, A THOROUGH INSPECTION BY QA PERSONNEL REVEALED NO DAMAGE OR OTHER INDICATION THAT THE AIRCRAFT SUSTAINED A DIRECT HIT OR CONDUCTED ANY PORTION OF THE CHARGE. NO DAMAGE TO THE FUEL TRUCK WAS IN EVIDENCE OR LATER REPORTED BY THE FUEL FARM. FOLLOWING THE LIGHTNING STRIKE, IT WAS NOTED THAT THE GROUNDING WIRE HAD NUMEROUS BURN SPOTS AND WAS SMOKING. FURTHER INSPECTION OF THE GROUNDING WIRE REVEALED THAT IT CONDUCTED A SUBSTANTIAL ELECTRICAL CHARGE AS EVIDENCED BY DISCOLORED WIRE, CRYSTALIZED METAL, AND MELTED POLYMER COATING. DURING THE INITIAL EXAMINATION BY CORPSMEN, ONE OF THE CREWMEMBERS COMPLAINED OF A TINGLING SENSATION IN HIS RIGHT ARM. SUBSEQUENT INVESTIGATION REVEALED THAT HE WAS HOLDING ON TO THE FUELING NOZZLE AT THE TIME OF THE STRIKE. THE OTHER CREWMEMBER INITIALLY HAD BLURRED VISION FOLLOWING THE STRIKE. IT IS BELIEVED THAT THIS WAS PROBABLY CAUSED BY HIM HITTING HIS HEAD ON THE UNDERSIDE OF THE WING ROOT AT THE TIME OF THE INCIDENT. AFTER THOROUGH INVESTIGATION BY THE AVIATION AND GROUND SAFETY OFFICER, IT WAS DETERMINED THAT ALL APPLICABLE DIRECTIVES AND REGULATIONS WERE STRICTLY ADHERED TO BY ALL PERSONNEL AND COMMANDS CONCERNED AND AS A RESULT, FURTHER SUBSTANTIATES THE VALUE OF PROPERLY GROUNDING THE AIRCRAFT AND FUEL TRUCK DURING FUELING OPERATIONS.'' This says it all - it is up to you to READ AND HEED!''

Comment: None required.

3.6 Measurement of static ground and electrical power ground points. Ground resistance measurements should be taken at periodic intervals to ensure that these measurements are made during different seasons over a period of years. A 15-month interval is recommended, although local site conditions may dictate other measurement intervals.

3.7 Grounding hardware/receptacle considerations. In all of the previously mentioned grounding procedures and considerations the receptacle is the preferred method of connection. Care must be taken to ensure that the receptacle is in good condition. Any evidence that the mating connection is loose indicates that the receptacle is defective and it must be replaced. Periodically, all receptacles must be inspected and their resistance to the aircraft structure should be measured and found to be less than 0.1 ohm. An MS 3493 plug should be inserted in the receptacle and found to be firmly seated. The pull required to withdraw the plug should be between 8 and 14 lb. A pull of less than 8 lb indicates a weak or damaged receptacle; a pull exceeding 14 lb may indicate a corroded receptacle. In either case, the receptacle must be replaced. Additionally, the complete cable must be maintained in good electrical condition.

CAUTION: Use of alligator clips or braided panel strap to ground or bond aircraft and support equipment is prohibited.

3.7.1 If a grounding receptacle is not available, an approved grounding cable constructed in accordance with MS 27574 must be used. Care must be taken that the clamp-type connector, if used, conforms to MIL-C-83413 and must be checked for weak spring, deformed or rusty jaws, or any other defect which would prevent a good connection.

3.8 Grounding hardware military specification sheet reference list. The following list of military specification sheets is included for reference purposes.

MS Number	Title
MS27574	Cable Configurations, Grounding
MS3493	Connector, Plug and Cap Electric, Grounding
MS0090298	Connector, Receptacle, Electric, Grounding
MS33645	Receptacle, Grounding, Installation of
MS25083	Jumper Assembly, Electric Bonding and Current Return
MIL-C-83413	Connector, Electric Ground
MS25486	Connector, Plug, Attachable, Ext. Electric Power, Aircraft 115/200 volt 400 hertz
MS25488	Connector, Plug, Attachable, Ext. Electric Power, Aircraft, 28 Volt DC Operating Power
MS25487	Connector, Plug, Attachable, Ext. Electric Power, Aircraft, 28 Volt DC, Jet Starting.

SECTION 4

4.0 THEORETICAL BASIS FOR AIRCRAFT GROUNDING

This section provides theory, background, and information necessary to understand the rationale behind the requirements for aircraft grounding and bonding. Theory and equations associated with both electrostatic charge generation in aircraft and grounding effects are discussed. The different aircraft scenarios or servicing situations are introduced with emphasis on the hazards that can be encountered.

4.1 Electrostatic theory. Static electricity, by definition ''electricity at rest,'' consists of opposite electrical charges that are usually kept apart by insulators. Potential differences involved may amount to thousands of volts. However, the flow of electricity during generation and accumulation is small, in the range of millionths of an ampere. A primary manifestation of static electricity is the discharge or sparking of the accumulated charges. Static electricity is generated by the separation of like or unlike bodies. Electrostatic charges, positive and negative, always occur in pairs. They become evident when these pairs, having been in contact with each other, are separated. For significant potential to be developed, the bodies holding the charges must become, and remain, insulated from each other. Insulation may occur through complete physical separation of the bodies or because at least one of the bodies is an insulator.

4.2 Scenarios. The following aircraft evolutions or scenarios are considered in this manual:

a. Stores handling (including ordnance)
b. Maintenance (flight line and hangar)
c. Fueling
d. Parked

Potential hazards considered during each scenario are:

a. Static electrical shock to personnel
b. Power system electrical shock to personnel
c. Ordnance misfire and/or inadvertent ordnance or stores release
d. Fuel vapor ignition
e. Damage or upset to electronic subsystems

4.3 Energy sources. The source mechanism and source magnitude of the electrical energy is critical in assessing the possible occurrence of a hazardous situation. The following energy sources are to be considered during the aircraft evolutions of stores handling, maintenance, fueling, and aircraft parked:

a. Static
   - Triboelectric
   - Induced
   - Friction
b. Power
   - Ground fault
   - RF electromagnetic energy
   - Lightning

4.3.1 Static sources. The static sources listed above are defined and evaluated in the following paragraphs.

4.3.1.1 Triboelectric effects. One type of charging mechanism that can create dangerous voltages on ungrounded aircraft is triboelectric effects. These effects are generally associated with the buildup of static charges on an aircraft in flight. High static voltages, however, can result from the interaction of various materials striking a parked aircraft. Wind-blown snow or dust particles are the usual objects responsible for this charge accumulation, commonly called precipitation static or p-static.

4.3.1.1.1 A conservative estimate of electrical current for a moderate wind-blown dust situation is 30 microamperes (μA). In an ungrounded aircraft, this current flows from earth to the snow, dust, etc, via the tires and airframe. Thus, the potential between airframe and earth is determined almost entirely by the tire resistance. A worst-case value of 40 megohms (MΩ) for tire resistance is used to compute an airframe potential of:

$$V = IR = (30\mu A)(40\ M\Omega) = 1200V$$

4.3.1.1.2 These charges will accumulate until a sufficient time to discharge has passed or a person touches the aircraft. Twelve hundred volts (1200V) exceeds parameters for nonlethal shock to personnel, and could cause a reflex action resulting in injury to personnel.

4.3.1.2 Induced charge. Electrical storms involve the relatively slow movement of heavily charged clouds which set up an electrostatic field over a large area of the earth's surface below the cloud. The presence of an electrical field between an active storm cloud system and the earth results in large induced charges on parked aircraft. As shown in figure 4-1, the negative charge in the cloud attracts a positive charge from the earth onto the aircraft via the tires. This charging usually occurs at a relatively slow rate which results in relatively small current flows that cause no damage to the aircraft. If a person is in contact with the plane throughout the charging period, ie, as the charged cloud moves slowly overhead, he will probably feel no effect.

4.3.1.2.1 The situation becomes a potential hazard if a sudden change in the electric field takes place (eg, a distant lightning strike discharging the overhead cloud). The earth's surface neutralizes more quickly than the ungrounded aircraft (due to the capacitance of the aircraft and the high resistance of the tires), resulting in potentials up to 60 kilovolts (kv) from airframe to ground. A person in contact with the aircraft during this change in the electrical field acts as a resistor connected to ground, facilitating another path to ground for the accumulated charges. (See figure 4-2.) This person will probably feel a sharp shock, the severity of which will depend on the extent to which the aircraft was originally charged. The current shock can result in injury to personnel in two different ways:

a. Involuntary reflex movements which can cause fatal or serious injury due to secondary effects, such as falling, and
b. Electrical effects which result directly in injury.

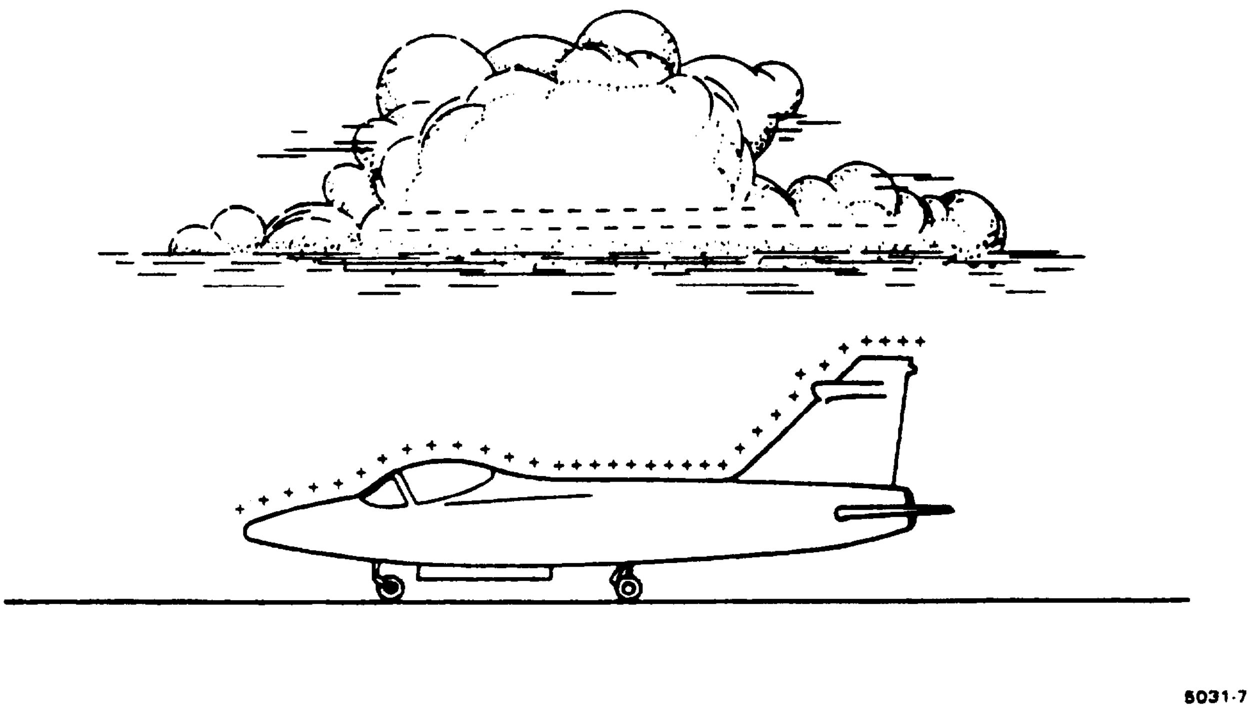


FIGURE 4-1. Cloud-inducing charge on aircraft.

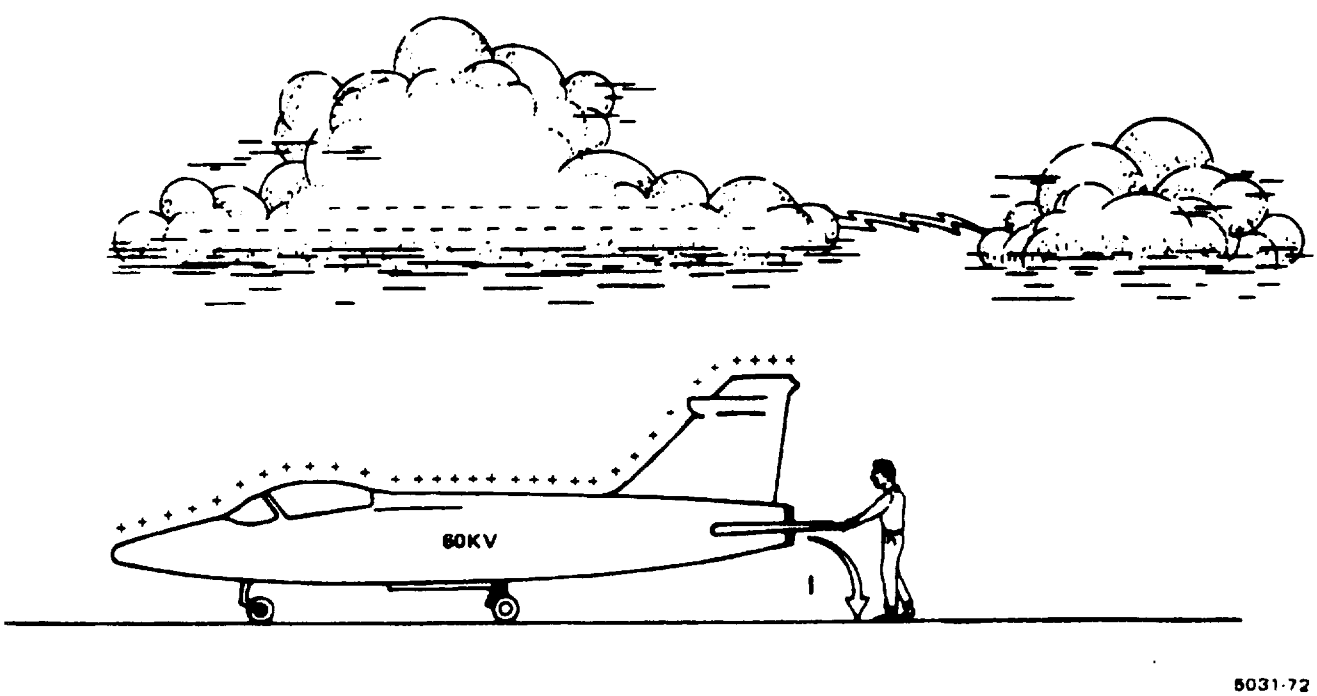


FIGURE 4-2. Possible return path for accumulated charge during remote discharge of cloud.

4.3.1.2.2 A person in contact with an aircraft charged by induction to 60 kV could discharge 9 joules (J) of energy from the aircraft.

$$U=1/2\ CV^2$$

$$=1/2\ (0.005\ \mu f)(60\ kV)^2$$

$$=9J$$

This level well exceeds the threshold value for lethal shock and could be fatal.

To further analyze potential hazards:

$$t=RC\ln\left(\frac{E_i}{E_s}\right)$$

where t = time to reach E_s after removal of source

R = aircraft resistance to ground (Ω)

C = aircraft capacitance to ground (f)

E_i = initial (source) voltage (V)

E_s = safe voltage level (V)

Using the ungrounded aircraft resistance of 40 MΩ, an aircraft capacitance to ground of 0.005 microfarad (µf), a safe voltage limit of less than 30V, and 60kV as the initial voltage

$$t = (40\ M\Omega)(0.005\ \mu f)\ln\left(\frac{60\ kV}{30}\right)$$

$$= 1.52\ sec$$

Heart discoordination (fibrillation) threshold levels have time durations as low as 0.2 second (sec), a fact that makes the 1.52-sec discharge time very dangerous and unacceptable.

4.3.1.3 Friction. Static electricity is generated when certain materials rub together. During such close moving contact between two materials, one of the materials is depleted of electrons, causing a surplus in the second. The magnitude of the static electrical charge thus produced depends on the materials involved and on the amount of humidity present during such friction. With synthetic materials (such as nylon) undergoing friction in a cold dry climate, the effect is greater.

4.3.1.3.1 Static electricity is generated on clothing by friction, especially by the action of removing garments. There is also a continuous generation of charges in the garments of a moving clothed person. The total amounts of charge at any time will depend on the rate of charge production and the rate of charge decay. If a person rubs against external objects, charges can be produced on the outside of the garments; otherwise, the charges will be produced within the clothing system as shown in figure 4-3.

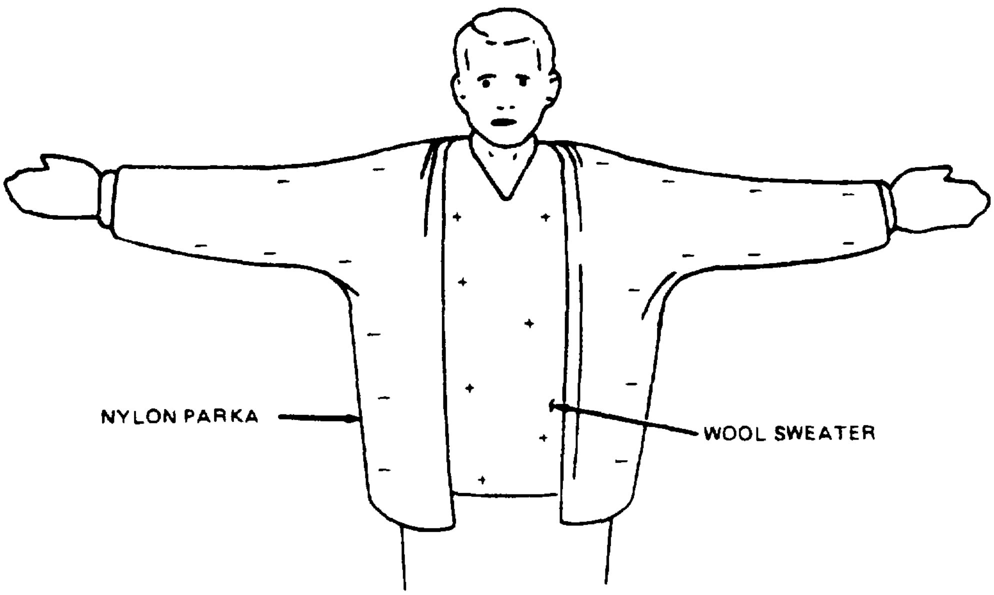


FIGURE 4-3. Charge accumulation on clothing.

4.3.1.3.2 It is generally considered that all parts of the skin are sufficiently moist to allow only negligible amounts of charge to be formed between the skin and the garment next to the skin. Provided the person does not remove any garments, the only effect of the charged clothing can be to cause an attraction between the layers (since opposite charges attract) or for the clothing to cling to the body.

4.3.1.3.3 However, if a person removes the outer garments (as shown in figure 4-4), a charge of up to 27,000V can reside on the outside surface of the newly exposed clothing. The positive charge on the wool sweater and the negative charge on the parka are available for ''static effects.'' The opposite charges on the sweater and parka may easily produce a spark from one to the other.

4.3.1.3.4 The 27-kV value is used herein as representative of the worst-case static electricity friction hazard levels produced by servicing personnel. Using $U = 1/2\ CV^2$ with C = 500 pF (picofarads) for body capacitance, the amount of available energy is 0.18J. This is well above the threshold levels for fuel vapor ignition, component damage, EED ignition, and relex action shock.

4.3.1.3.5 Fuel flow. During the fueling process, the passage of fuel from the supply vehicle through the fueling hose to the aircraft provides the mechanism for a recurring electrostatic energy source. The friction effect between the moving fuel and fuel filter, hose, and other surfaces results in charge separation and a consequent buildup of electrostatic charges. (See figure 4-5.) Since fuel is normally an excellent insulator, separated charges are easily removed by the flowing fuel to a distant location. If no electrically conductive return path is

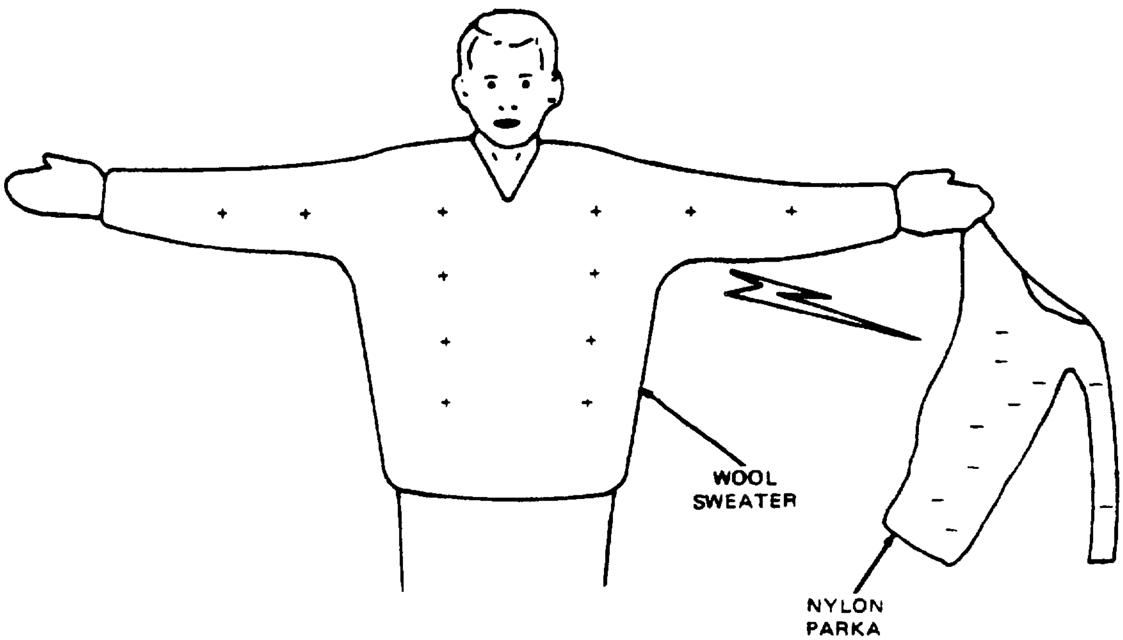


FIGURE 4-4. Possible discharge of accumulated charge.

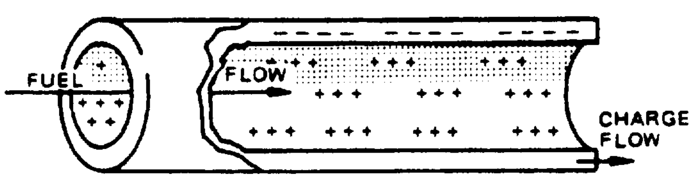


FIGURE 4-5. Charge separation due to fuel flow.

available, the charge accumulates on metallic surfaces and represents a high potential energy. As the accumulation of charge continues, sufficient electrical potential is generated to cause an arc across insulating barriers. These voltages build up within the aircraft fuel tank and represent a serious danger. If these voltages arc over to points of lower potential when the right fuel-air vapor mixture is present, an explosion will occur. Bonding the aircraft frame to the fuel supply vehicle provides a method of dissipating these high voltages. Bonding does not prevent the generation of high voltages within the fuel hose and the fuel tank, but provides a return path for the accumulated charges as contact is made with the inside fuel tank surface.

4.3.1.3.6 Studies by Naval Research Laboratory (NRL), German Air Force, United States Air Force (USAF), and others have provided data on the magnitude of voltages and current which might be encountered during the fueling process. Field strengths generated by this process may range to 500 kilovolts/meter (kV/m); thus, at a centimeter distance, a 5 kV potential may be present. The 500 kV/m field is normally confined to the fuel tank interior. However, depending on the locations of the separated charges and the degree of electrical isolation of the aircraft, fields of this intensity may appear on the exterior as charge bleed-off occurs. The resulting voltage on the exterior of the tank is dependent on the physical configuration and could reach breakdown or arcing level near sharp edges. Measurements after fueling aircraft have provided values of 2.5 kV.

4.3.1.3.7 A person in contact with an aircraft charged by induction to 2.5 kV could discharge 15.6 millijoules (mJ) of energy from the aircraft.

$$U = 1/2\ CV^2$$

$$= 1/2\ (0.005\ \mu F)(2.5\ kV)^2$$

$$= 15.6\ mJ$$

This level exceeds the threshold value for reflex shock reaction.

To further analyze potential hazards:

$$t = RC \ln \left(\frac{E_i}{E_s} \right)$$

where t = time to reach E_s after removal of source

R = aircraft resistance to ground (Ω)

C = aircraft capacitance to ground (f)

E_i = initial (source) voltage (V)

E_s = safe voltage level (V)

Using the ungrounded aircraft resistance of 40 MΩ, an aircraft capacitance to ground of 0.005 μF, a safe voltage limit of less than 30V, and 2.5 kV as the initial voltage.

$$t = (40\ M\Omega)(0.005\ \mu F)\ln\left(\frac{2.5\ kV}{30}\right)$$

$$= 0.88\ sec.$$

Heart discoordination (fibrillation) threshold levels have time durations as low as 0.2 sec, which makes the 0.88-sec discharge time very dangerous and unacceptable.

4.3.2 Power. Various types of electrical power, such as 115 volts, alternating current (vac), 28 volts, direct current (vdc), lightning, and radio frequency (rf) are discussed in the following paragraphs. The term power used in this context assumes electric current flow measuring amps, in contrast to static electricity whose current flow, typically, is in the range of thousandths of an ampere.

4.3.2.1 Ground power fault. The purpose of the equipment grounding conductor in an electrical system is to provide a path for current to flow under ground fault conditions. The equipment ground path must have sufficiently low impedance to limit voltage rise and to permit ample current to flow. This ensures rapid operation of the overcurrent device when a ground fault occurs. If a ground fault occurs and the overcurrent device operates slowly or not at all, the result can be electrocution of personnel, fire, or destruction of equipment.

4.3.2.1.1 Ground power fault occurs when the high voltage side of an external power connection is brought into contact with the airframe. The main reason for this occurrence is an internal miswiring of the connector plug or backward attachment of the connector. Component failure has also been partly responsible. The best way to avert as many problems as possible is to carefully examine the connectors for any evidence of damage prior to connecting to aircraft or chassis receptacles. These connectors are particularly prone to damage because of the nature of their function, repetitive connection, and disconnection under all conditions.

4.3.2.1.2 Due to differences between power and static energy sources, a ground point with a much lower impedance to earth is needed. A distinction must be made between the power or maintenance ground (less than 10 ohms) and the static ground (less than 10,000 ohms).

4.3.2.1.3 When the aircraft power is being supplied by a Mobile Electrical Power Plant (MEPP), the problem is that of parallel ground paths. Whether an engine-driven ground power unit (GPU), electrical-driven unit, Flight Line Electrical Distribution systems, (FLEDS), or deck edge power is used, all systems face the same problem. (See figure 4-6.)

4.3.2.1.4 The direct current (dc) is 28V and is a two-wire system with a positive and negative. The negative of the system is connected to the aircraft structure and cart chassis through the connector. The alternating current is 115V ac, 400 hertz (Hz) and is a four-wire system consisting of phase A, phase B, phase C, and a neutral (N). The neutral wire is connected to the aircraft structure and cart chassis through the connectors. As the figure illustrates, the purpose is to keep the aircraft at ground potential but also to let the circuit breakers operate

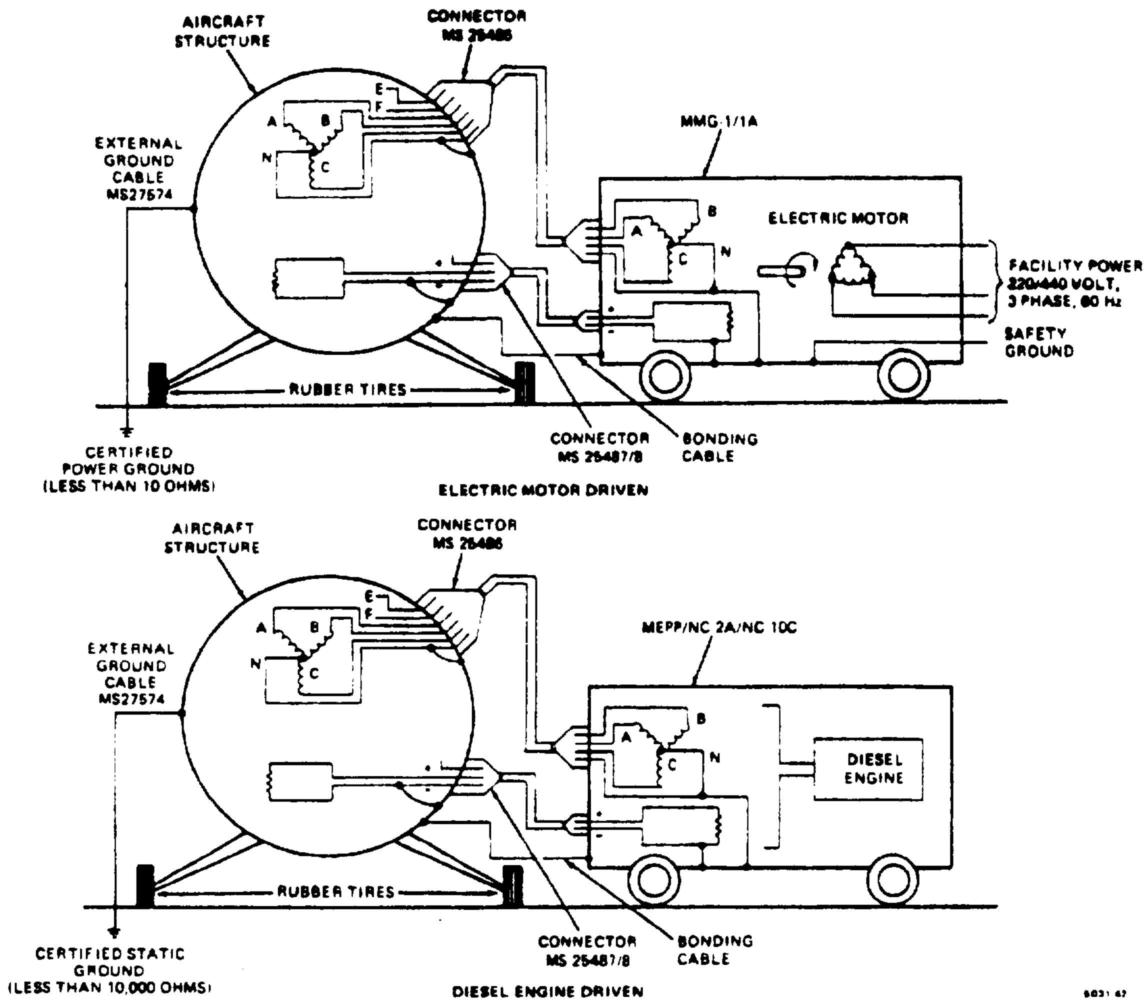


FIGURE 4-6. Ground power fault scenario.

properly. Bonding the aircraft to ground power unit (GPU), using a suitable grounding cable, will help avert dangerous situations. When the fault occurs, the entire airframe is at power line potential, 120V to 220V and may be capable of supplying currents as high as 200 amps. Power introduced from an external source complicates the selection of an earth return limit. The maximum allowable earth resistance is dictated by the requirement that sufficient current flows to trip power circuit protective devices under earth fault conditions. The trip time (time to open circuit, a function of the earth path resistance) for power faults must also be considered. Personnel safety requires that the earth path resistance be low enough to allow a 500% to 600% overload current with a trip time of approximately 0.2 sec. Thus a 120V, 50 amp service requires an earth path return resistance of 0.5 ohm for safety under power fault conditions. Locations which do not provide 0.5-ohm earth resistance are limited in the safe maximum load which can be handled. As an example, a 120V source with 10 ohms in the return path and a 600% overload trip level of 0.2 sec response time is limited to a service current of:

$$I = \frac{E}{R \quad \text{overload}} = \frac{(120)}{(10)\ (6.00)} = 2A$$

Unfortunately, very few ground points are able to meet a 0.5 ohm or less require- A more practical value of less than 10 ohms for power grounds is recommended.

4.3.2.2 RF electromagnetic energy. Today's environment has many unintended side effects caused by radio frequency (rf) transmitting devices used in conjunction with naval flight operations. Of concern are those high power communication and radar transmitters which may be located near parked aircraft. The best example of this situation is the carrier flight deck, which probably contains the highest concentration of transmitted rf energy to be found on any base from which aircraft operate. Although high power communication and radar transmitters may be found at greater distances from parked aircraft at a shore station, an aircraft may be affected by an adjacent aircraft whose onboard communication system or radar transmitters are being tested.

4.3.2.2.1 The principal problem is the amount of rf energy which is induced into the aircraft frame and circulating on the aircraft skin. This quantity or level of rf energy is greatly affected by the position of the aircraft relative to a particular rf transmitter, the power output of that transmitter, and the actual frequency of the rf energy being transmitted. It is further affected by the actual location of any connections between the aircraft and ground (deck). Where the position of one ground may have a significant effect on the induced current, other ground connections from different locations on the aircraft to other locations on the deck may not have the same effect. Any existing aircraft grounding scheme should not be altered in an effort to provide the aircraft with additional protection against rf energy. If the ground connection is broken while the rf transmission is in progress, an electric arc may be drawn out. This is an important fact to note. If an arc is produced while disconnecting a ground, the source may be rf energy, caused by a local transmitter and the current flow can be high. (A power line short circuit to ground may also produce an arc when the ground is disconnected.) If, on the other hand, an arc is drawn while a ground is being attached to the aircraft, the source is static electricity and the current flow will be light.

4.3.2.2.2 RF arcing is not limited to aircraft only. In high rf fields, arcs generally occur at the discontinuities in conductors (conductor meaning any metal surface). A discontinuity is any place where the nature of the conductor changes. Examples of this include gaps between metal surfaces and places where the type of metal changes or the thickness of the metal changes.

4.3.2.2.3 Another factor which has an influence on the occurrence of rf arcing is the actual physical dimensions of the metal surface. Not all conductors within an rf field are susceptible to arcing at their discontinuities. Objects which are large with respect to a wavelength (several wavelengths in each direction perpendicular to the line of transmission) tend to reflect the rf energy and are less apt to produce arcing. Objects which are long in one dimension but not in the other tend to be a more favorable site for arcing.

4.3.2.2.4 RF arcing can be separated into two categories: rf glow discharges and rf arc discharges. In rf glow discharges, a high minimum voltage is necessary to maintain the discharge. The voltage rises linearly to an ignition voltage of 350V to 500V, then decreases slightly after the current flow begins. The current flow ceases when the field can no longer sustain the high voltage. Even at very small separations between elements, a minimum voltage of 275V is necessary to sustain the glow.

4.3.2.2.5 Conversely, rf arc discharges are sustained at relatively low voltages. The events leading to the formation of the arc plasma are similar to those of glow discharge. However, once the arc plasma forms, the voltage can usually drop to as low as 30V without the arc extinguishing.

4.3.2.3 Lightning. Lightning is a discharge of atmospheric electricity from one cloud to another, within a cloud, or from a cloud to earth. Table 4-I provides a listing of lightning characteristics. The cloud to earth or ground strike is the type of discharge that produces the direct lightning strike. Due to its large amount of energy and potential for destruction, the direct lightning strike is one source of energy that can be very dangerous to personnel and aircraft. A direct lightning strike can damage an aircraft and its equipment. Voltages as high as 500 kV and currents to 200 kiloamperes (kA) have been known to occur.

4.3.2.3.1 These high levels could puncture the aircraft if the skin is not sufficiently thick or could possibly cause localized melting. Damage to the aircraft's electronic equipment or ignition of the fuel tank could occur, depending on the location of the strike.

4.3.2.3.2 A person in contact with the ungrounded aircraft during a direct lightning strike risks death or severe injury. For personnel who wear communication headsets the probability of occurrence and the severity of injury increase.

TABLE 4-I. Lightning characteristics.

Characteristic	Specification
Types	Intra/intercloud Cloud-ground Positive Negative
Potential	30-100 million volts
Current	20-200 kA (peak)
Power	10^{12}W nominal (peak)
Energy	$5x10^{8}$J nominal (200 lb TNT equivalent per strike)
Extent	3-30 km/strike (path is predominately horizontal)
Spectrum	Peak energy near 10 kHz, some above 10 MHz
Duration	Strike - 100 μs Flash - 0.2 sec (1-20 strikes)

4.3.2.3.3 A typical discharge between cloud and ground starts in the cloud and eventually neutralizes tens of coulombs of negative cloud charges. The total discharge is called a flash and lasts about 1/2 sec. A flash is made up of various discharge components, among which an average of three or four high-current pulses occur, called strokes, and a possible continuing current stage. In the idealized model, electrical storms cause the clouds to acquire a negative charge. The earth, or in this case the aircraft, has an opposite charge and lightning occurs when the electric potential overcomes the insulation of the air.

4.3.2.3.4 The breakdown within the cloud produces what is called a stepped leader. The leader starts from the cloud and heads toward the ground. The leader advances in a series of rapid discontinuous steps each about 50 meters (m) long and separated by pauses of about 50μs. The luminous diameter of the stepped leader is between 1 and 10 m, although it is thought that the leader current of about 100 amps flows in a small diameter core at its center. The average propagation velocity is about 1 m/s. It looks like a column of light with branches emanating from the sides. The electric potential of the leader channel with respect to the ground is about -1×10^8 V. As the leader tip nears ground or aircraft, the electric field beneath it becomes very large and causes one or more upward-moving discharges which start the attachment process. When one of the upward-moving discharges from the ground contacts the downward-moving leader, the leader tip is connected to ground or aircraft potential. The leader channel is then discharged into the aircraft. The height of the aircraft affects the probability of this happening. The taller the aircraft the more likely it is to happen. Thus, by locally compressing the field, there are more likely to be points where the discharge takes place. (See figure 4-7.)

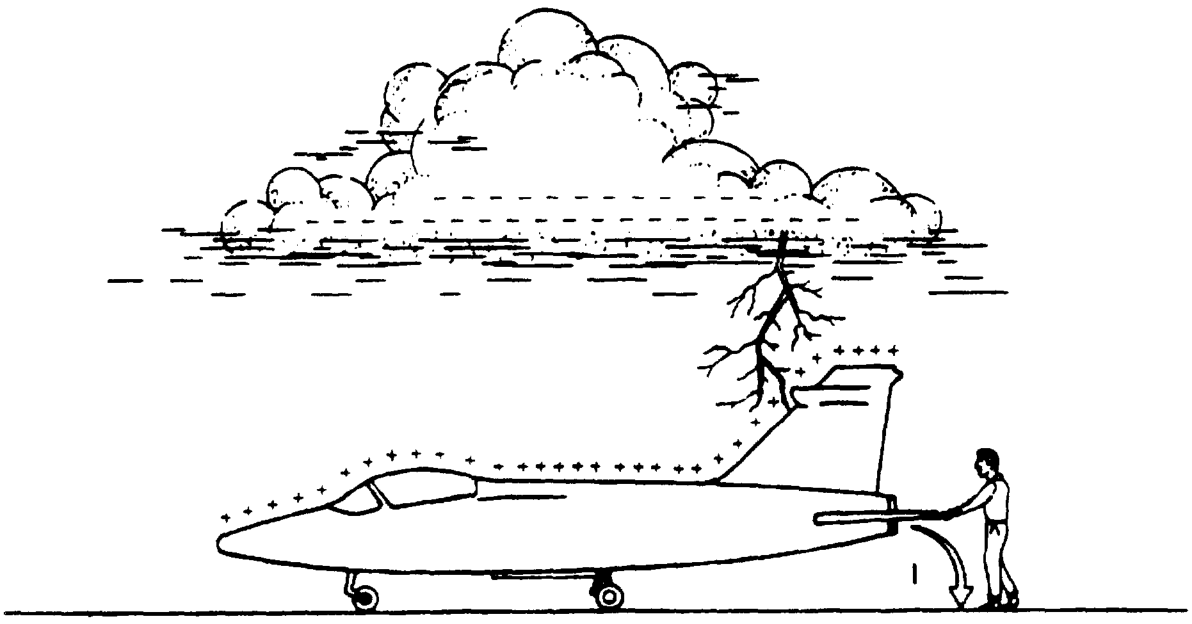


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FIGURE 4-7. Lightning strike to parked aircraft.

4.3.2.3.5 Intracloud and intercloud lightning discharges occur between positive and negative cloud charges and have total durations about equal to those of ground discharges (1/2 sec). A typical cloud discharge neutralizes 10 to 30 coulombs (C) of charge over a total path length of 5 to 10 km. (See figure 4-8.)

4.3.2.3.6 Intracloud and intercloud discharges have not been studied as extensively as cloud discharges to ground, and hence much less is known about their detailed physical characteristics. The charge motion for intracloud and intercloud discharges produces electric fields whose frequency spectra have roughly the same amplitude distribution as electric fields produced by cloud to ground discharges for frequencies below about 1 kHz and above 100 kHz. Between 1 and 100 kHz, the ground discharge is a more efficient radiator.

4.3.2.3.7 Energy levels of near strikes can be sufficiently high to damage electronic equipment, again, depending on the location of the strike. Distant lightning strikes and lightning from one cloud to another will also charge an aircraft. Grounding will not keep these induced charges from accumulating on an aircraft, but will reduce the amount of time required to bleed off the charge.

4.3.2.3.8 The most important parameters of the current waveform are peak current, rate of rise, total duration, charge transferred, and action integral. The units of action integral are amp^2 sec which may alternatively be expressed in units of joules per ohm since the action integral is proportional to the energy dissipated in a given resistance. (See figures 4-9 and 4-10.)

4.3.2.3.9 The charge transfer, Q, is defined as the integral of the time-varying current over its entire duration, or

$$Q = \int_0^T i\,dt \text{ (ampere-seconds or coulombs)}$$

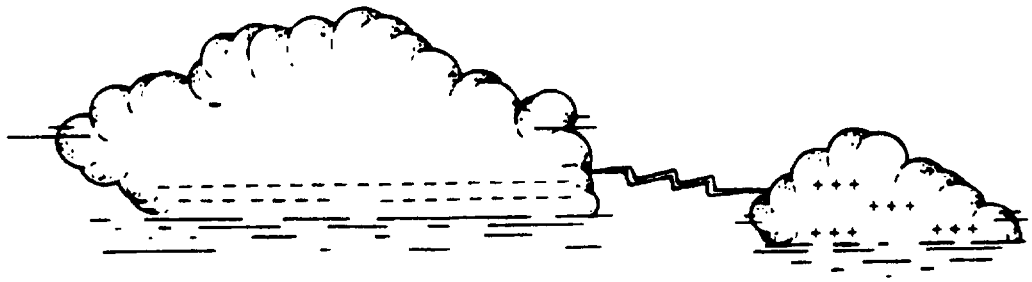
and is equivalent to the area beneath the current waveform as shown in figure 4-11.

4.3.2.3.10 The action integral of a current waveform is a measure of the ability of the current to deliver energy and is defined as the integral of the square of the time-varying current over its entire duration.

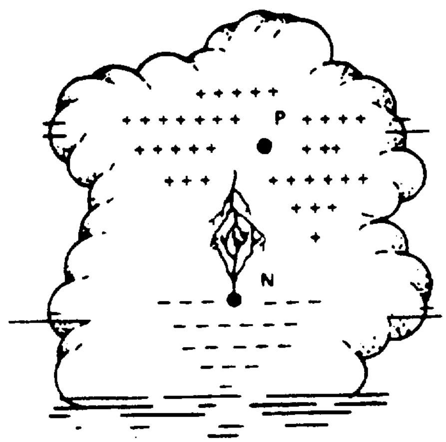
$$\int_0^T i^2\,dt \text{ (ampere}^2\text{-seconds)}$$

4.3.2.3.11 Grounding an aircraft offers some protection against lightning, even a direct strike. A major direct lightning strike usually is preceded by less powerful leaders which determine the direction of the main strike. Grounds can control the direction of the leaders away from the tires and consequently control the direction of the main strike. In addition, if a direct strike occurs, the ground wire may vaporize contributing to the conductivity of the ionized path, and thereby minimizing leakage currents through nearby personnel.

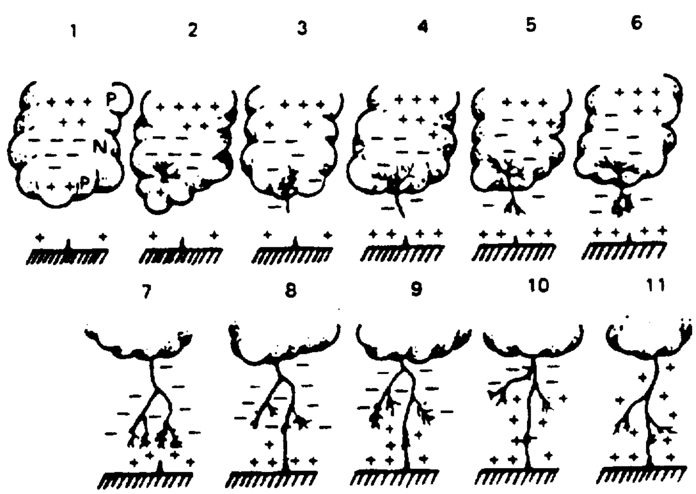
4.3.2.3.12 Lightning discharge through an aircraft to earth is an extremely variable phenomenon. Voltages as high as 0.5 million volts and currents from 200 to 200,000 amps are cited in the literature. At such high levels, grounding will not afford the degree of protection or confidence factor attained for static electric protection. Nevertheless, a safety ground will aid in protecting personnel and equipment to some extent, especially for the lower energy strikes.



CLOUD TO CLOUD DISCHARGE(INTERCLOUD STRIKE)



INTRA CLOUD DISCHARGE(WITHIN A CLOUD)



CLOUD TO GROUND DISCHARGE(BUILDUP PROCESS)

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FIGURE 4-8. Various cloud discharges.

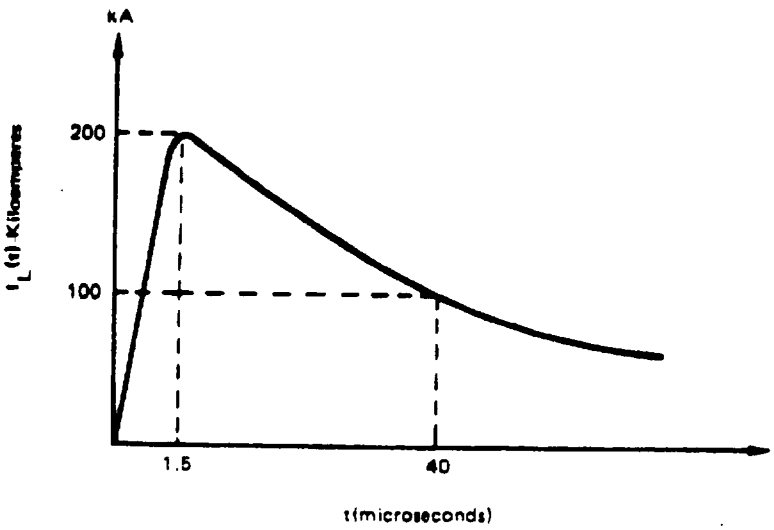

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FIGURE 4-9. Lightning current pulse, time domain.

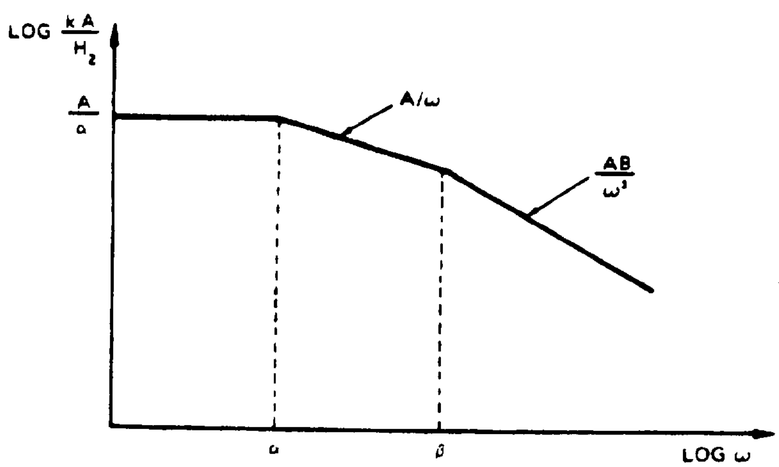

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FIGURE 4-10. Lightning current pulse, frequency domain.

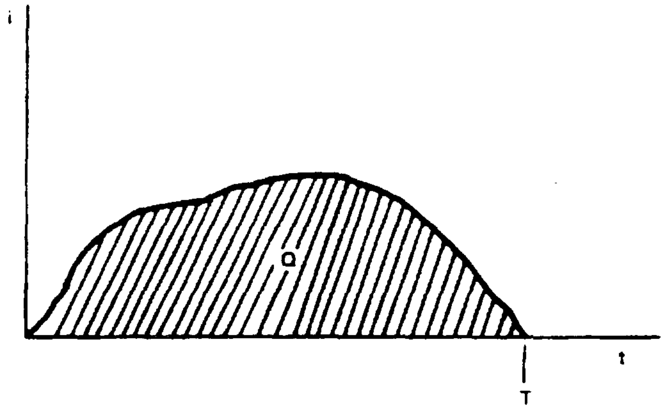


FIGURE 4-11. Charge transfer of a current waveform.

4.3.3 Summary. In summary, the levels of electrostatic and electrical energies considered are given in table 4-II.

4.4 Airframe/personnel electrical parameters. When energy sources are considered in terms of voltage or current, the electrical characteristics (ie, tire resistance to ground and airframe capacitance to ground) are required to establish time duration and other parametric relationships (eg, current to voltage and current or voltage to total energy). Airframe electrical parameters interact with charge generation mechanisms and thereby establish the actual hazard levels and time duration for these hazards. Airframe capacitance to earth and airframe resistance to earth are most relevant. Capacitance establishes the total charge stored due to a particular potential and the time factor required to dissipate a charge from a surface through a particular resistance. Resistance establishes the voltage associated with known current flows and the time factor for charge reduction when the capacitance is known. Resistance was found to be the more variable parameter.

TABLE 4-II. Summary of electrical energy sources.

Source	Level	
	Voltage	Current
Triboelectric	-	0.03 mA
Fuel flow	2.5 kV	0.013 mA
Induced charge	60 kV	-
Friction	27 kV	-
Ground power fault	220 V	200 A
RF induced	No established values	No established values
Lightning	500 kV	200 kA

4.4.1 The ability of a body to store electrostatic charge is determined by the capacitance of that body. The amount of charge that can be stored on a capacitor is expressed by the mathematical expression

$$Q = CV$$

where Q is the amount of charge (in coulombs), C is the capacitance of the body (in farads), and V is the voltage (in volts) developed between the plates of the capacitor. The rate at which the capacitor charges or discharges is determined by the electrical resistance, R (in ohms), through which the capacitor charges or discharges (see figure 4-12.)

4.4.2 Aircraft in their normal environment have electrical properties similar to resistors and capacitors. The resistance is usually determined by tires, mooring chains, or static ground straps. This is illustrated in figure 4-13.

4.4.3 Aircraft resistance is affected by both the resistances of its tires and the runway surface and also by the contact between the tires and the surface. Tire resistance is a highly variable parameter. As a tire wears, its resistance increases due to the breaking of the carbon black chains.

4.4.4 The load on the aircraft and the pressure of the tire affect the resistance of the aircraft by affecting the tires' contact with ground. Increasing tire pressure increases resistance, and increasing load decreases resistance. Laboratory measurements have indicated tire resistances as high as 3400 MΩ.

4.4.5 Finally, the material of the runway is a factor in the resistance of the aircraft to the ground. Dry asphalt has an exceedingly high resistance, while snow and water on surfaces decrease the resistance. Field measurements have measured total aircraft resistance to ground as high as 40 MΩ.

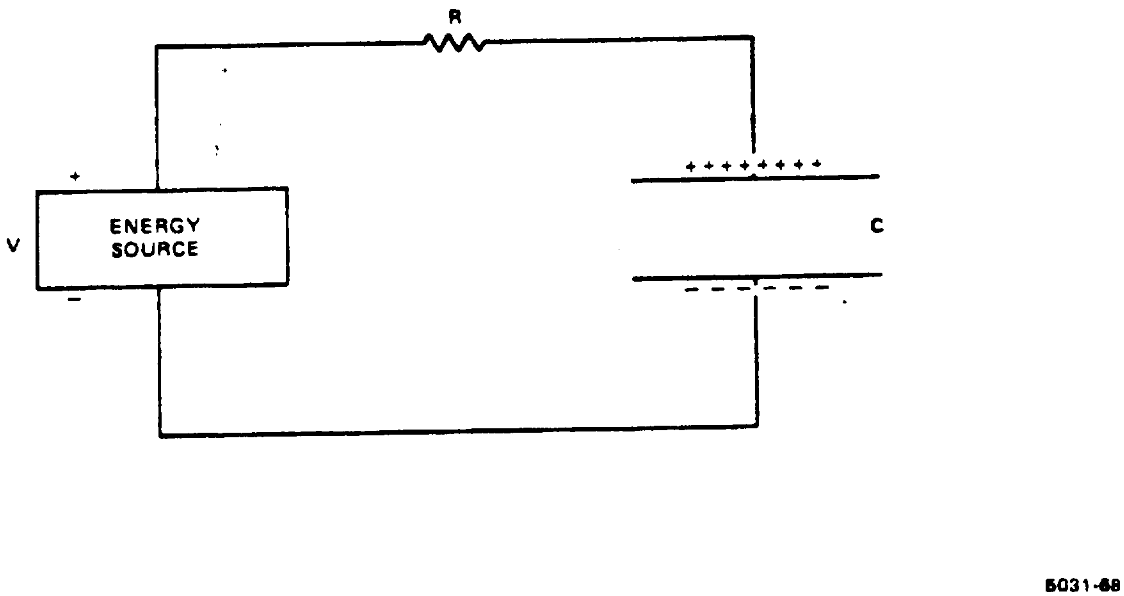


FIGURE 4-12. Simulated RC network.

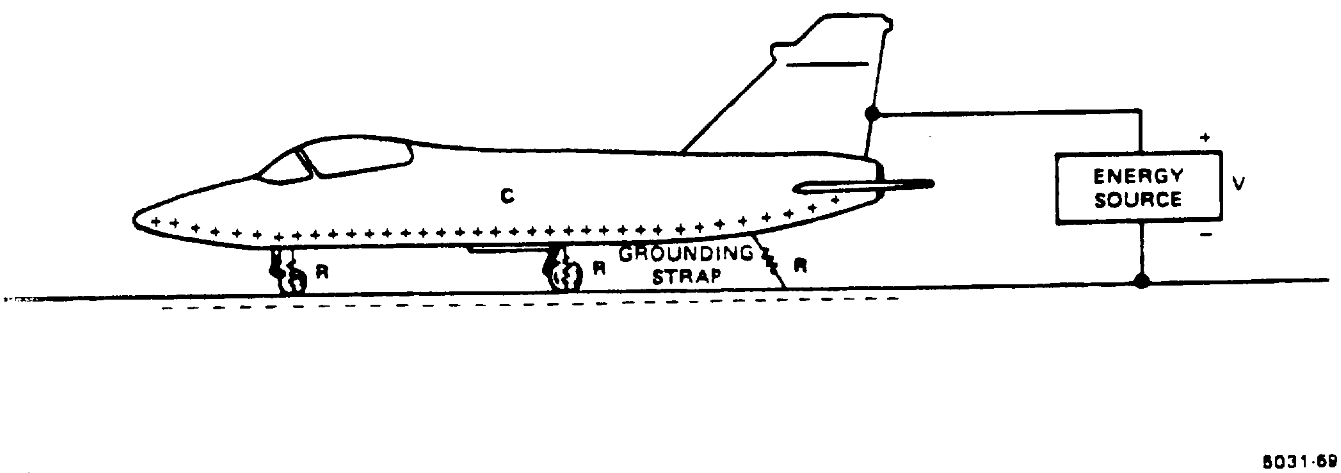


FIGURE 4-13. Aircraft acting as capacitor.

4.4.6 The capacitance of aircraft was found to be a consistent parameter. Values of 0.002 to 0.005μF were measured over a wide range of aircraft types and ground plane materials.

4.4.7 In addition to the characteristics of the aircraft, the values of human body electrical parameters are needed. Values of 500 pF capacitance and 50 to 1500 ohms resistance are representative values for descriptive/discussion purposes. The pertinent electrical characteristics are summarized in table 4-III.

4.4.8 The rate at which a capacitor or an aircraft discharges is determined by its time constant and is given by the relationship

$$T = RxC$$

where T is time in seconds. A capacitor can be assumed to be completely discharged after five time constants or 5T. Aircraft capacitance is a fixed quantity under a particular parked configuration. Therefore, in order to reduce the discharge time, the resistance must be reduced. Aircraft tires measured in the field have resistances as high as 40MΩ. Aircraft capacitance values have been measured as high as 0.005 μF. Using the previous equation

$$T = (40 \times 10^{6}) \times (.005 \times 10^{-6})$$

$$T = 0.2 \text{ sec}$$

$$5T = 1 \text{ sec}$$

4.4.9 Discoordination threshold levels of the human heart action have time durations as low as 0.2 sec. Thus, 1 sec for the aircraft to discharge is unacceptably long. If, for example, a maximum resistance of 10,000 ohms is considered, the same calculation yields a capacitance discharge time of 0.25 ms. This is well below the 0.2 sec critical value. Therefore, it is necessary to reduce aircraft-to-ground resistance by grounding the aircraft, thus bypassing the aircraft tires and mooring chains.

4.5 Damage threshold levels. The third variable needed for analysis is the threshold for injury or damage due to electrical effects.

4.5.1 Fueling. The minimum energy threshold for ignition of fuel is 0.25 mJ.

4.5.2 Stores. A level of 35 mJ is the potential danger level during stores and ordnance handling. The ignition of electroexplosive devices (EED) in various actuating mechanisms is the most common danger area.

TABLE 4-III. Electrical parameters.

Characteristic	Specification
Aircraft capacitance	0.002 to 0.005 μF
Aircraft resistance	1.0KΩ to 40 MΩ
Body capacitance	500 pF
Body resistance	50 to 1500 ohms

4.5.3 Shock to personnel. There are two possible sources of injury to personnel from shock:

a. Involuntary reflex movements which can result in injury due to secondary effects, such as falling.
b. Electrical effects which result directly in injury.

4.5.4 Reflex action appears in the area of 10 to 30 mJ (1 to 3 mA across 10,000 ohms); a representative voltage is approximately 50V (30 mJ and 1500 ohms). The threshold level for potentially lethal shock was established as 30 vac and 45 vdc at energy levels of 600 mJ ac and 1.35 J dc, assuming a body resistance of 1500 ohms.

4.5.5 Equipment damage level. The threhsold level for equipment damage is a function of dielectric breakdown (high voltage effect), high temperature damage (high power effect), or a combination of both. One mJ an cause upset when directly injected into sensitive circuits. However, since direct injection is unlikely, a coupling factor of approximately 10 is assumed to establish a minimum threshold of 10 mJ for the practical lower limit of sensitive equipment upset. Damage levels are taken as 35 mJ, comparable with ordnance thresholds.

4.5.6 Summary of damage threshold levels. In summary, the levels of electrostatic and electrical energies considered are tabulated in table 4-IV.

4.6 Analysis. The basic purpose of the previous material of this section has been to establish the data which verify or disprove the hypotheses that an electrical hazard exists and grounding will eliminate or reduce this hazard. The first hypothesis (hazard exists) is assessed by a comparison of energy source levels with hazard threshold levels and scenario particulars. The second hypothesis (grounding reduces hazard) is assessed by considering the extent to which application of an electrical ground alters the available energy, location of discharge, or duration of hazard. The results of the analyses are summarized in paragraph 4.6.3 following the detailed analysis below.

TABLE 4-IV. Summary of damage threshold levels.

Action	Electrical energy
Reflex action shock	10 mJ, 50V
Shock to personnel power	600 mJ (ac) or 32 vac or 3 mA 1.35 J (dc) or 45 vdc or 3 mA
Stores and equipment	
EED ignition	35 mJ
Component damage	35 mJ
Component upset	10 mJ
Fuel vapor ignition	0.25 mJ or 40 kV

4.6.1 Source magnitude and hazard threshold level. The magnitude of potential energy sources is compared with hazard threshold levels to identify those combinations which could result in a hazard.

4.6.1.1 An upper boundary of 0.03 mA defines the worst case triboelectric energy source. Since in an ungrounded aircraft this current flows from earth, through the aircraft tire resistance, to the airframe, and thence to the snow, dust, etc. causing the effect, the potential between airframe and earth is determined almost entirely by the tire resistance. While laboratory measurements of tire resistance in the 100-MΩ range have been made, the worst case measured value of 40 MΩ, obtained in the field, is used here to compute airframe potential of

$$V = IR = (0.03 \text{ mA})(40 \text{ M}\Omega) = 1200\text{V}.$$

Using a value of C=0.005 μF, the energy level, U, could reach

$$U=1/2CV^2 = 1/2(0.005 \mu F)(1200V)^2 = 3.6 \text{ mJ}.$$

The value of U and V above exceed the hazard threshold levels for fuel vapor ignition and nonlethal shock to personnel.

4.6.1.2 The value for the worst case static voltage level is 27 kV. In addition, energy levels may range as high as 0.18 J. Comparison with the hazard threshold values in paragraph 4.5.5 shows that the thresholds for reflex level shock to personnel, fuel vapor ignition, and stores or equipment damage are exceeded.

4.6.1.3 During fuel transfer the separation of charge can result in electrical current of 13 μA. Also, measurements indicate that at the termination of a fueling operation, after bonding straps are disconnected, a completely isolated aircraft may exhibit static voltage levels of as high as 2.5 kV. The 13-μA current flow due to fuel transfer can result in voltages of

$$V = IR = 13 \mu A \times 40 \text{ M}\Omega = 520V$$

if only return path is through the airframe. While this condition will not exist when the aircraft is properly bonded to the fuel supply system, both improper connection of bond clips (to painted or nonmetallic surfaces) and poorly maintained bonding cables (loose and/or rusted connections) were observed during the field survey. Thus reliance on the bonding strap alone could, if the bond is faulty, produce 520V between airframe and earth or refueler. This represents an energy level, U, of

$$U = 1/2CV^2 = 1/2(0.005 \mu F)(520V)^2 = 0.68 \text{ mJ}.$$

4.6.1.4 In the case of electrically isolated aircraft, after disconnection of the bond the available energy can reach

$$U = 1/2CV^2 = 1/2(0.005 \mu F)(2.5 \text{ kV})^2 = 15.6 \text{ mJ}.$$

4.6.1.5 These values exceed the threshold hazard values for ignition for fuel vapor. Therefore, fuel vapor ignition should be considered during fuel transfer. For the electrically isolated aircraft, fuel vapor ignition, equipment upset, and reflex shock reaction by personnel must be considered.

4.6.1.6 The source level has been established as due to charge induced by storm activity. Energy levels may then reach

$$U = 1/2CV^2 = 1/2\ (0.005\ \mu F)(60\ kV)^2 = 9\ J.$$

These levels exceed threshold values for all hazards:

4.6.2 Time duration considerations. Some of the phenomena cited in paragraph 4.6.1 are transient in nature. Knowledge of their duration is necessary to assess them as realistic hazards. Induced voltages, friction voltages, and voltage buildups following fueling are considered transients.

4.6.2.1 Using the ungrounded aircraft resistance of 40 MΩ, an aircraft capacitance to ground of 0.005 μF, and a safe voltage limit of less than 30V, the following time durations were computed from:

$$t = RC\ \ln\left(\frac{E_i}{E_s}\right)$$

where t = time to reach E_s after removal of source

R = aircraft resistance to ground

C = aircraft capacitance to ground

E_i = initial (source) voltage

E_s = safe voltage level

Transient Source	E_i Source Magnitude	Time to E_s
Friction	27.0 kV	1.36 sec
After-fueling potential	2.5 kV	0.88 sec
Induced	60.0 kV	1.52 sec

4.6.2.2 Any transient is objectionable from a safety standpoint. As stated earlier, heart action discoordination (fibrillation) threhsold levels have time durations as low as 0.2 sec. Thus, the duration of even the shortest of the three transients considered is unacceptably long.

4.6.3 Hazards. Ungrounded aircraft must be considered to be in jeopardy from the indicated energy source, since at least one (and generally more than one) hazard threshold level is exceeded during each scenario. These results are summarized in table 4-V below. The possibility of these hazardous events occurring is ensured by the physical data available. However, each is dependent on a number of factors which may occur simultaneously only very rarely (for example, the refueling of an aircraft with 40 MΩ impedance to earth, a fuel spill, and an electrical spark located at the right point in the volume of fuel vapor or misted fuel to cause ignition). In any single one-time event, such as an aircraft repair or refueling operation, consideration could be given to the fact that hazardous combinations appear so seldom that they may be neglected. However, when consideration is given to the number of naval aircraft involved, the rapid tempo of operations, the fact that these are military operations (not always conducted under ideal conditions), the high cost of equipment, and the threat to personnel safety, electrical grounding for safety becomes an imperative requirement. Electrical airframe grounding, like safety belts in automobiles, is statistically indicated by, among other things, the vast numbers involved.

4.6.4 Effects of grounding. In each of the scenarios considered, the use of a proper ground connection ensures that the airframe is maintained at the same potential as the ground point for those sources considered, except in the case of external power systems. In addition, since the airframe resistance to ground is greatly reduced, the duration of such effects as induced voltages is reduced to fractions of a millisecond. As an additional advantage, the use of a proper grounding procedure ensures that any arcing or electrical discharge associated with the act of connecting grounds take place at the ground point rather than near the airframe.

TABLE 4-V. Potential hazard relationship to energy sources and scenarios.

Scenario	Energy Source					
	Tribo	Friction	Fuel trans	Atmospheric induced fields	External power system	Lightning
Maintenance	AD	ADE	-	ADE	BD	BCDE
Fuel	AD	ADE	ACDE	ACDE	BCDE	BCDE
Stores Handling	AD	ACE	-	ACE	-	BCDE
Park	AD	ACDE	-	ACDE	-	BCDE

where: A = Static shock to personnel
B = Power shock to personnel
C = Ordnance EED/stores misfire/release
D = Fuel vapor ignition
E = Electronic equipment damage

SECTION 5

5.0 TESTING AND IDENTIFICATION OF GROUND POINTS.

This section describes techniques necessary for accurate measurement of resistance ground points. Intended for use by public works department personnel, this section gives the theoretical background, required measurement equipment, and measurement procedures. Also provided are a suggested schedule for testing, the identification of ground points, and the use of mooring eyes as static ground points.

5.1 Theoretical background. For explanation of the three terminal fall of potential method, see circuit shown in figure 5-1. With a 30V source and a measurement current of 6 amps, the resistance of the resistor is 5 ohms, as calculated by Ohm's law.

5.1.1 In measuring ground points, measurement is taken of the resistance between the driven ground rod and the main body of earth. If a test connection could be made on the centerline of the earth (see figure 5-2), Ohm's law could again be applied to the circuit. Since such a connection is impractical, an alternate method must be used.

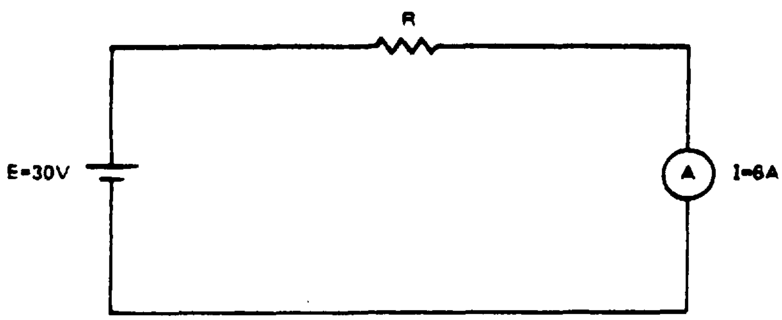
5.1.2 Picture a ground rod being surrounded by shells of earth, all of equal thickness (see figure 5-3). The earth shell closest to the rod has the greatest resistance due to the fact that it has the smallest surface area. Each successive shell has a larger area than the previous one and thus less resistance. Farther out, a point is reached where the inclusion of additional earth shells has no significant effect on the resistance of the earth surrounding the rod. Therefore a measurement can be made (within a reasonable distance) between the ground rod and a test rod.

5.1.3 In reality, the rod has a resistance (R_c) associated with it. To exclude this resistance from the measurement, a three terminal test technique is used, as shown in figure 5-4. The use of a potential probe enables a voltage measurement to be made across R. Using the ammeter reading for the current through R, we can compute the value of R using Ohm's law. The resistance of R_p is very high, a characteristic of all voltmeter probes.

5.2 Measurement equipment. Below is a list of the preferred measurement equipment manufactured by James G. Biddle Instruments. Similar testers by other manufacturers that have equivalent characteristics may also be used. Other meters, such as VOMS and VTVMs, are not suited for the task of providing accurate resistance measurements of ground points, and therefore should not be used.

a. 1 - Null balance earth tester, Biddle model no. 63241; with accessories case, model no. 63850; accessory kit, model no. 63578; spare leads, model no. 63576.

b. 1 - Megger, Biddle model no. 21159; with accessories case, model no. 217719; two sets leads, model no. 21963B.



$$R = \frac{E}{I} = \frac{30}{6} = 5\Omega$$

5031-3

FIGURE 5-1. Simple electrical circuit utilizing Ohm's law.

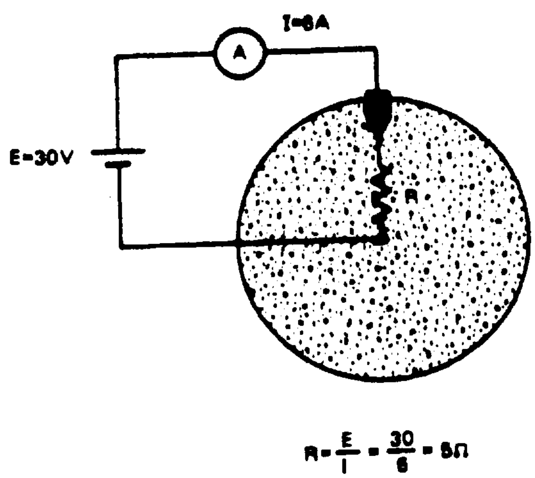


FIGURE 5-2. Illustration of earth resistance.

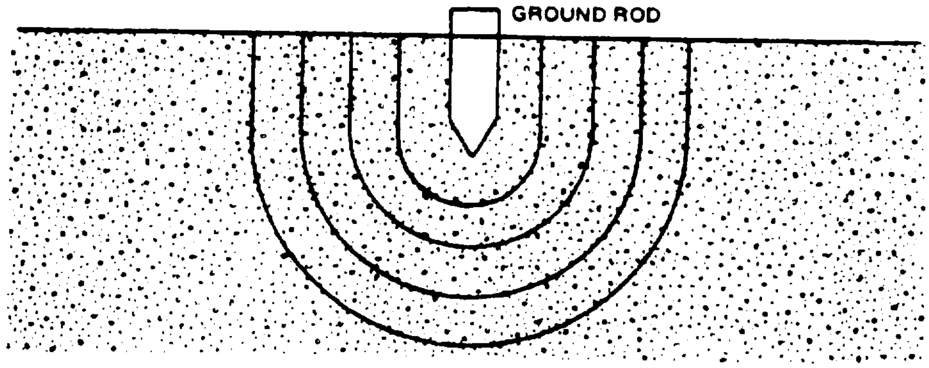


FIGURE 5-3. Illustration of earth shells.

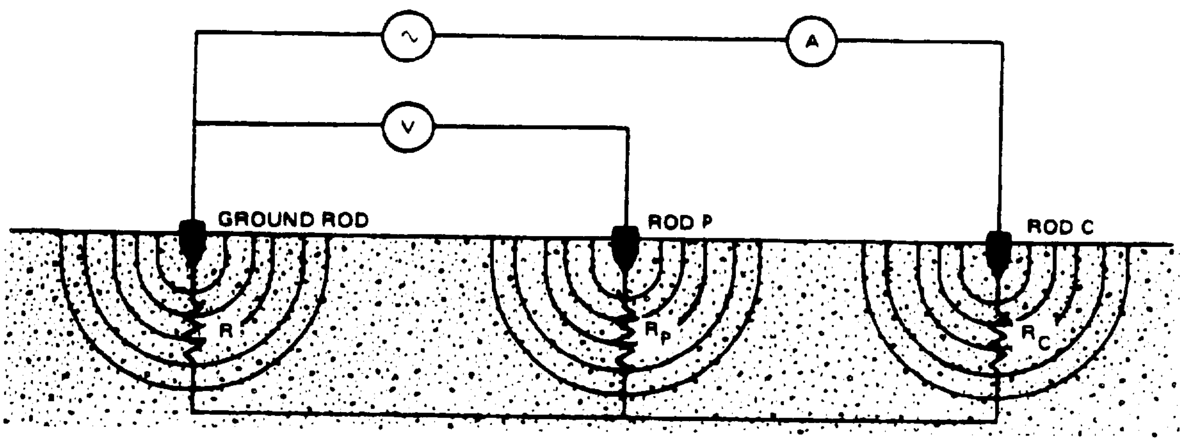


FIGURE 5-4. Three-terminal test technique.

5.2.1 The null balance earth tester includes batteries for its voltage source and an ohmmeter to measure the resistance directly. The tester generates an ac test current which is passed between the ground rod and the current rod. AC is used to eliminate errors due to existing dc currents and voltages that may be present in the earth. The voltage drop at the potential rod is applied to a bridge circuit and nulled with a three-decade variable resistance. When at balance (no current flowing through the potential rod), the ground resistance is obtained from the readout of the digital decade switches. Although other equivalent meters may have different types of power supplies (such as hand-cranked generators) and different readout devices, the principles of operation are still the same.

5.3 Ground points measurement procedures. The following paragraphs provide step-by-step procedures for performing accurate ground point resistance measurements. The three-terminal fall of potential method should be used when measuring ground points on the apron. This includes certified power grounds, certified static grounds, mooring eyes, and FLEDS lightning protection grounds. The two-terminal method should be used when measuring hangar ground points, the facility's ac neutral line, and in situations where the three-terminal method is impractical. A resistance value of less than 10 ohms is recommended for certified power grounds, FLEDS lightning protection grounds, hangar ground points, and the facility's ac neutral line. Certified static grounds and mooring eyes are recommended to be less than 10,000 ohms.

5.3.1 Three-terminal fall of potential method. The test setup for performing the three-terminal fall of potential method is shown in figure 5-5. This test is performed as follows:

a. Connect test lead I from the tester to the ground point being evaluated.
b. Drive a metal reference rod (rod C) into the ground at a distance of 100 ft (30.5 m) from the ground point being evaluated. Connect test lead C from the tester to this rod.
c. Drive a metal rod (rod P) into the ground approximately 62 ft (18.9 m) from the ground point being evaluated and in line with the reference rod (rod C) installed in step b above. Connect test lead P from the tester to this rod (rod P).
d. Adjust the resistance dials on the tester until the indicator dial is centered (zeroed) on the scale. When the dial is centered, the resistance value (in ohms) of the ground point being evaluated can be read directly on the tester's digital readout.

5.3.2 Two-terminal method (direct method). The test setup for performing the two-terminal method is shown in figure 5-6. This test is performed as follows:

a. Connect a jumper across the P and C terminals of the tester.
b. Connect test lead I from the tester to the ground point being evaluated.

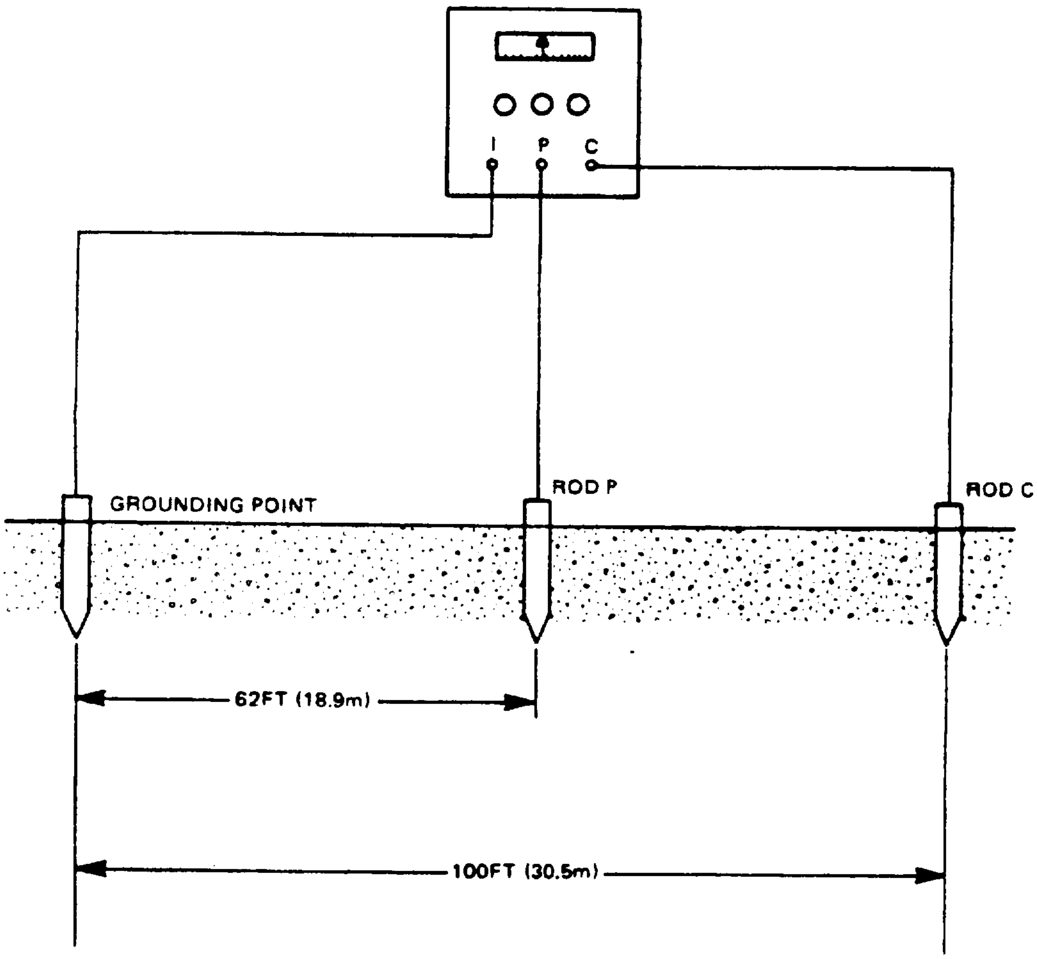


FIGURE 5-5. Three-terminal fall of potential method test setup.

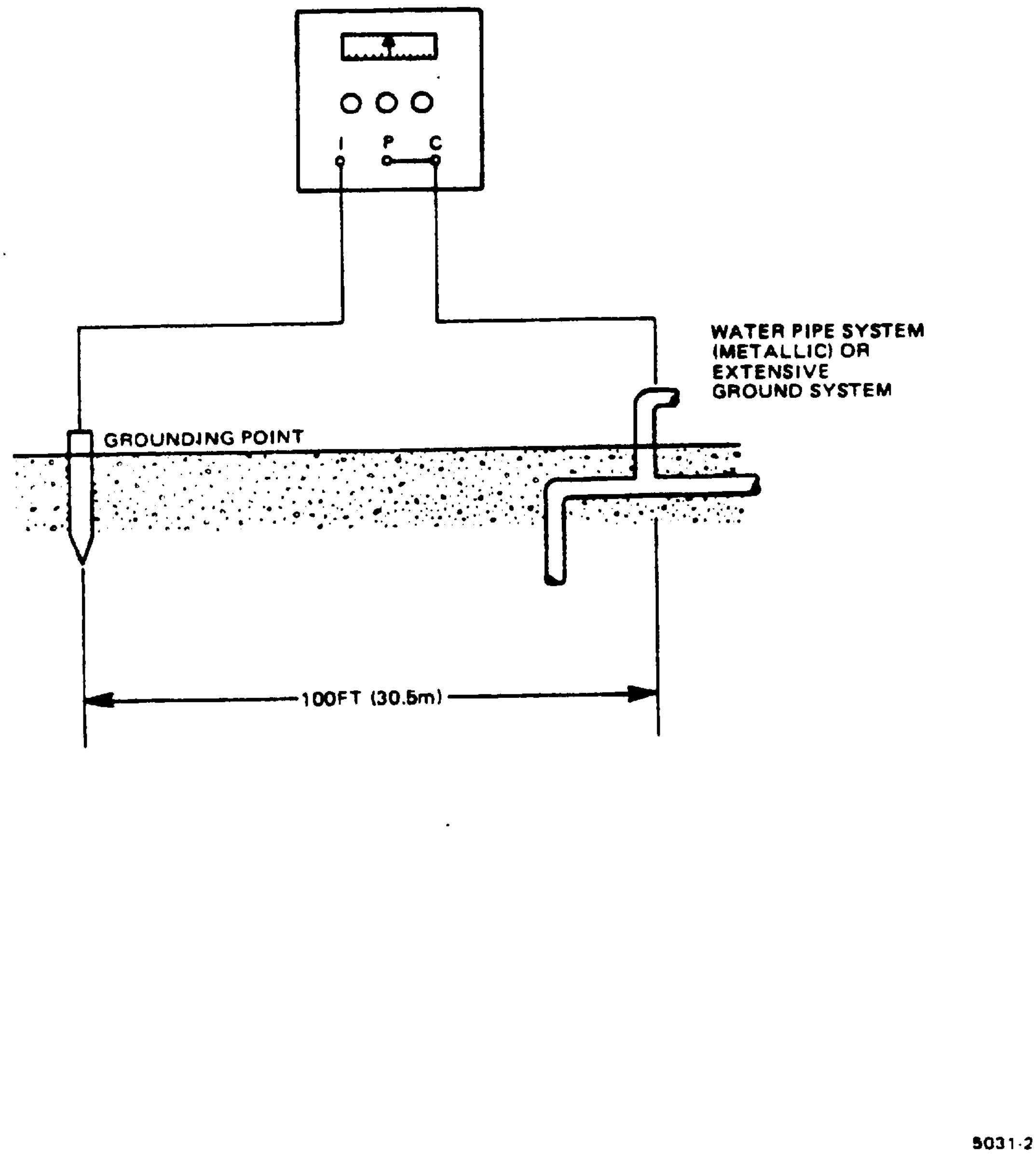


FIGURE 5-6. Two-terminal method test setup.

c. Locate a large, unpainted, metal water pipe at least 100 ft (30.5 m) from the ground point being evaluated and connect test lead C from the tester to this water pipe.
d. Adjust the resistance dials on the tester until the indicator dial is centered (zeroed) on the scale. When the dial is centered, the resistance value (in ohms) of the ground point being evaluated can be read on the tester's digital readout.

5.4 Schedule for resistance testing of ground points. It is recommended that resistance measurements of a facility's ground points be performed periodically in order to determine if there has been any degradation of the grounding system. It is important to verify that the resistances of the ground points are at or below recommended maximum values so as to minimize likelihood of injury or damage. The recommended maximum resistance values are 10 ohms for a power ground point and 10,000 ohms for a static ground point.

5.4.1 The recommended time interval between resistance testing is 15 months. This ensures that over a 5-year period, the ground points will be tested during all seasons, thereby providing a profile of seasonal resistance variations. Depending on the number of ground points to be measured, it might be more feasible to employ a rotational method, rather than measure all of the points in a single time span. For example, if the facility were divided into five sections, the measurement task would be initiated every three months in a different section.

5.4.2 The task of measuring ground points normally comes under jurisdiction of the public works department of the facility. Additionally, their responsibilities will include setting up and carrying out the test schedule.

5.5 Identification of ground points. It is recommended that ground points already measured should be identified in the manner indicated in figure 5-7. This identification indicates to personnel that the ground point is satisfactory.

5.6 The use of mooring eyes as static ground points. Mooring eyes (also referred to as padeyes) may be used as static ground points provided that they have been measured and identified in a proper manner (see paragraphs 5.3 and 5.5). Surveys (AIR-5181-1000) have indicated that samplings of the resistance values of mooring eyes showed them to be under 10,000 ohms and therefore acceptable as static ground points.

5.6.1 Figure 5-8 shows typical mooring eye installation details. Additional information is available in NAVFACENGCOM Technical Specification TS-02614. At some facilities, a stainless steel bead has been welded to the upper exposed area of the mooring eye. This prevents corrosion buildup on the mooring eye and reduces its likelihood of providing a poor ground.

NOTES:
1. ALL LETTERS SHALL BE 1" HIGH.
2. TESTING INFORMATION SHALL BE CENTERED AS SHOWN WITH 3/4" SPACING BETWEEN LINES.

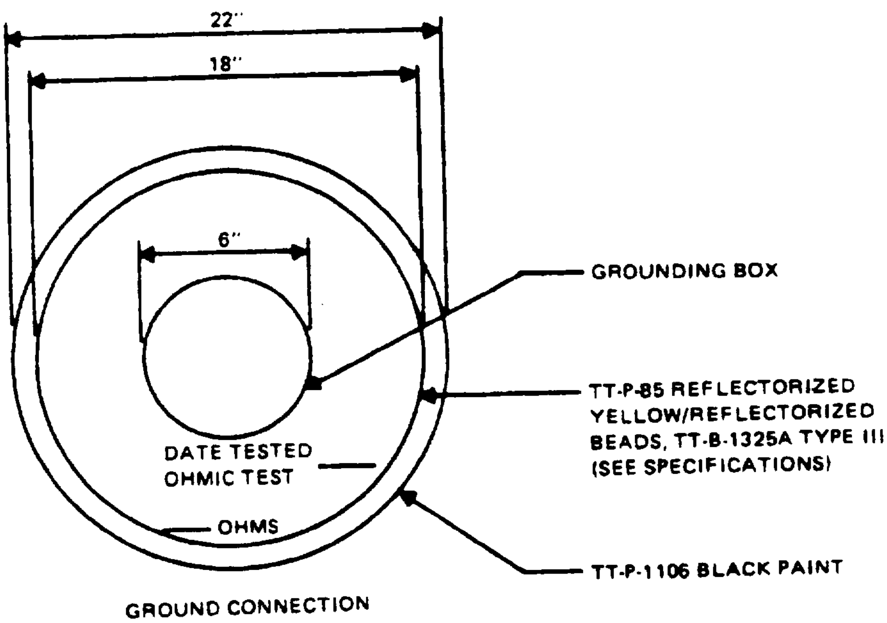


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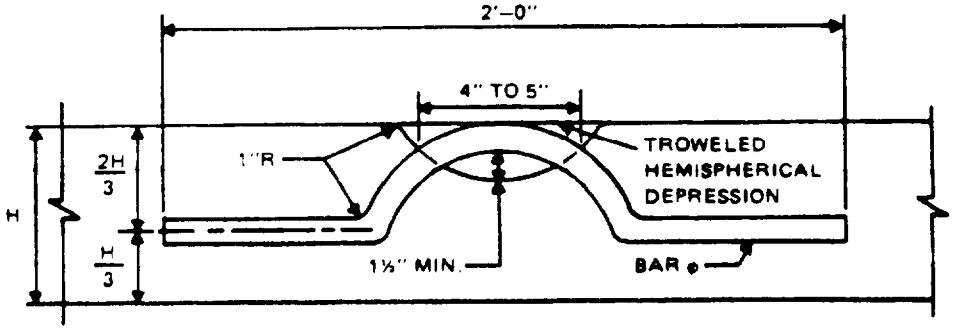
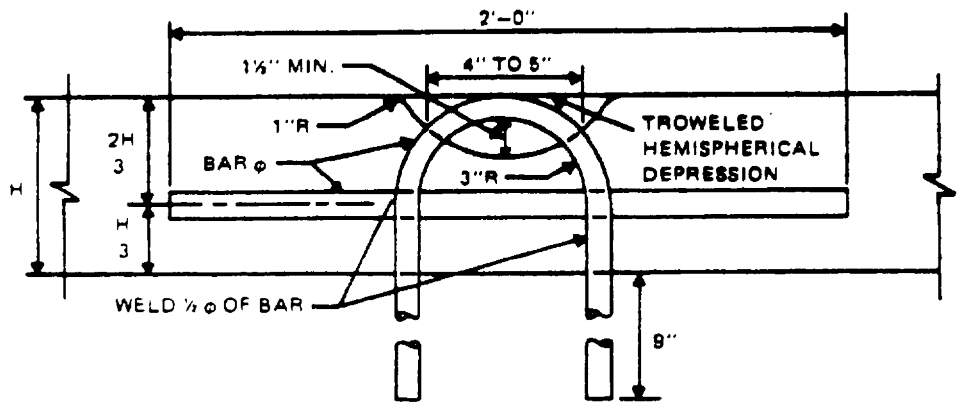
FIGURE 5-7. Measured ground point identification.



TYPE "A"



TYPE "B"

BAR SIZES FOR TYPES A & B	
H	BAR φ
<10"	3/4"
10" TO 12"	1"
13" TO 16"	1-1/4"

NOTES:

1. PLACE MOORING EYES IN THE CENTER OF EACH 12.5' BY 15.0' SLAB OVER ENTIRE SURFACE OF WARM-UP OR PARKING AREA PAVEMENTS UNLESS OTHERWISE INDICATED.

2. PLACE MOORING EYES IN HANGAR FLOORS AS DETERMINED BY PROJECT REQUIREMENTS.

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FIGURE 5-8. Mooring eye details.

5.7 <u>Resistance measurements for alternate grounding and bonding points.</u> If conditions prevent the use of known aircraft grounding or bonding points, a resistance check must be performed to verify that the alternate location is an acceptable grounding or bonding point. It is recommended that a Shallcross No. 670-A Milliohmmeter or equivalent be used.

5.7.1 Prior to performing resistance measurements, the meter must be calibrated. Routine checks on the reliability of the readings are obtained by using test standard resistors. A test standard resistor of 0.0025 ohms is supplied with the meter. The calibration reading should be accurate within 5 percent of full scale. Should the reading not be accurate, resistor values within the meter must be changed. For a detailed procedure of changing internal resistors, refer to the Shallcross Operating and Maintenance Instruction Manual.

5.7.2 <u>Test method for resistance measurements of alternate grounding and bonding points.</u> The test setup for performing resistance measurements is shown in figure 5-9. This test is performed as follows:

a. Connect the clamp type probe to the known aircraft grounding point.
b. Connect the second probe to the proposed alternate grounding or bonding location. Make certain that the probe's two tips are making good contact with this location.
c. Place ''OHMS FULL SCALE'' selector switch on highest range and change the range setting in descending order until largest deflection is obtained when the ''TEST'' switch is depressed. Prior to depressing ''TEST'' switch, make sure meter is properly adjusted to the red line or full scale position as determined by the range selector.

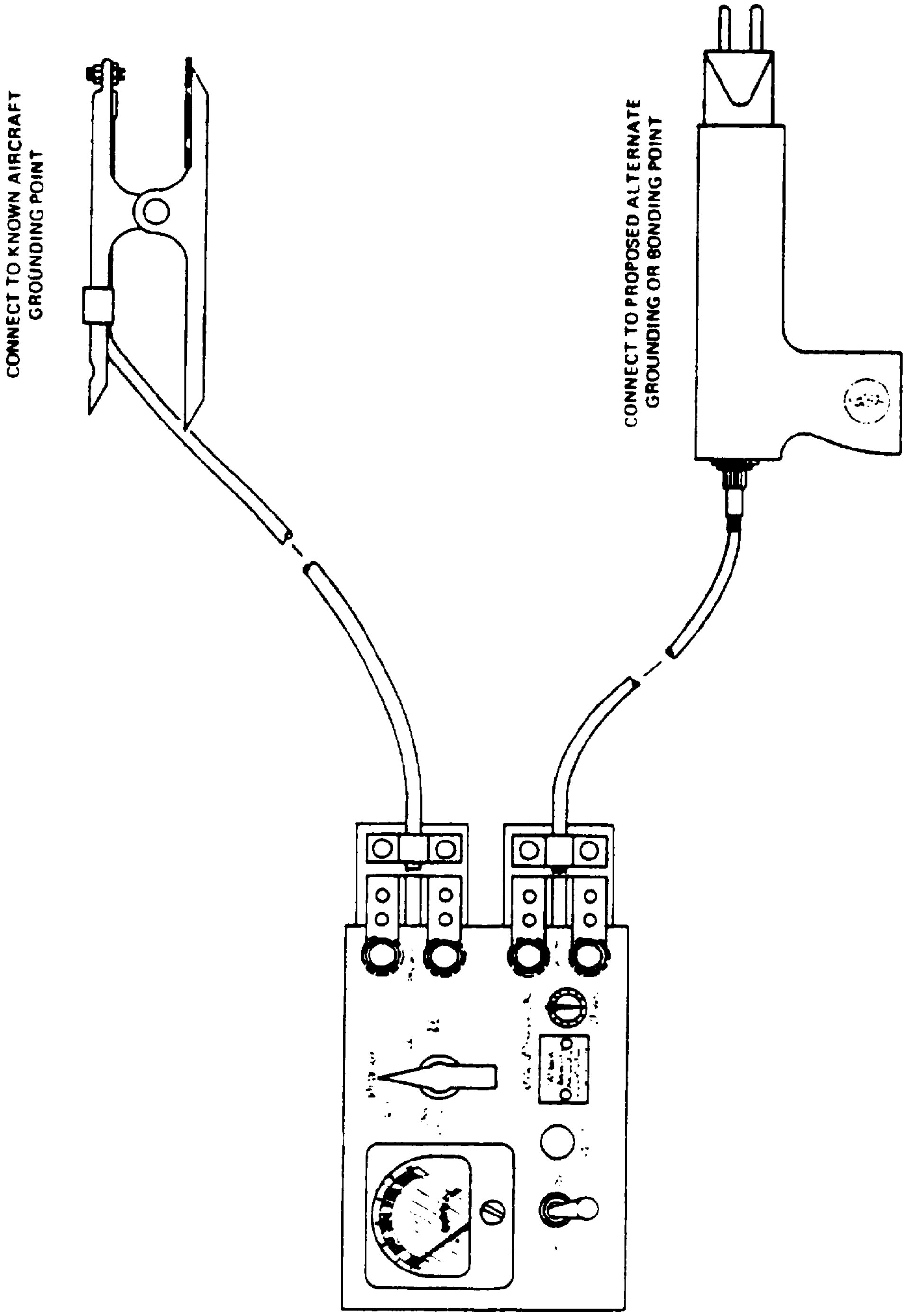

FIGURE 5-9. Test setup for resistance measurements of alternate grounding and bonding points.

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NOTICE 1
29 June 1990

MILITARY HANDBOOK

ELECTRICAL GROUNDING FOR AIRCRAFT SAFETY

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CONTENTS

Supersedes page v of 1 November 1983

FIGURES

SECTION 1

1.0 SCOPE

1.1 Purpose. The purpose of this handbook is to provide aircraft maintenance personnel with the information required for electrical safety grounding of each type of operational aircraft in the U.S. Navy inventory.* In addition, this handbook provides background information pertaining to the operational concerns for aircraft grounding, static electricity theory and how it affects aircraft, and techniques used for measurement of grounding points. This handbook is divided into five sections as follows:

SECTION 1 - SCOPE
SECTION 2 - AIRCRAFT GROUNDING AND BONDING METHODS
SECTION 3 - OPERATIONAL GROUNDING CONCERNS
SECTION 4 - THEORETICAL BASIS FOR AIRCRAFT GROUNDING
SECTION 5 - TESTING AND IDENTIFICATION OF GROUND POINTS

1.1.1 This handbook is intended for use by all U.S. Naval aircraft operational and maintenance personnel including maintenance officers and public works officials for the purposes of ensuring that each aircraft is properly grounded and that the grounding system is adequate for this purpose. Sections 1 and 2 are intended primarily for use by line maintenance personnel. Sections 3 and 4 contain material intended for those desiring to obtain additional theoretical and background information. Section 5 is essential for public works department personnel. Each section is designed to stand alone.

1.1.2 The information contained in Section 2 is intended to be used by line maintenance personnel. This section provides step-by-step instructions for grounding each of the aircraft in the Navy inventory during each of the following evolutions: parked, fueling/defueling, maintenance, and stores loading/unloading. Each evolution is shown in a separate illustration depicting the particular aircraft with proper grounding/bonding cables connected. The illustrations show primary grounding points and also provide alternate grounding points should the primary grounding point be inaccessible. Also provided on the illustrations are pertinent cautions and warnings to be observed during the grounding procedure. Accompanying each illustration is a step-by-step procedure for grounding/bonding the particular aircraft.

1.1.3 Section 3 provides background and general information necessary to understand the rationale behind the requirements for grounding and bonding. This section also discusses the grounding problems and hazards encountered in the everyday ground handling of aircraft during flight operations. Energy sources and grounding effects are identified. The aircraft scenarios or servicing situations (evolutions) are introduced and the aircraft safety problems associated with each are described. In addition, a brief discussion of static electricity and how it affects aircraft operation is provided.

*U.S. Navy aircraft use power equipment not equipped with ground fault interrupters (GFI).

1.1.4 Section 4 details basic electrostatic theory and its application to aircraft grounding. Sources of static electricity associated with aircraft operation are also described. These include triboelectric effects, fuel flow, induced charge, and friction. Hazards from ground power faults, rf energy, and lightning are presented. Also included in this section are descriptions of aircraft electrical parameters and a discussion of hazardous threshold and the possible dangers they present to personnel and aircraft safety. The section also illustrates that proper grounding will reduce these hazards.

1.1.5 Section 5 is intended for use by the public works department personnel and provides a description of the methods and techniques used to measure the resistance of the grounding system. Also included in Section V is a suggested schedule for accomplishing the measurement of ground points, identifying ground points, the use of mooring eyes as static ground points, and a discussion of the test equipment used to measure ground point resistance.

1.2 Referenced Documents. The following documents are referenced in this handbook.

Document No.	Title
MIL-C-83413	Connector, Electric Ground
MIL-C-83413/1	Connectors and Assemblies, Electrical, Aircraft Grounding: Type I Grounding Assembly, Discharger, Electrostatic
MIL-C-83413/3	Connectors and Assemblies, Electrical, Aircraft Grounding: Type III Grounding Assembly, Discharger, Electrostatic
MIL-C-83413/7	Connectors and Assemblies, Electrical, Aircraft Grounding: Grounding Clamp Connector for Types I and III Grounding Assemblies Clip, Electrical
MS3493	Connector, Plug and Cap Electric, Grounding
MS25083	Jumper Assembly, Electric Bonding and Current Return
MS25486	Connector, Plug, Attachable, External Electric Power, Aircraft, 115/200 volt 400 hertz
MS25487	Connector, Plug, Attachable, External Electric Power, Aircraft, 28 Volt DC, Jet Starting
MS25488	Connector, Plug, Attachable, External Electric Power, Aircraft, 28 Volt DC Operating Power
MS33645	Receptacle, Grounding, Installation of
MS90298	Connector, Receptacle, Electric, Grounding
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipments and Facilities, 21 January 1982

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Document No.	Title
NAVAIR AIR-5181-1000	Airframe Electrical Grounding Requirements Program Final Report, 17 Feb 1981
NAVAIR 00-80T-96	U.S. Navy Support Equipment, Basic Handling and Safety Manual, 1 April 1981
NAVAIR 19-45-1	Index and Applications Tables for Mobile Electric Power Plants, 1 September 1972
NAVSEA OP4 Vol. 2	Ammunition Afloat, 15 February 1972
NAVSEA OP5 Vol. 1	Ammunition and Explosives Ashore, 15 October 1974
COMNAVAIRPAC/ COMNAVAIRLANTINST 3100.4A	Air Department Standard Operating Procedures (SOP)

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SECTION 2

2.0 AIRCRAFT GROUNDING AND BONDING METHODS

This section provides step-by-step procedures for grounding and bonding operational aircraft in the Navy inventory. Various handling evolutions, both landbased and carrier-based, of the different aircraft are described and illustrated with appropriate warnings and cautions. Note that the word "carrier" is meant to refer to any ship which supports aircraft flight operations.

By referring to the particular aircraft procedures in this section and the applicable aircraft NATOPS, organizational maintenance personnel will be able to properly determine aircraft grounding requirements before beginning other servicing. Recommended grounding and bonding locations are illustrated. If conditions prevent the use of these locations, a resistance check using a milliohmmeter must be performed to verify that the alternate location is an acceptable grounding or bonding attachment point. A location is an acceptable grounding or bonding point if the resistance measured from the point to the airframe is less than 10 milliohms. Using a milliohmmeter (Shallcross Model 670A or equivalent), connect one probe to the known aircraft grounding point and the other probe to the proposed grounding point. Observe the milliohmmeter for a reading of less than 10 milliohms. If the milliohmmeter reading is less than 10 milliohms, the proposed grounding point is acceptable. Painted, corroded, dirty, greasy areas or areas of composite materials should not be used for grounding points. In addition, if the intended grounding point is loosely connected to the aircraft structure by way of bearings or springs, an unacceptable intermittent ground or bond could result.

When employing grounding cables, the specific type of connector required on the ends will be determined by the aircraft type. Many Navy aircraft do not have grounding receptacles available in other than the fueling area, and they are therefore not readily available for use as the static grounding point on the aircraft. In these instances a cable having an M83413-1 connector on each end may be used, one end attached to an approved static ground point, the other to a clean metal area of the aircraft.

Cables shall be of 7 x 7 construction, 0.094 inch nominal diameter wire rope in accordance with M83413-1 or with MIL-C-83413/7 clamps at each end. Cable length shall be determined by user requirements but shall not exceed 40 feet. The maximum resistance of all cable configurations shall not exceed 10 ohms. The cables must be identified and serialized. As a minimum, resistance of complete cable assemblies must be measured, recorded and verified annually.

2.1 Land-Based Aircraft. The following paragraphs provide step-by-step procedures for grounding land-based aircraft.

Evolutions requiring external power are detailed in paragraphs 2.4 through 2.6.

Fueling evolutions shown here do not indicate external electrical power. These illustrations apply to gravity fueling as well as hot fueling from fuel trucks. Figures 2-160 and 2-161 illustrate grounding and bonding procedures for the A-6 using external electrical power during fueling. The grounding and bonding procedures for other aircraft requiring external electrical power during fueling are similar.

2.1.17 A-6 stores loading/unloading evolution. To ground A-6 aircraft during stores loading or unloading, proceed as follows (see figure 2-14):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.18 A-7 parked evolution. To ground A-7 aircraft when in the parked evolution, proceed as follows (see figure 2-15):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.19 A-7 fueling/defueling evolution. To ground A-7 aircraft when fueling or defueling, proceed as follows (see figure 2-16):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to nose gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove bonding or grounding cable, reverse above procedures.

2.1.20 A-7 hangar-based maintenance evolution. To ground A-7 aircraft during maintenance in the hangar, proceed as follows (see figure 2-17):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).

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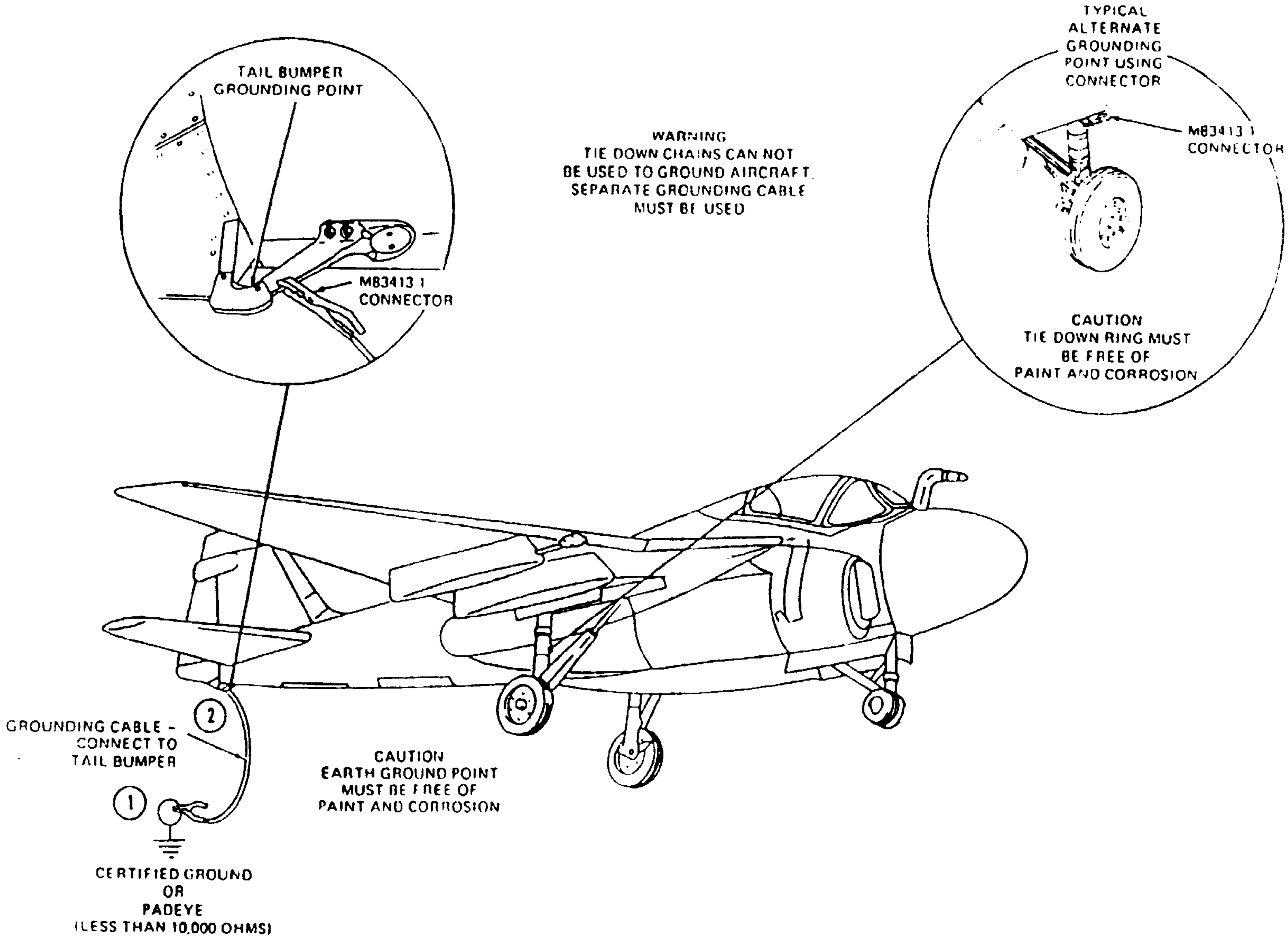

FIGURE 2-14. A-6 aircraft grounding, stores loading/unloading evolution.

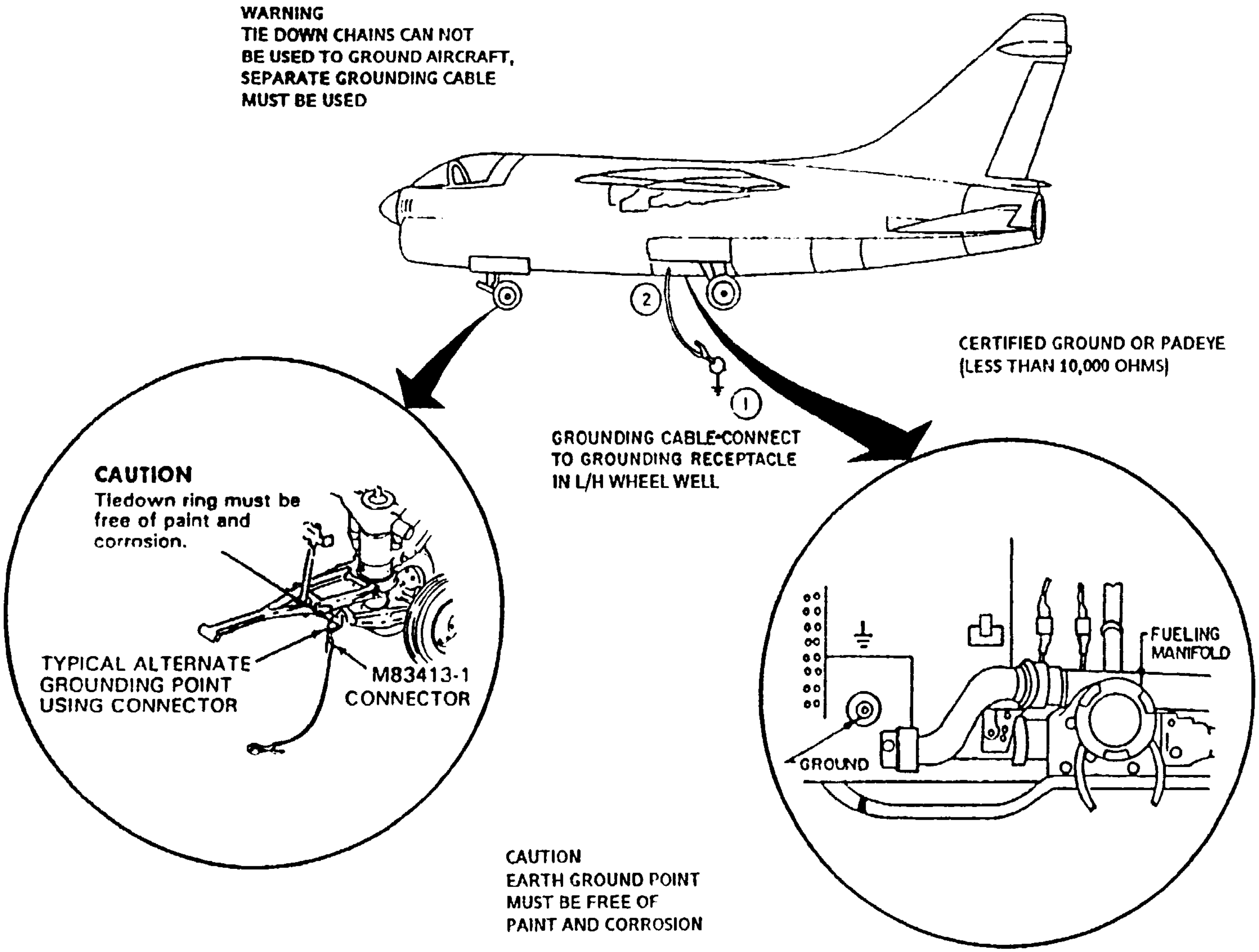

FIGURE 2-15. A-7 aircraft grounding, parked evolution.

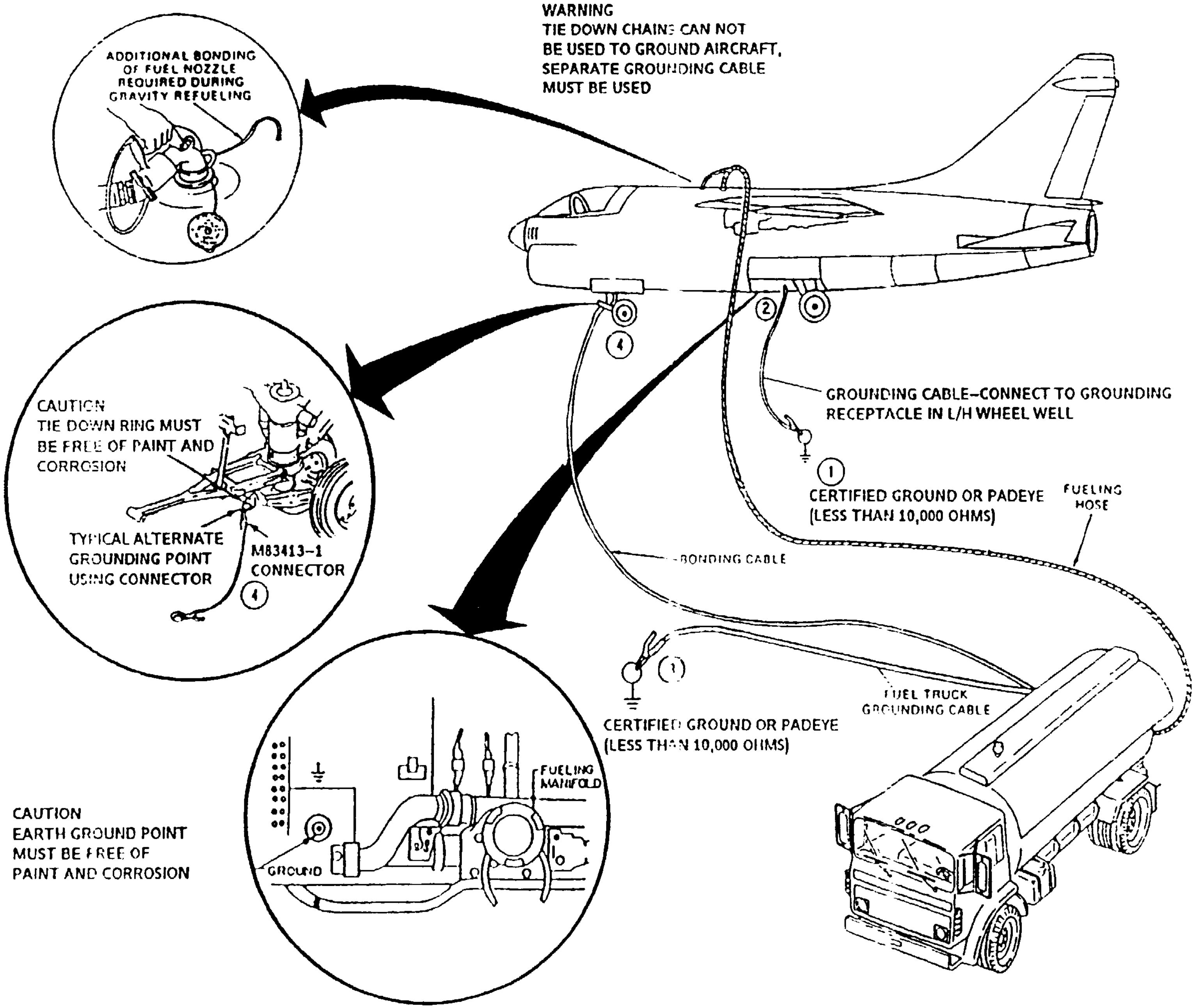

FIGURE 2-16. A-7 aircraft grounding, fueling/defueling evolution.

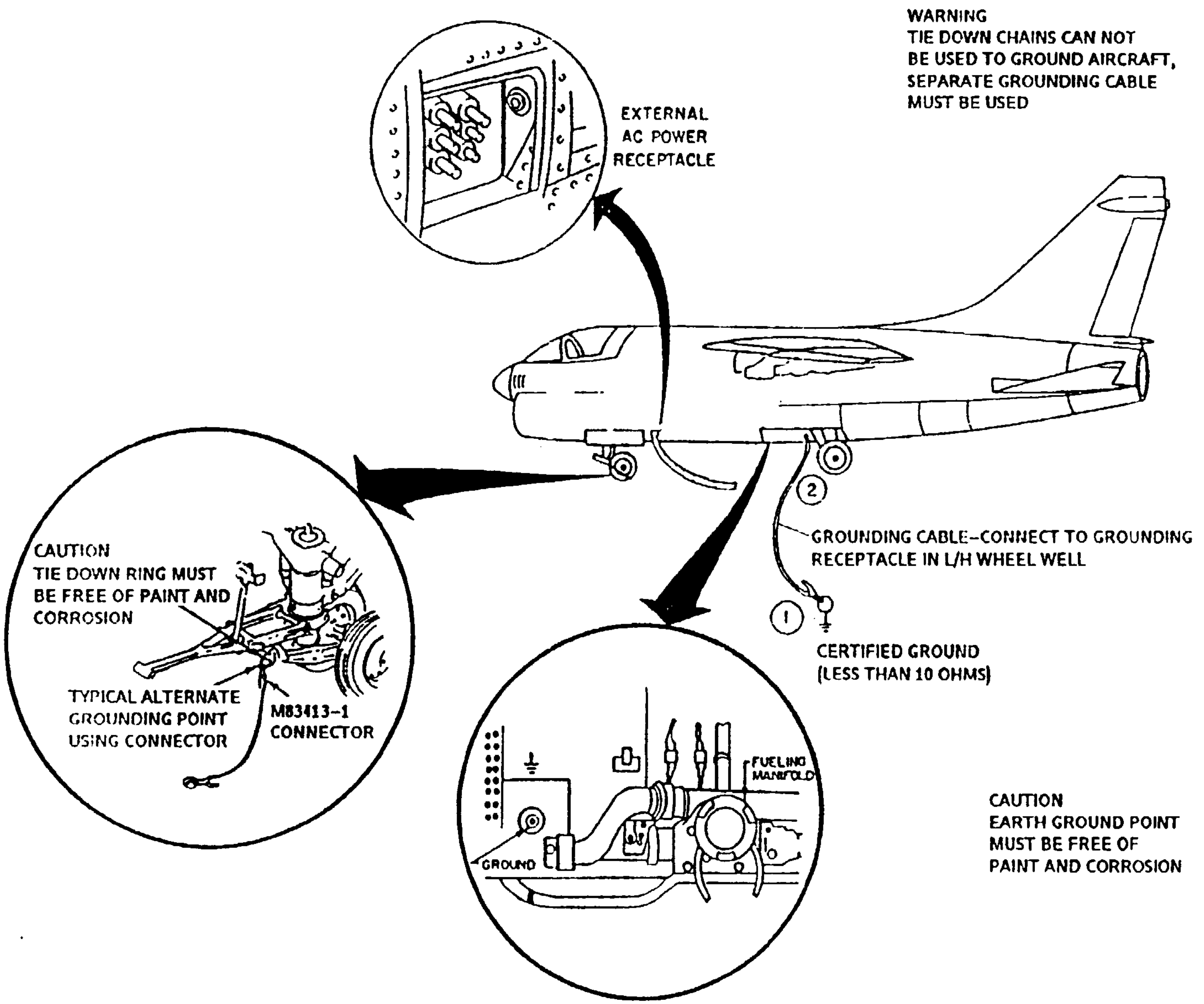

FIGURE 2-17. Hangar-based A-7 aircraft grounding, maintenance evolution.

c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.21 A-7 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground A-7 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-18):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.22 A-7 apron-based maintenance evolution (using FLEDS). To ground A-7 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-18):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

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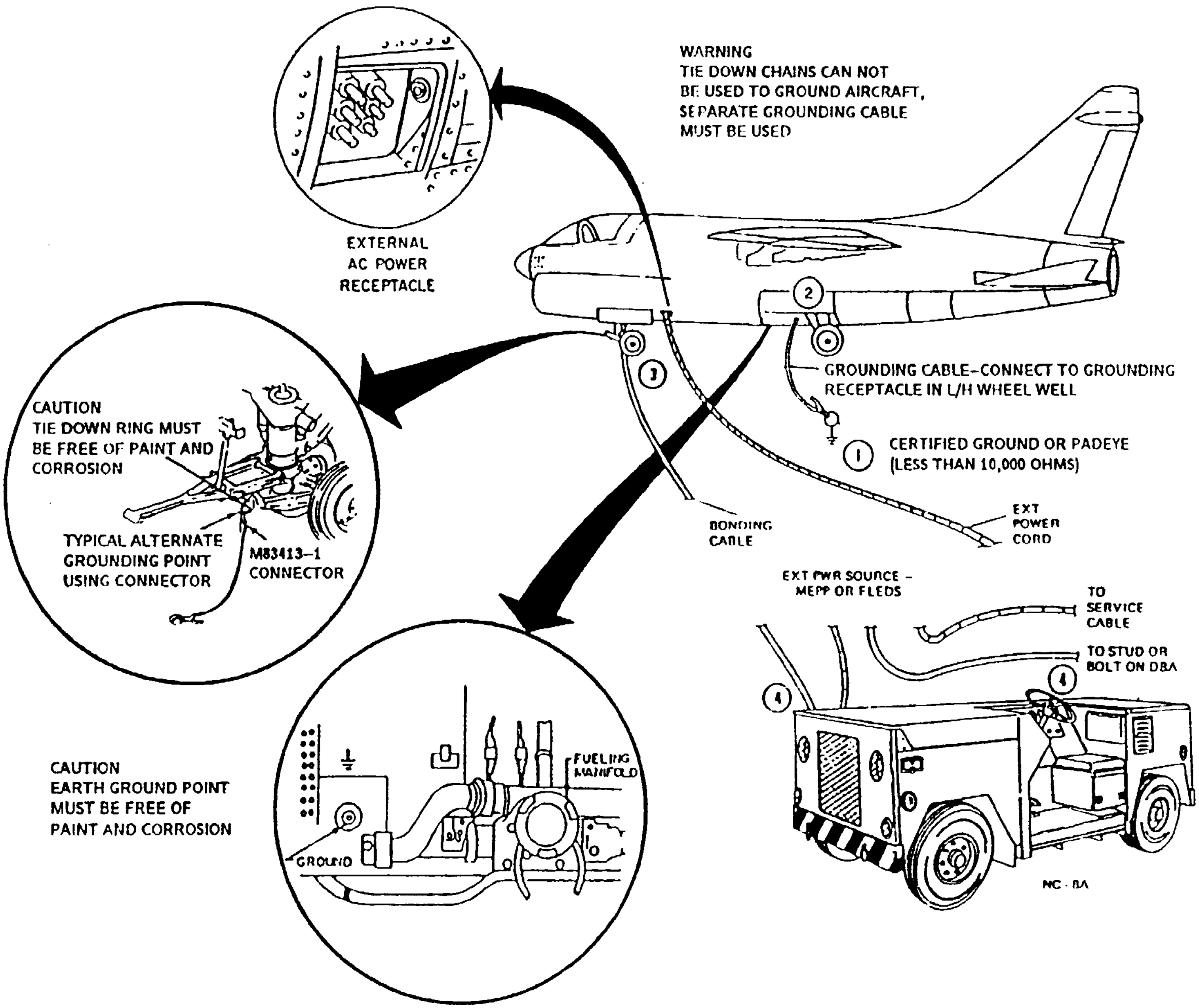

FIGURE 2-18. Apron-based A-7 aircraft grounding, maintenance evolution.

2.1.23 A-7 stores loading/unloading evolution. To ground A-7 aircraft during stores loading or unloading, proceed as follows (see figure 2-19):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.24 AH-1 parked evolution. To ground AH-1 aircraft when in the parked evolution, proceed as follows (see figure 2-20):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.25 AH-1 fueling/defueling evolution. To ground AH-1 aircraft when fueling or defueling, proceed as follows (see figure 2-21):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to front right towing ring (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.26 AH-1 hangar-based maintenance evolution. To ground AH-1 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-22):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

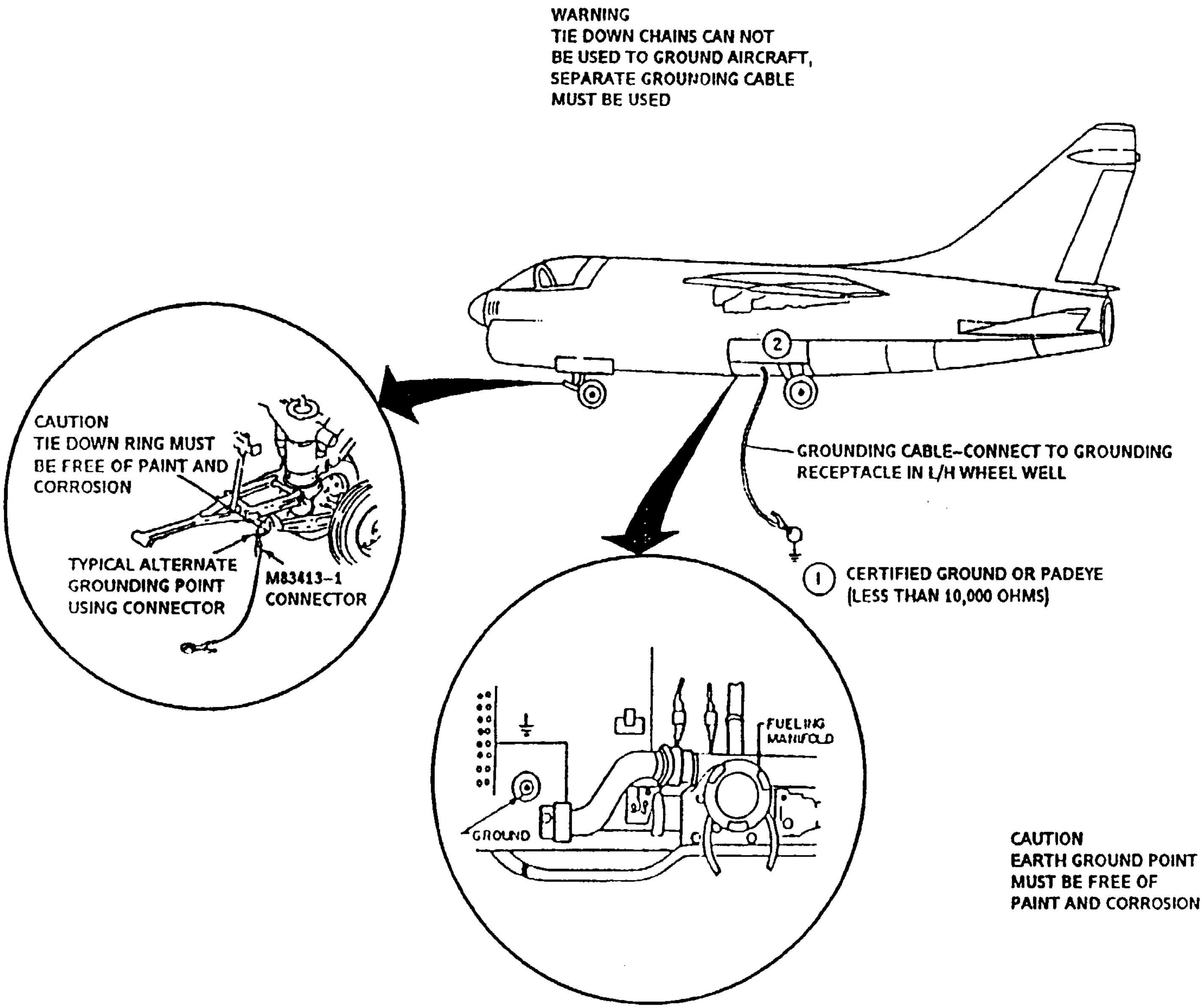

FIGURE 2-19. A-7 aircraft grounding, stores loading/unloading evolution.

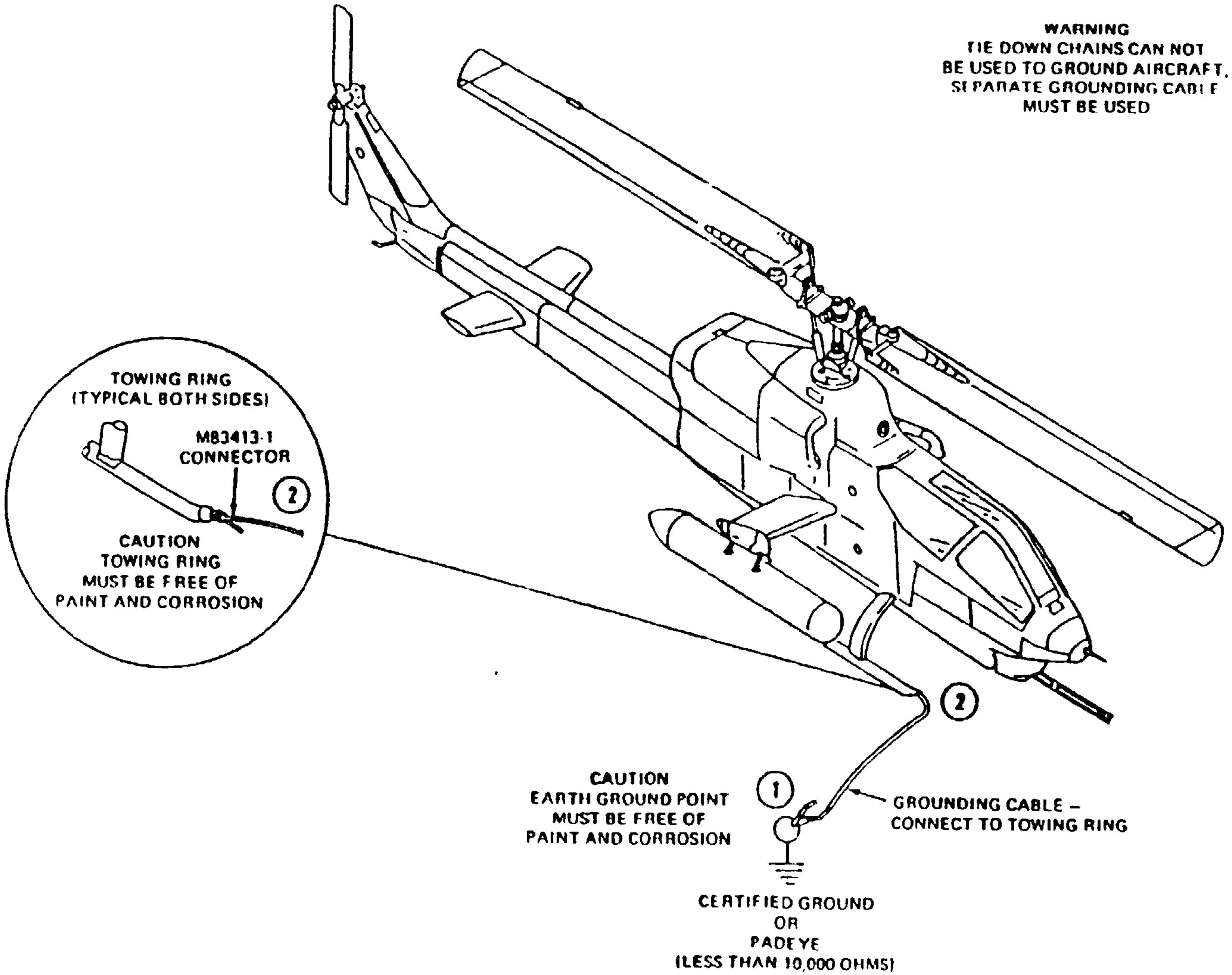

FIGURE 2-20. AH-1 aircraft grounding, parked evolution.

2.1.27 AH-1 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground AH-1 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-23):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

c. Attach bonding cable with M83413-1 electrical ground connector to front right towing ring (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.28 AH-1 stores loading/unloading evolution. To ground AH-1 aircraft during stores loading or unloading, proceed as follows (see figure 2-24):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to front right towing ring (2). If this location is not accessible, then connect grounding cable to front left towing ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.29 AV-8 parked evolution. To ground AV-8 aircraft when in the parked evolution, proceed as follows (see figure 2-25):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point) or to grounding point under main wing tips (2a) (as applicable) or grounding point on forward fuselage (2b) (as applicable).
c. To remove grounding cable, reverse above procedures.

2.1.30 AV-8 fueling/defueling evolution. To ground AV-8 aircraft when fueling or defueling, proceed as follows (see figure 2-26):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

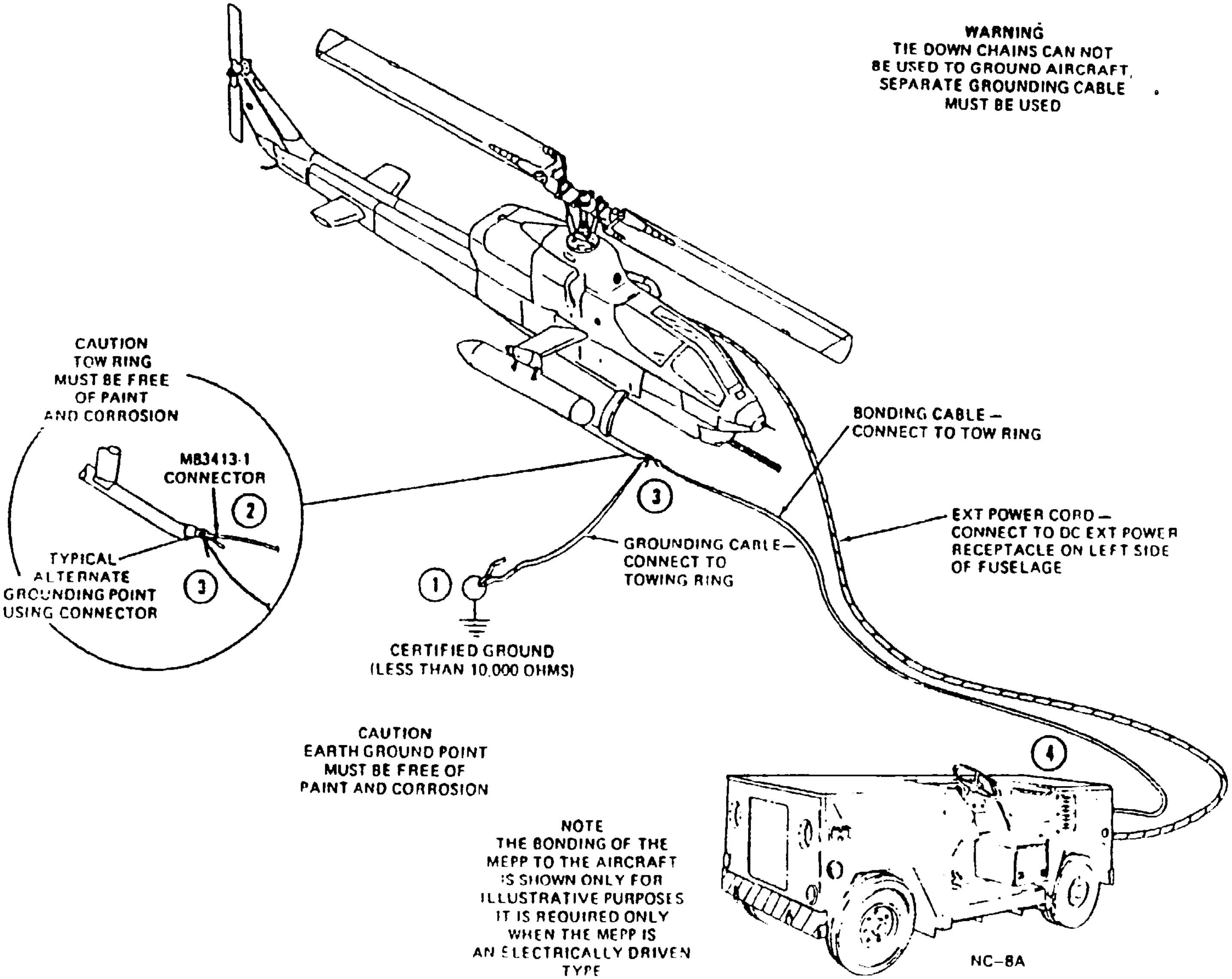

FIGURE 2-23. Apron-based AH-1 aircraft grounding, maintenance evolution.

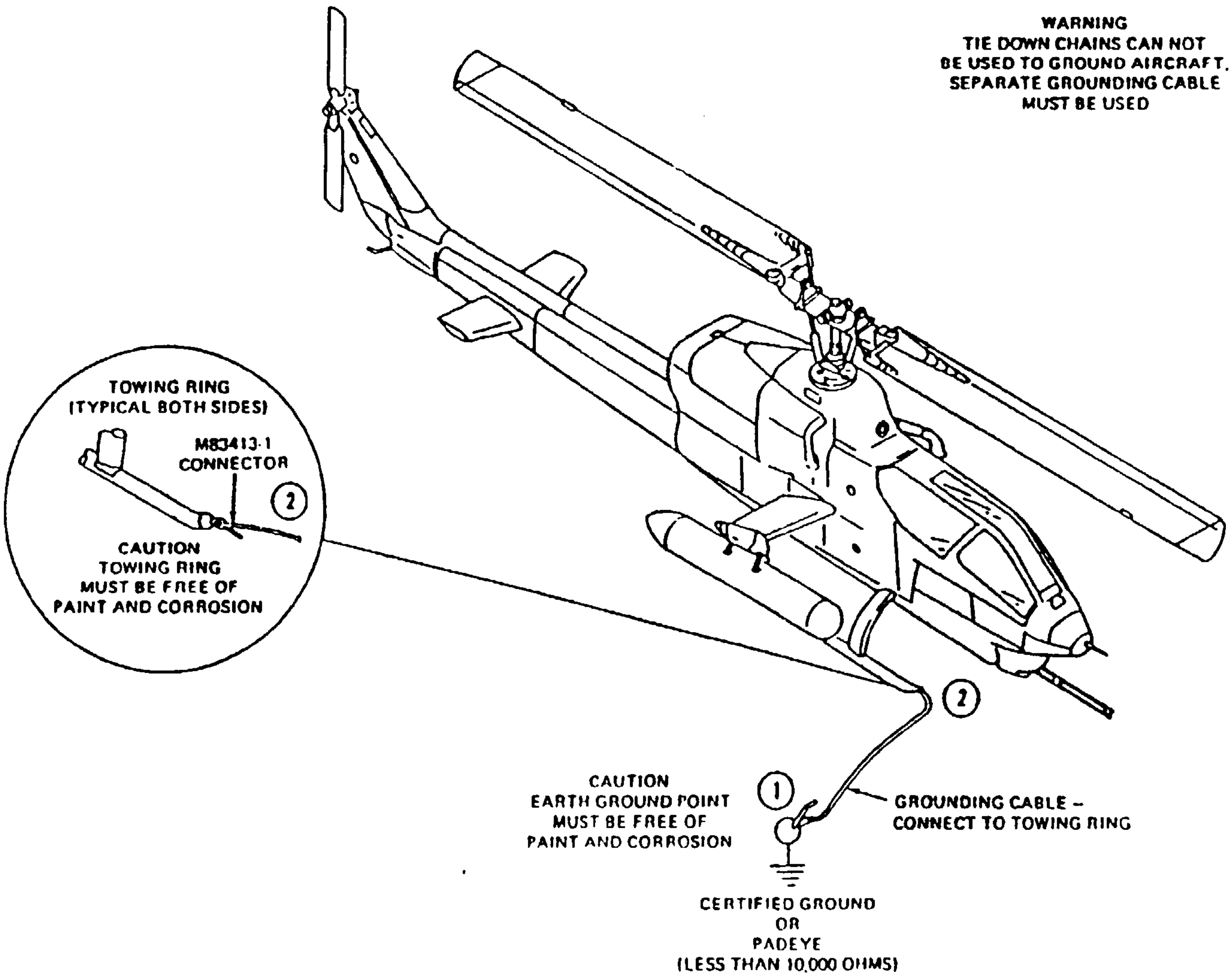

FIGURE 2-24. AH-1 aircraft grounding, stores loading/unloading evolution.

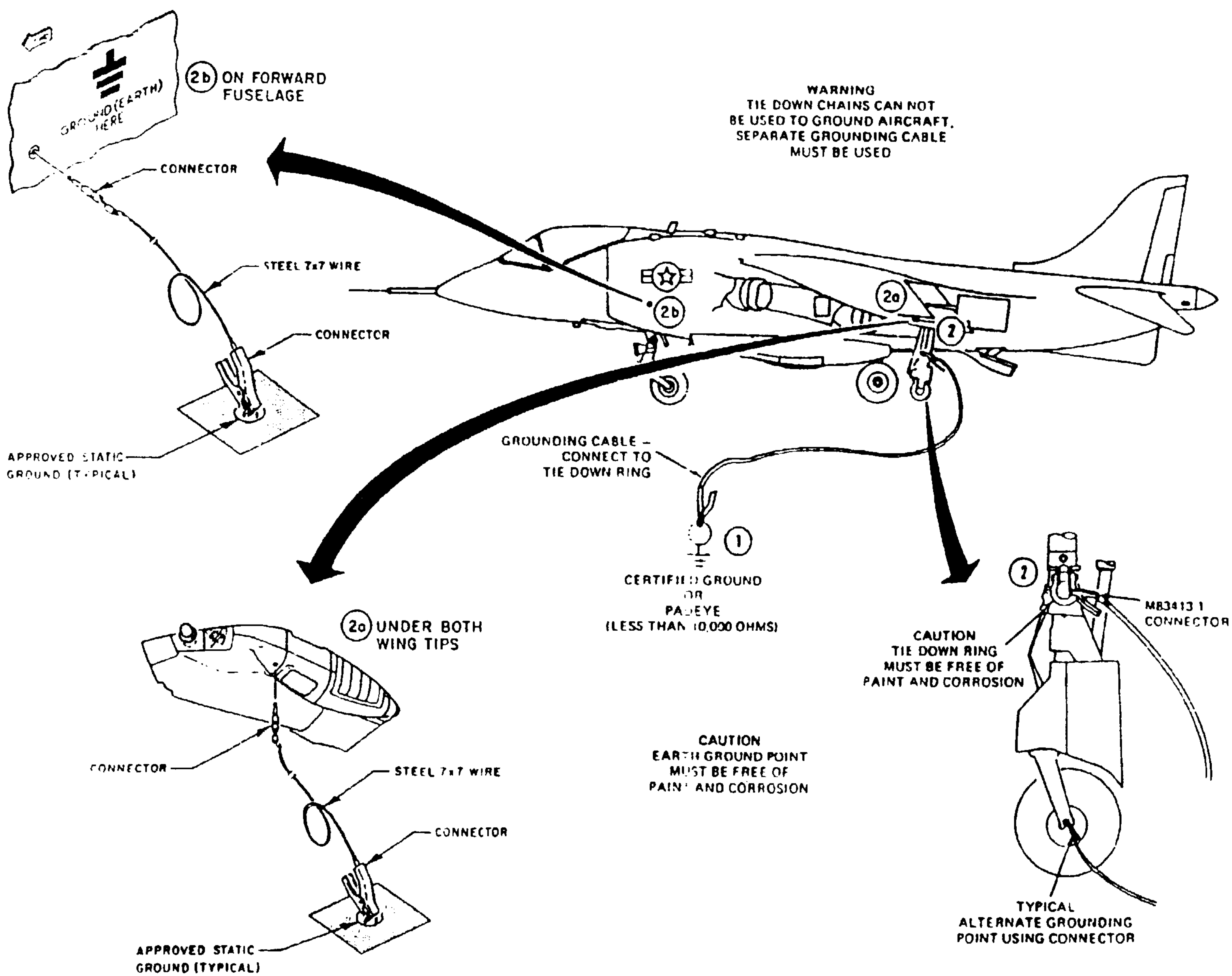

FIGURE 2-25. AV-8 aircraft grounding, parked evolution.

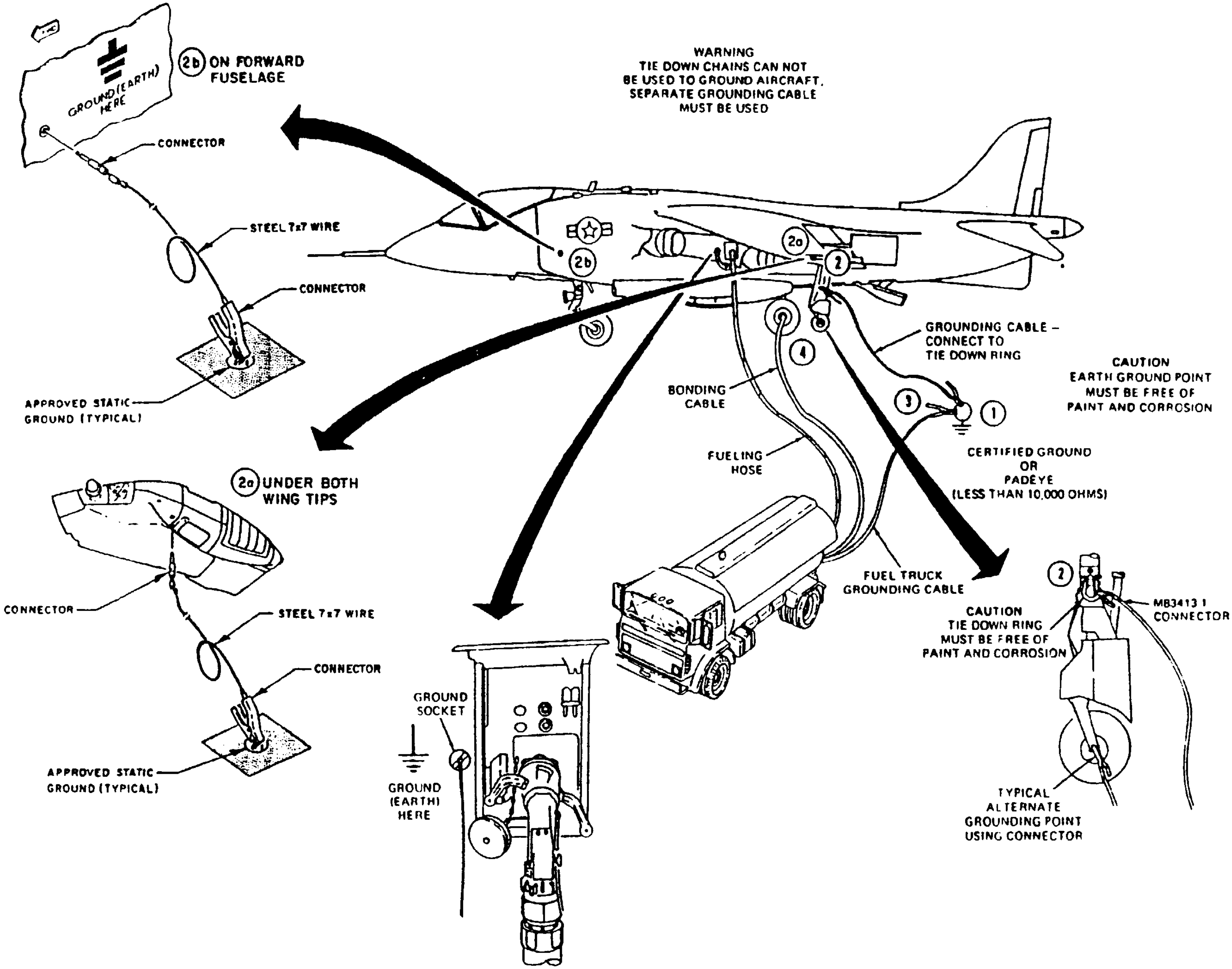

FIGURE 2-26. AV-8 aircraft grounding, fueling/defueling evolution.

b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point) or to grounding point under main wing tips (2a) (as applicable) or grounding point on 0 forward fuselage (2b) (as applicable).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to main wheel axle (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.31 AV-8 hangar-based maintenance evolution. To ground AV-8 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-27):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point) or to grounding point under main wing tips (2a) (as applicable) or grounding point on forward fuselage (2b) (as applicable).
c. To remove grounding cable, reverse above procedures.

2.1.32 AV-8 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground AV-8 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-28):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point) or to grounding point under main wing tips (2a) (as applicable) or grounding point on forward fuselage (2b) (as applicable).
c. Attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse the above procedures.

2.1.33 AV-8 apron-based maintenance evolution (using FLEDS). To ground AV-8 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-28):

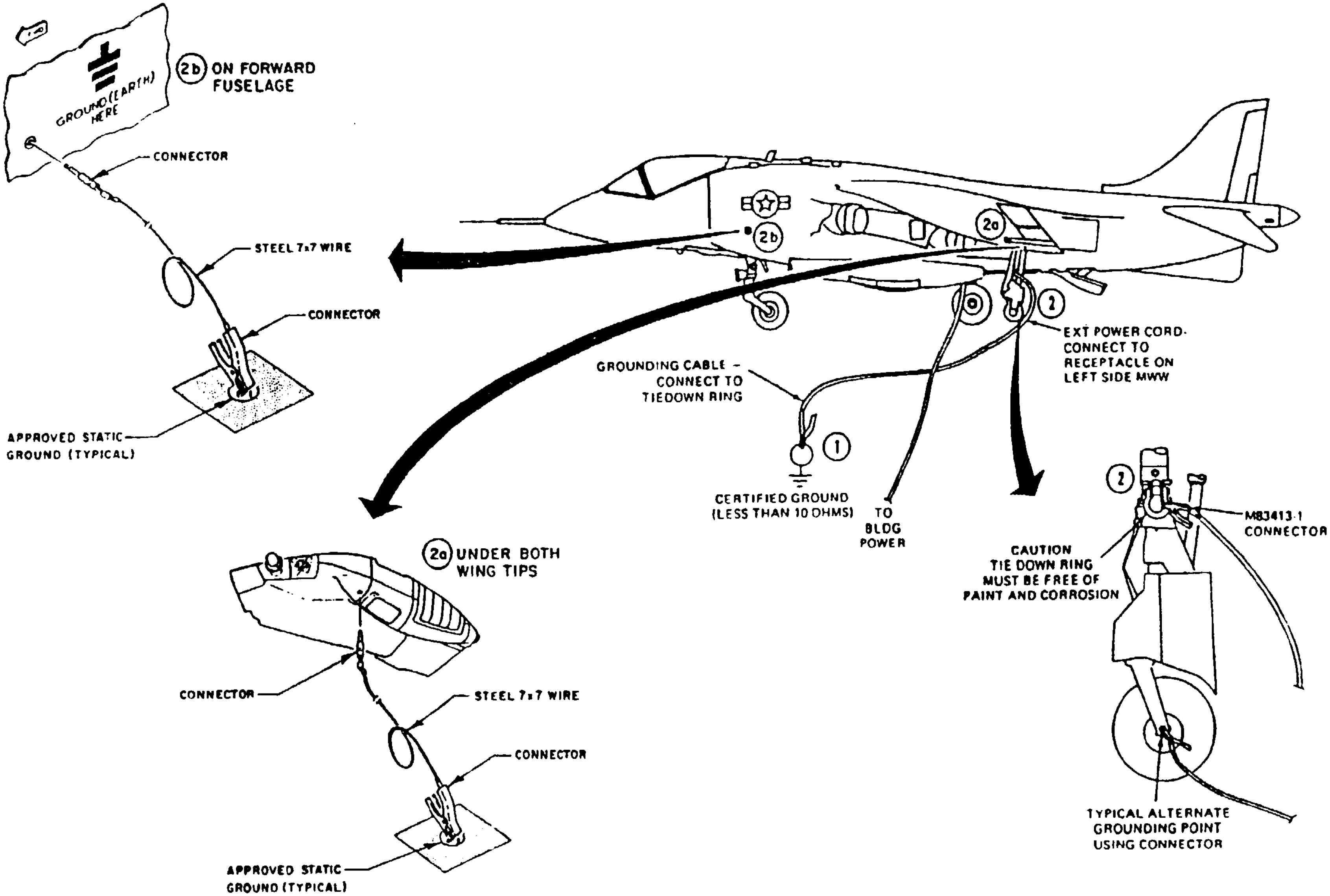

FIGURE 2-27. Hangar-based AV-8 aircraft grounding, maintenance evolution.

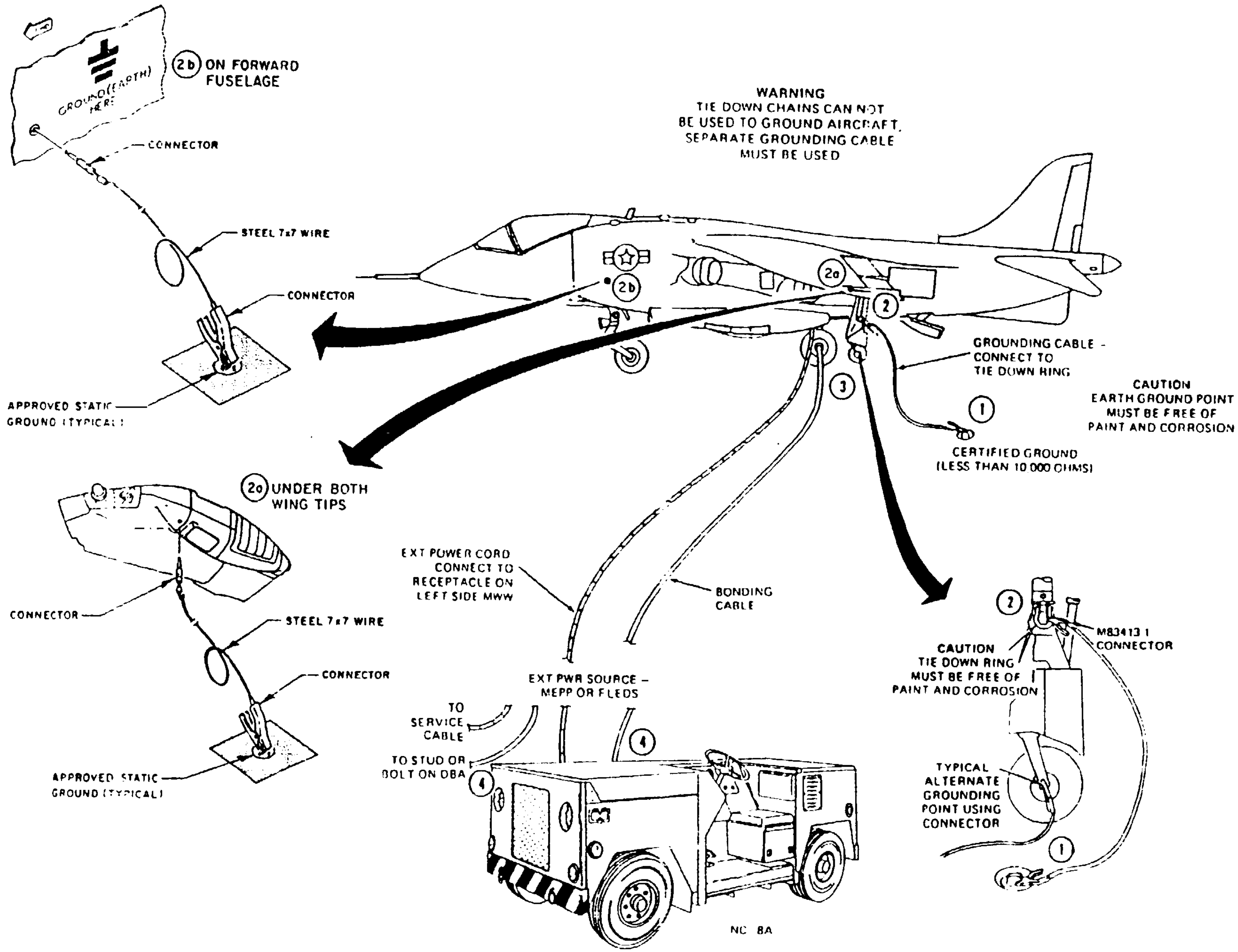

FIGURE 2-28. Apron-based AV-8 aircraft grounding, maintenance evolution.

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point) or to grounding point under main wing tips (2a) (as applicable) or grounding point on forward fuselage (2b) (as applicable).
c. Attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.34 AV-8 stores loading/unloading evolution. To ground AV-8 aircraft during stores loading or unloading, proceed as follows (see figure 2-29):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to outrigger gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bottom part of outrigger gear leg (typical alternate grounding point) or to grounding point under main wing tips (2a) (as applicable) or grounding point on forward fuselage (2b) (as applicable).
c. To remove grounding cable, reverse above procedures.

2.1.35 C-1 parked evolution. To ground C-1 aircraft when in the parked evolution, proceed as follows (see figure 2-30):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.36 C-1 Fueling/defueling evolution. To ground C-1 aircraft when fueling or defueling, proceed as follows (see figure 2-31):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of ground cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to nose gear towing ring (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

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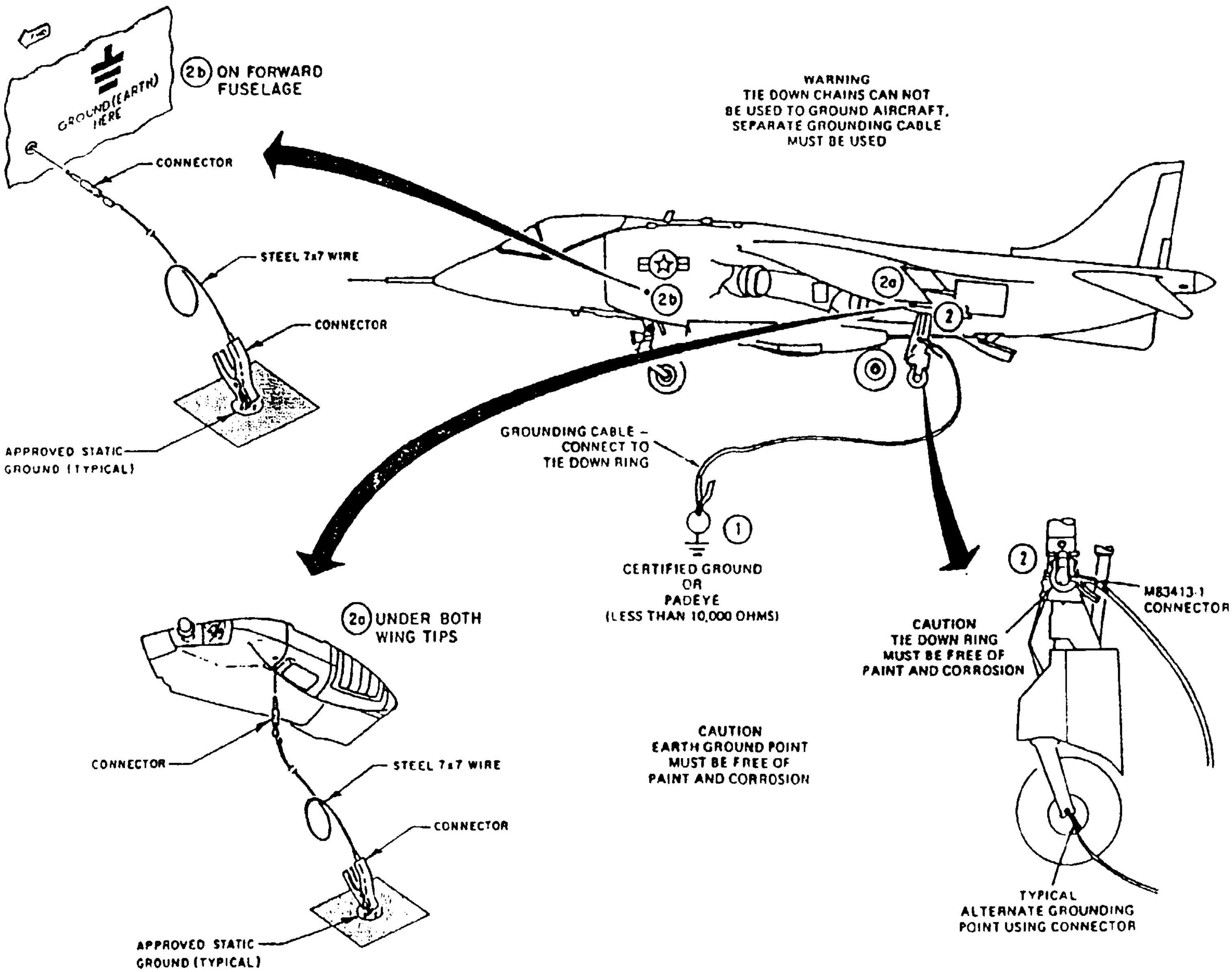

FIGURE 2-29. AV-8 aircraft grounding, stores loading/unloading evolution.

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2.1.37 C-1 hangar-based maintenance evolution. To ground C-1 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-32):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to nose gear towing ring (2). If this location is not accessible, then connect grounding cable to main gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

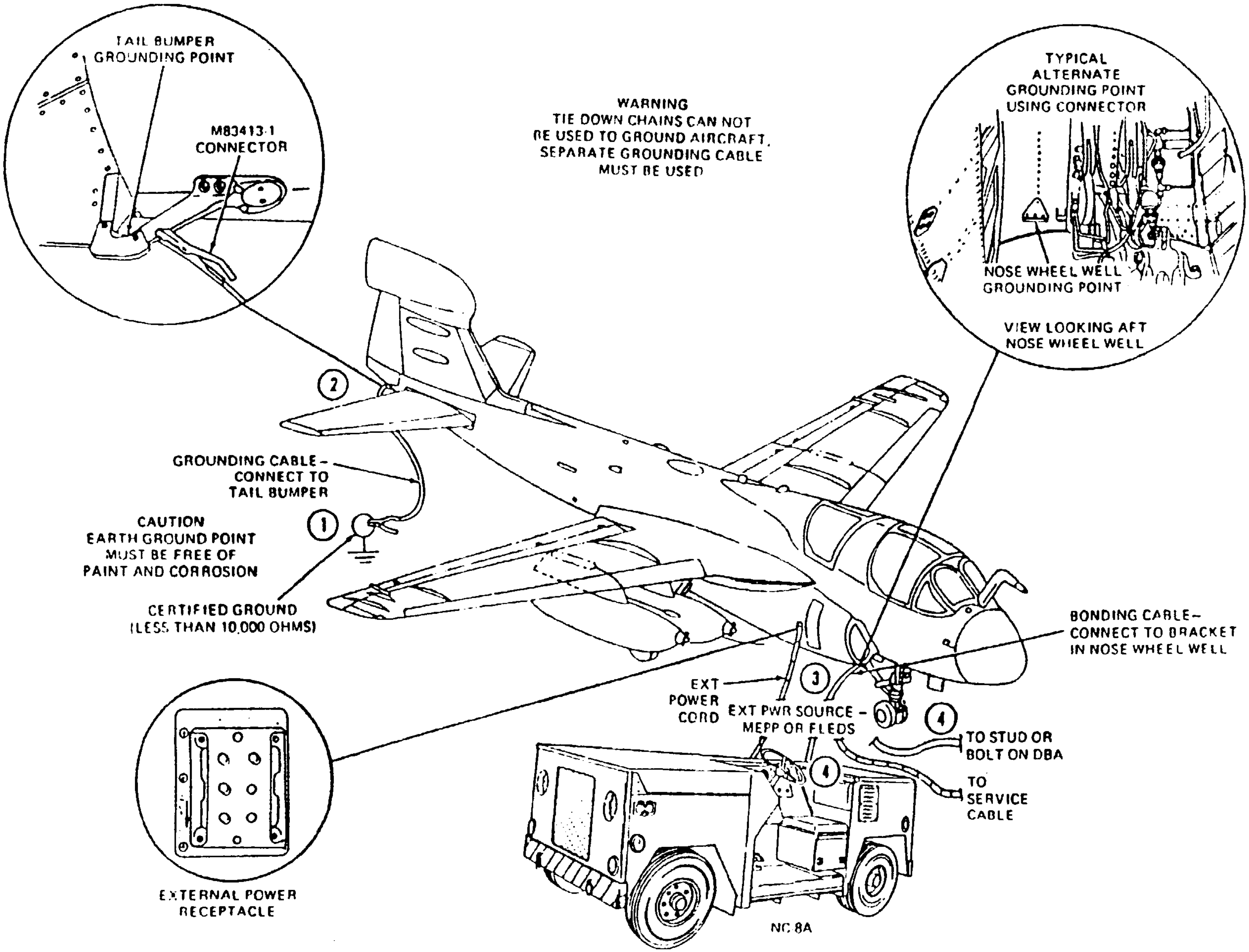

FIGURE 2-50. Apron-based EA-6 aircraft grounding, maintenance evolution.

c. Attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.59 EA-6 apron-based maintenance evolution (using FLEDS). To ground EA-6 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-50):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. Attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
e. To remove grounding or bonding cable, reverse above procedures.

2.1.60 EA-6 stores loading/unloading evolution. To ground EA-6 aircraft during stores loading or unloading, proceed as follows (see figure 2-51):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to tail bumper (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.61 F-4 parked evolution. To ground F-4 aircraft when in the parked evolution, proceed as follows (see figure 2-52):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.62 F-4 fueling/defueling evolution. To ground F-4 aircraft when fueling or defueling, proceed as follows (see figure 2-53):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

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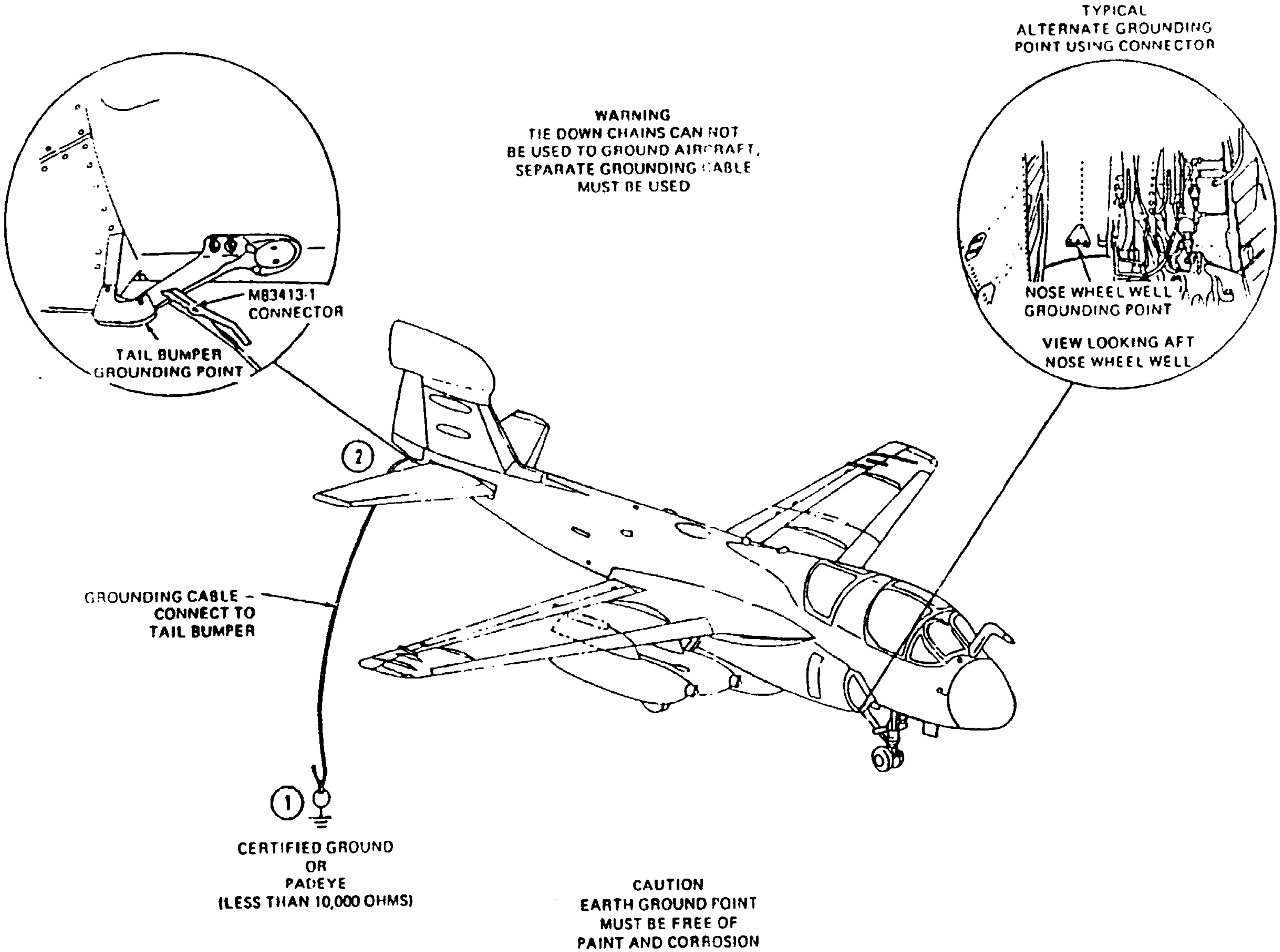

FIGURE 2-51. EA-6 aircraft grounding, stores loading/unloading evolution.

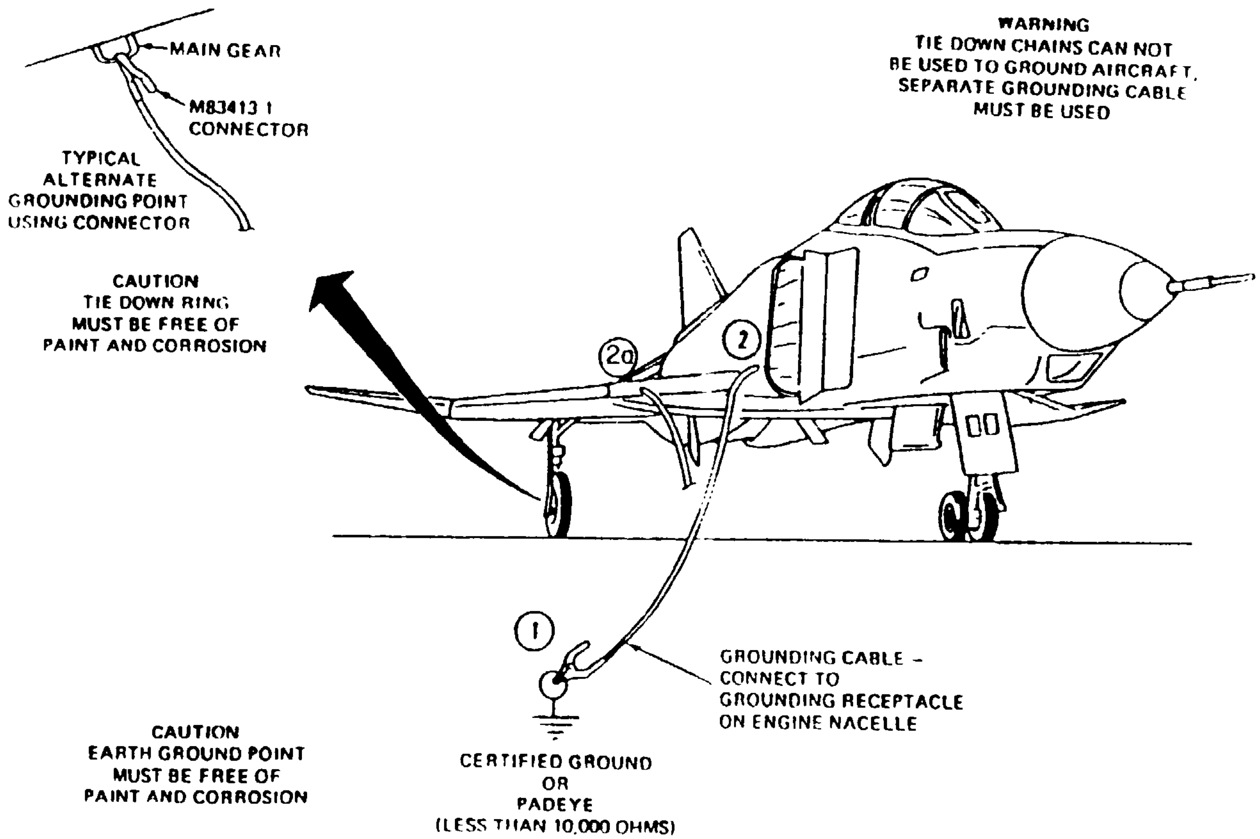

FIGURE 2-52. F-4 aircraft grounding, parked evolution.

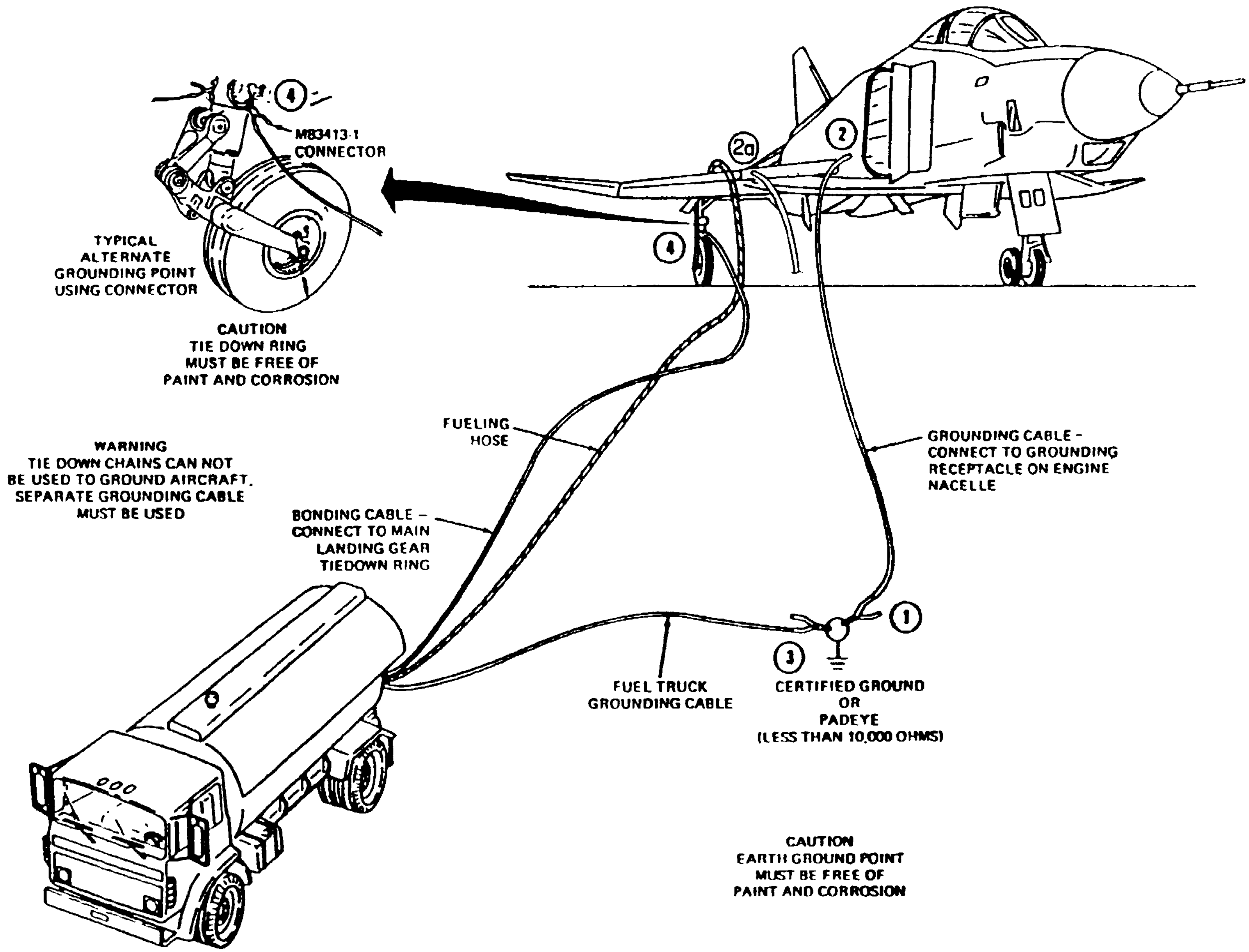

FIGURE 2-53. F-4 aircraft grounding, fueling/defueling evolution.

b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
e. Connect fuel truck bonding cable to main gear tiedown ring (4).
f. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
g. To remove grounding or bonding cable, reverse above procedures.

2.1.63 F-4 hanger-based maintenance evolution. To ground F-4 aircraft during maintenance in the hangar, proceed as follows (see figure 2-54):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.64 F-4 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground F-4 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-55):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

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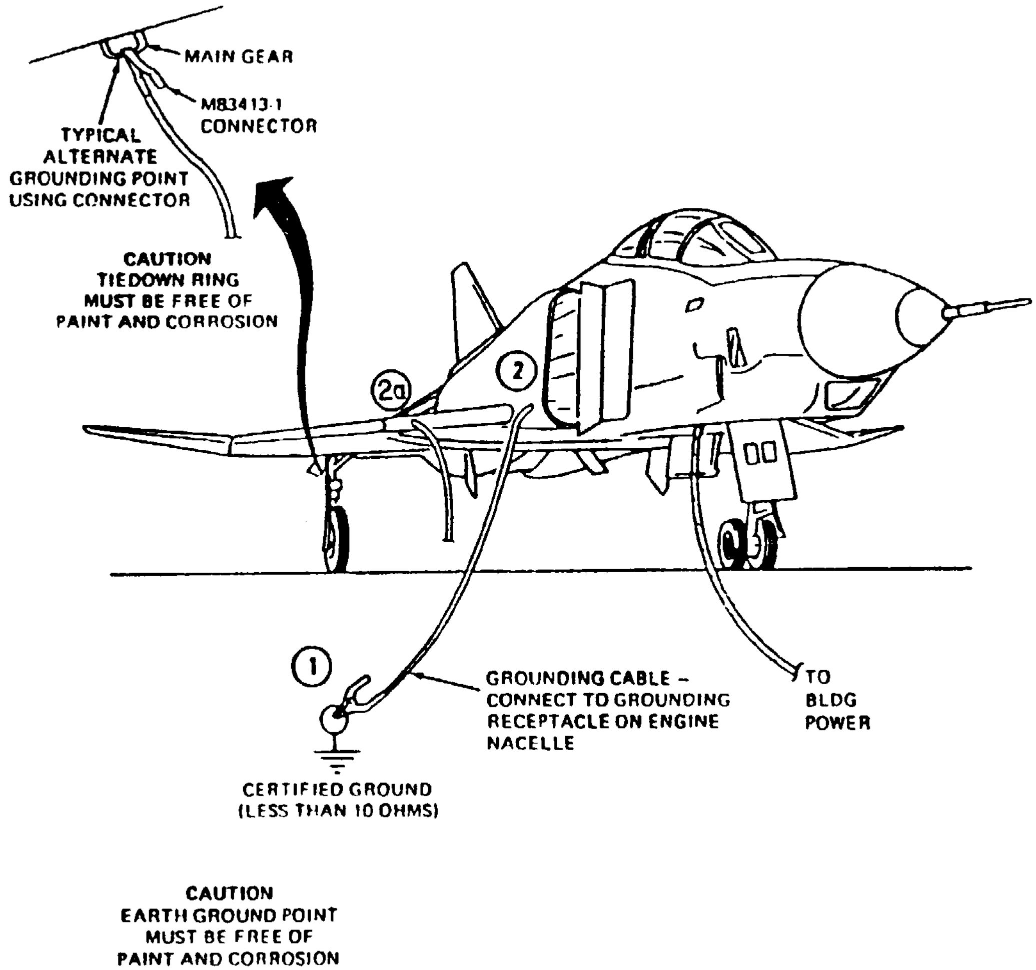

FIGURE 2-54. Hangar-based F-4 aircraft grounding, maintenance evolution.

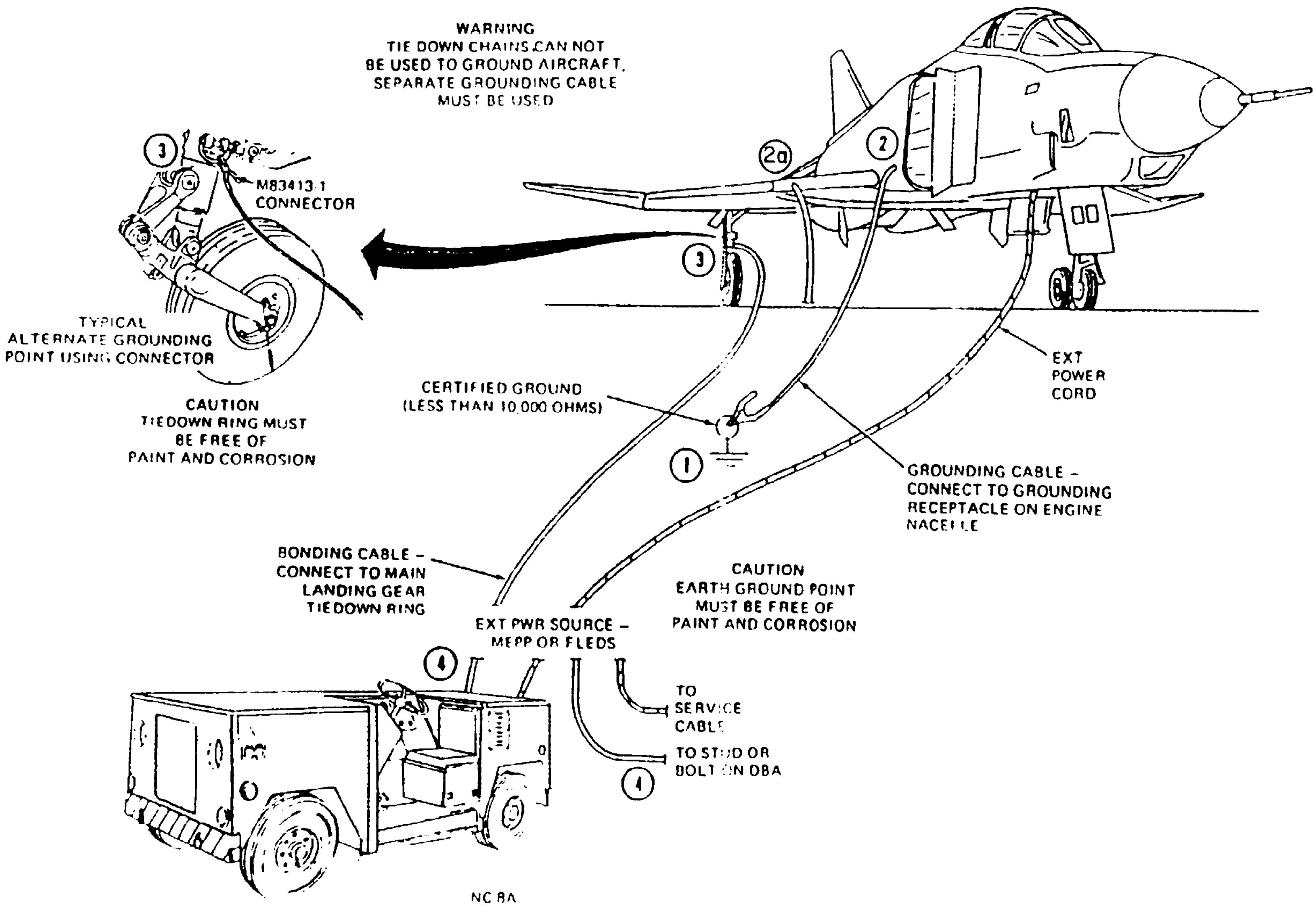

FIGURE 2-55. Apron-based F-4 aircraft grounding, maintenance evolution.

2.1.65 F-4 apron-based maintenance evolution (using FLEDS). To ground F-4 aircraft when in the maintenance evolution on the apron using FLEDS, proceed as follows (see figure 2-55):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. Attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the DBA such as the stud or bolt (4) (see figure 2-155).
f. To remove grounding or bonding cable, reverse above procedures.

2.1.66 F-4 stores loading/unloading evolution. To ground F-4 aircraft during stores loading or unloading, proceed as follows (see figure 2-56):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.1.67 F-14 parked evolution. To ground F-14 aircraft when in the parked evolution, proceed as follows (see figure 2-57):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.68 F-14 fueling/defueling evolution. To ground F-14 aircraft when fueling or defueling, proceed as follows (see figure 2-58):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).

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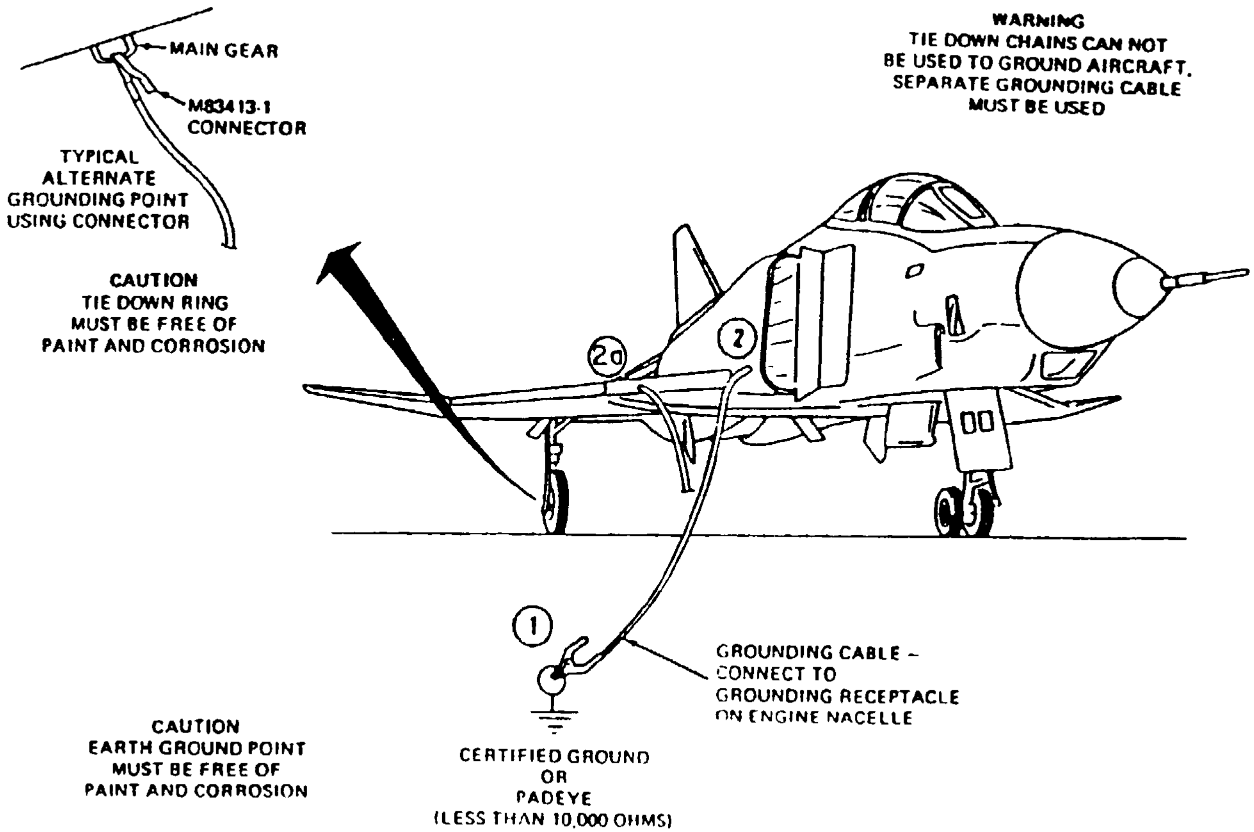


FIGURE 2-56. F-4 aircraft grounding, stores loading/unloading evolution.

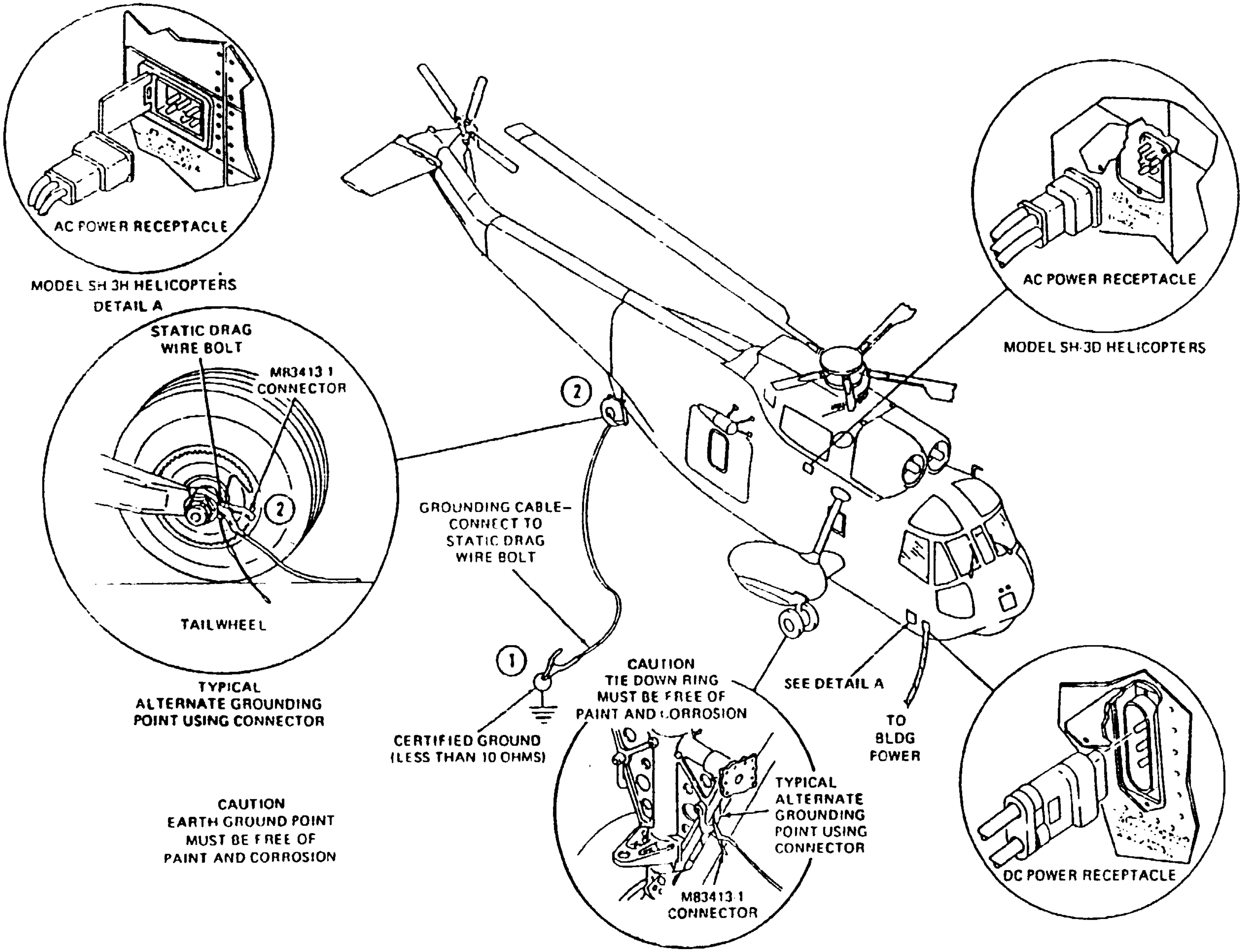
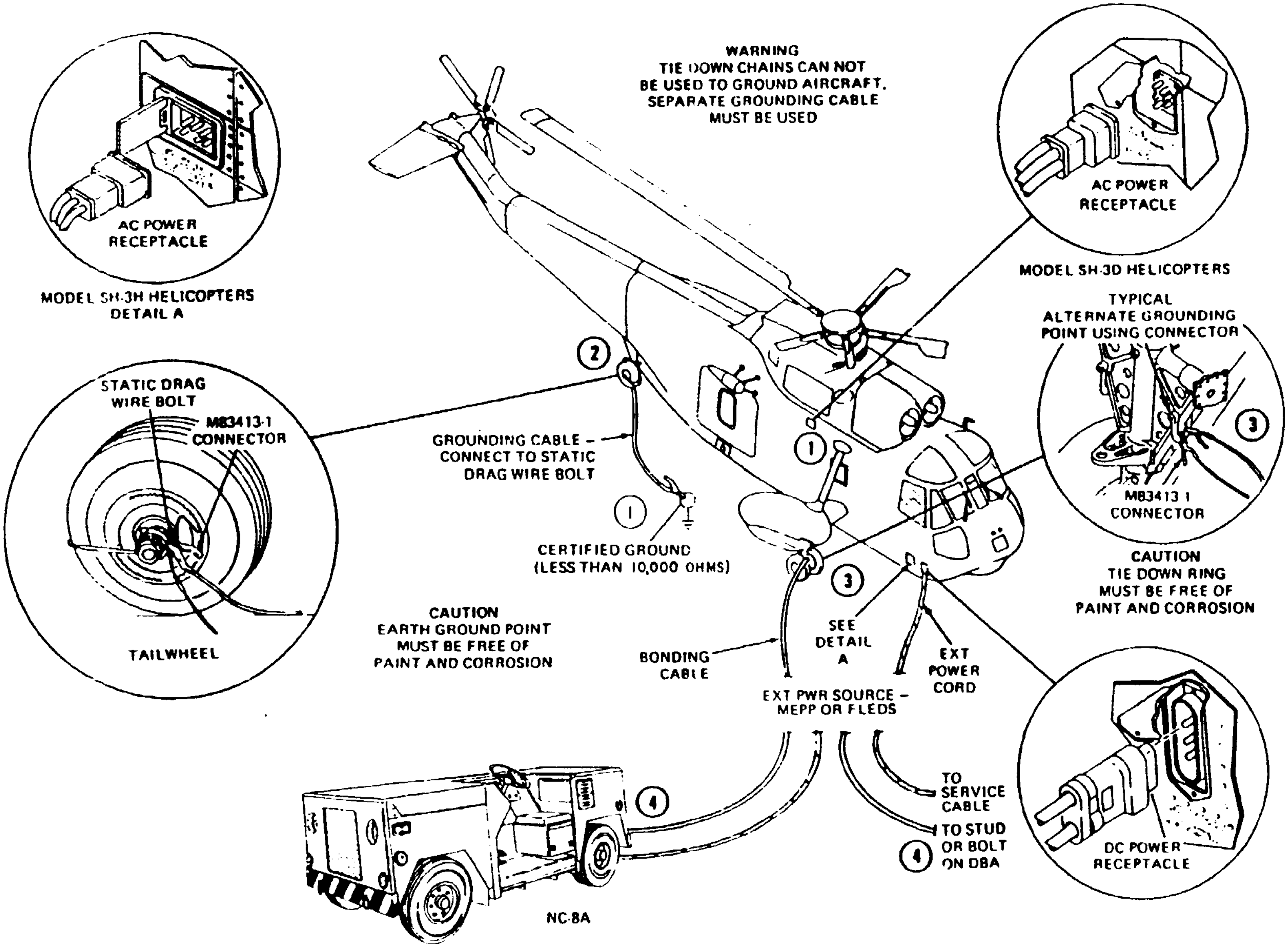


FIGURE 2-94. Hangar-based SH-3 aircraft grounding, maintenance evolution.


WARNING
TIE DOWN CHAINS CAN NOT
BE USED TO GROUND AIRCRAFT.
SEPARATE GROUNDING CABLE
MUST BE USED
AC POWER
RECEPTACLE
MODEL SH-3H HELICOPTERS
DETAIL A
AC POWER
RECEPTACLE
MODEL SH-3D HELICOPTERS
TYPICAL
ALTERNATE GROUNDING
POINT USING CONNECTOR
M83413-1
CONNECTOR
CAUTION
TIE DOWN RING
MUST BE FREE OF
PAINT AND CORROSION
STATIC DRAG
WIRE BOLT
M83413-1
CONNECTOR
TAILWHEEL
GROUNDING CABLE -
CONNECT TO STATIC
DRAG WIRE BOLT
CERTIFIED GROUND
(LESS THAN 10,000 OHMS)
CAUTION
EARTH GROUND POINT
MUST BE FREE OF
PAINT AND CORROSION
BONDING
CABLE
SEE
DETAIL
A
EXT
POWER
CORD
EXT PWR SOURCE -
MEPP OR FLEDS
TO
SERVICE
CABLE
TO STUD
OR BOLT
ON DBA
DC POWER
RECEPTACLE
NC-8A

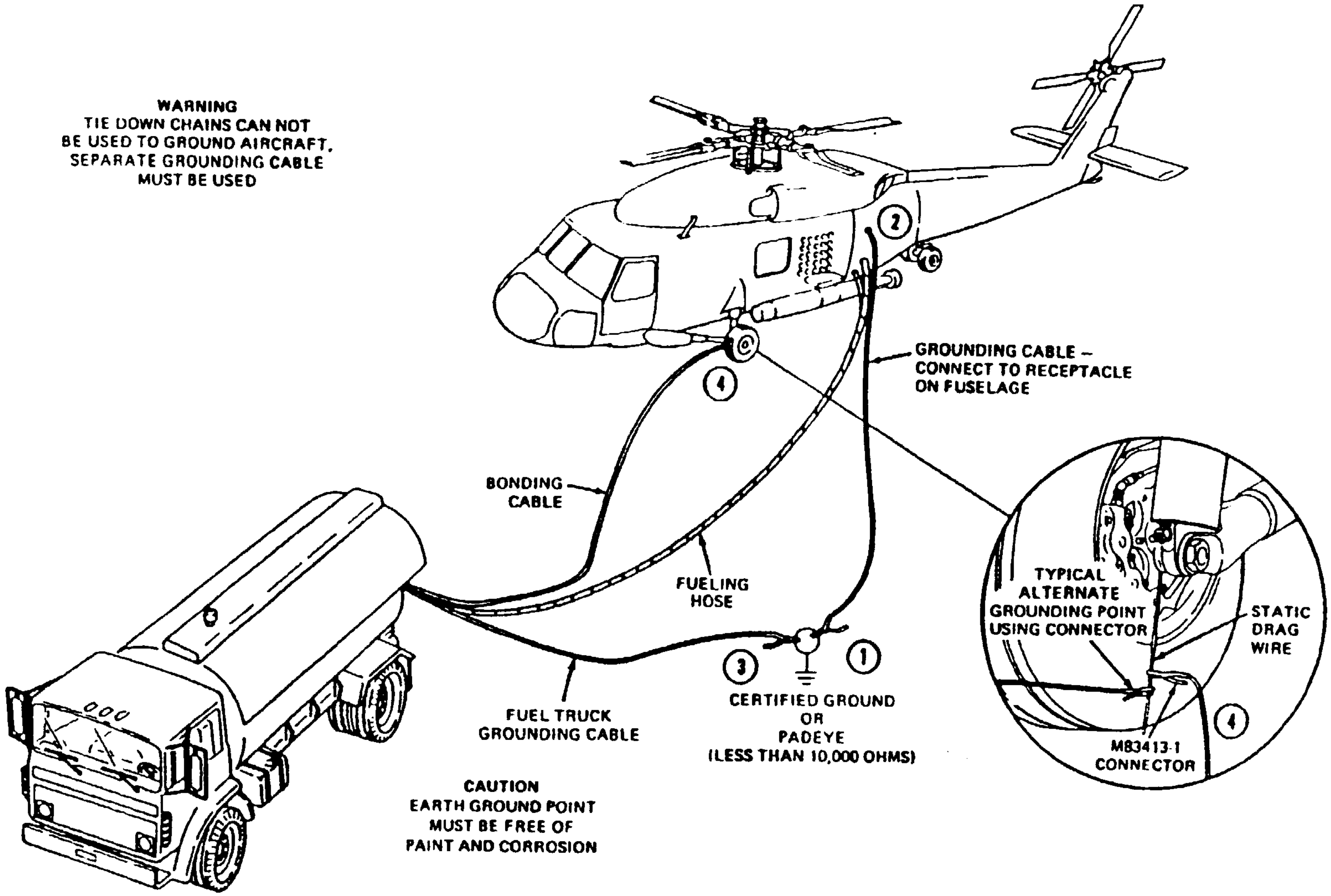


FIGURE 2-98. SH-60 aircraft grounding, fueling/defueling evolution.

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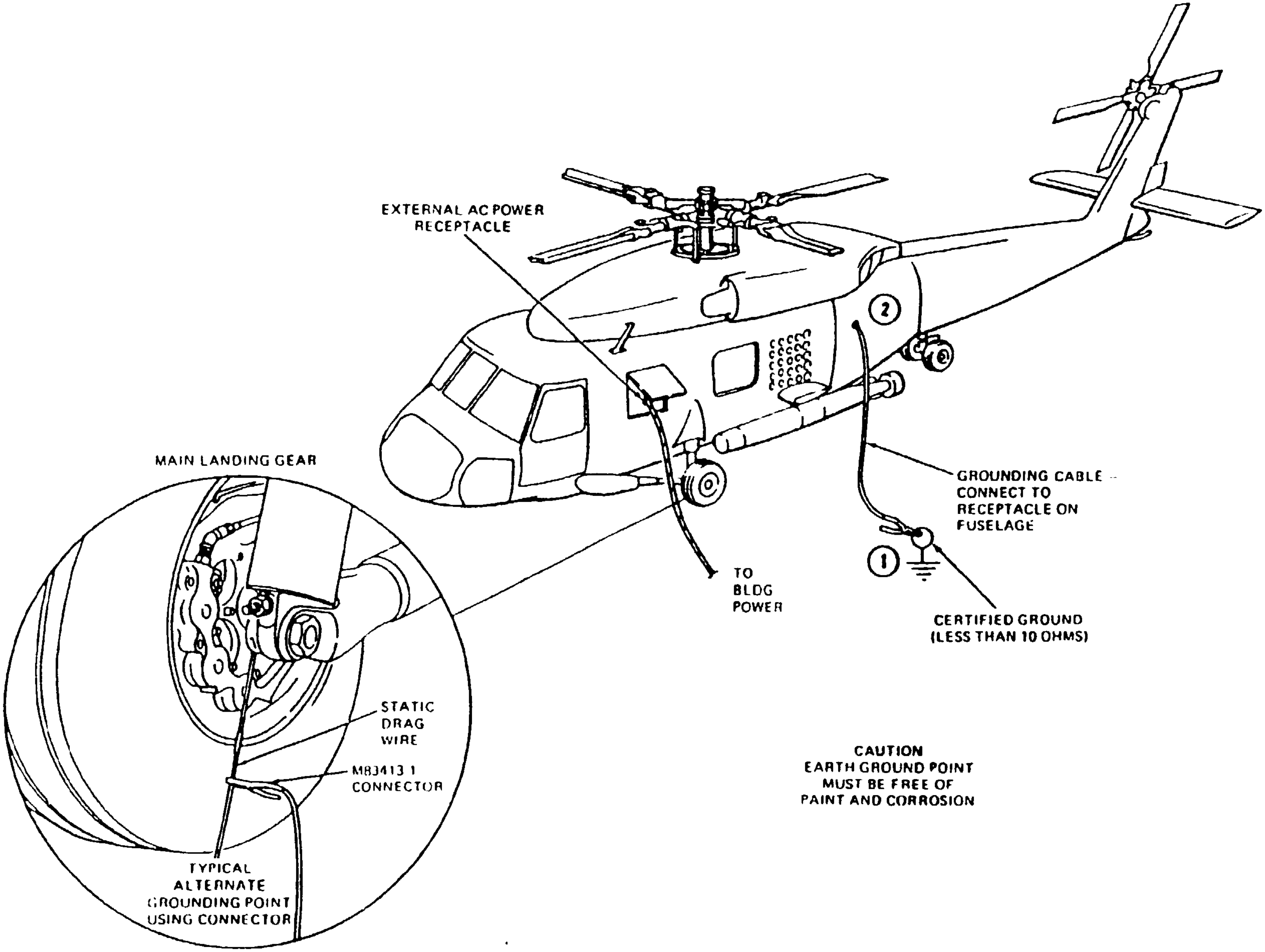

FIGURE 2-99. Hangar-based SH-60 aircraft grounding, maintenance evolution.

b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).
c. If using fuel truck, attach its grounding cable to a certified static ground or padeye (3).
d. Connect fuel truck bonding cable to main wheel axle (4).
e. When fueling/defueling evolution has been completed, wait a minimum of 2 min before removing bonding cable.
f. To remove grounding or bonding cable, reverse above procedures.

2.1.126 UC-12 hangar-based maintenance evolution. To ground UC-12 aircraft during maintenance evolution in the hangar, proceed as follows (see figure 2-108):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified power ground (1).
b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.1.127 UC-12 apron-based maintenance evolution (with MEPP plugged into aircraft). To ground UC-12 aircraft when in the maintenance evolution on the apron with MEPP plugged into aircraft, proceed as follows (see figure 2-109):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a certified static ground or padeye (1).

NOTE: If the MEPP is an electrically-driven type, then a power ground must be used.

b. Connect free end of grounding cable to nose wheel axle (2). If this location is not accessible, then connect grounding cable to main wheel axle (typical alternate grounding point).

NOTE: If the MEPP is a diesel engine-driven type, then the following bonding requirement is waived.

c. Attach bonding cable with M83413-1 electrical ground connector to main wheel axle (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2 Carrier-based aircraft. The following paragraphs provide step-by-step procedures for grounding carrier-based aircraft. Note that the word "carrier" is meant to refer to any ship which supports aircraft flight operations. The airframe electrical grounding procedures presented in the handbook are valid for aircraft operations on all ships.

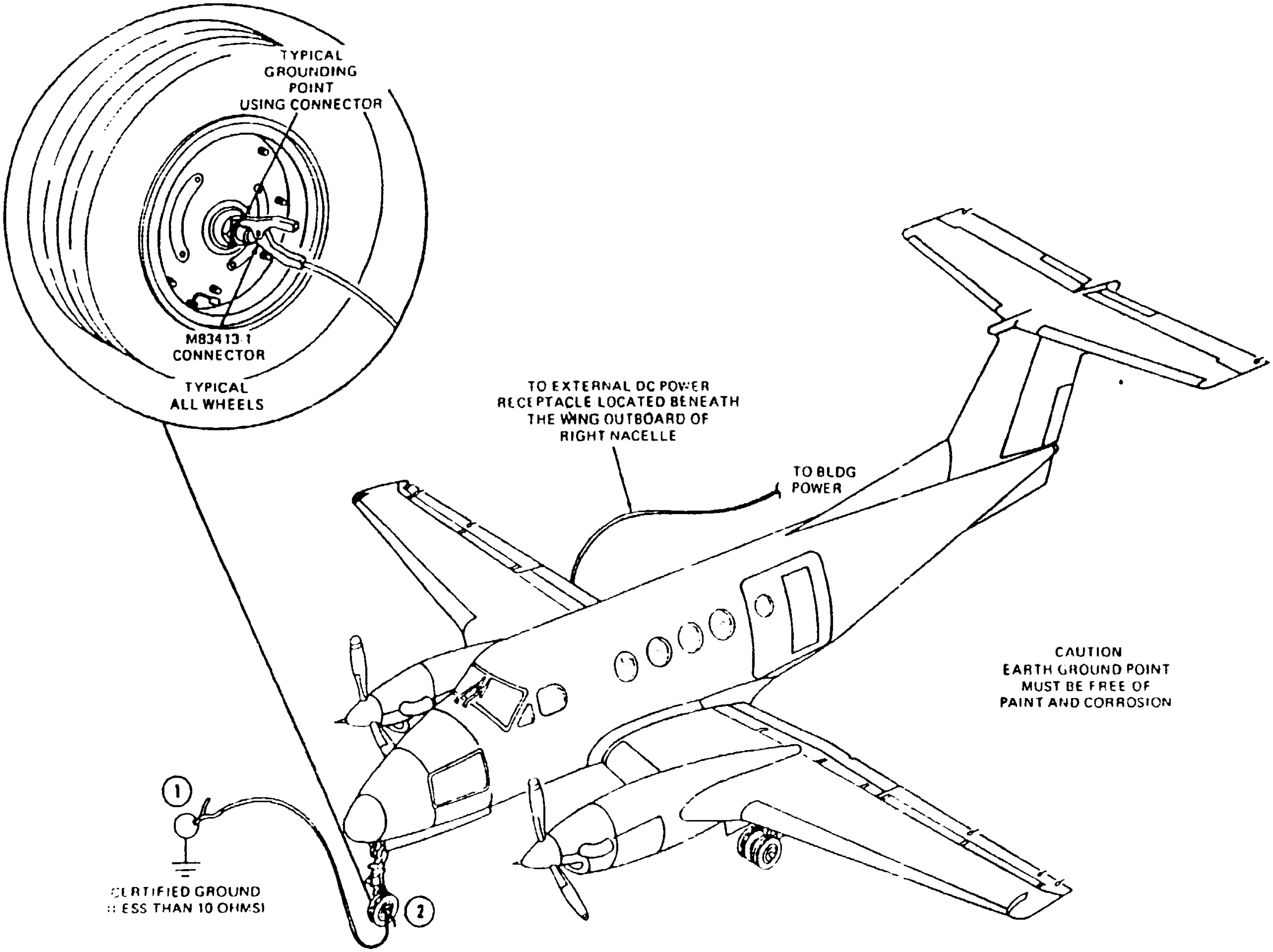

FIGURE 2-108. Hangar-based UC-12 aircraft grounding, maintenance evolution.

NOTE: COMNAVAIRPAC/COMNAVAIRLANTINST 3100.4A REQUIRES SINGLE POINT PRESSURE FUELING ONLY ON CV/CVN CLASS SHIPS. ALL REFERENCES TO "GRAVITY FUELING" IN THE ILLUSTRATIONS THAT FOLLOW DO NOT APPLY TO CV/CVN VESSELS.

Before attaching grounding cables, ensure that the aircraft has been tied down and secured to the carrier deck. Tiedown chains cannot be relied upon for grounding. A grounding cable must be used to properly implement the grounding methods presented in this section.

Maintenance evolutions and fueling evolutions are represented for each aircraft type while the parked and stores loading/unloading evolutions are illustrated for

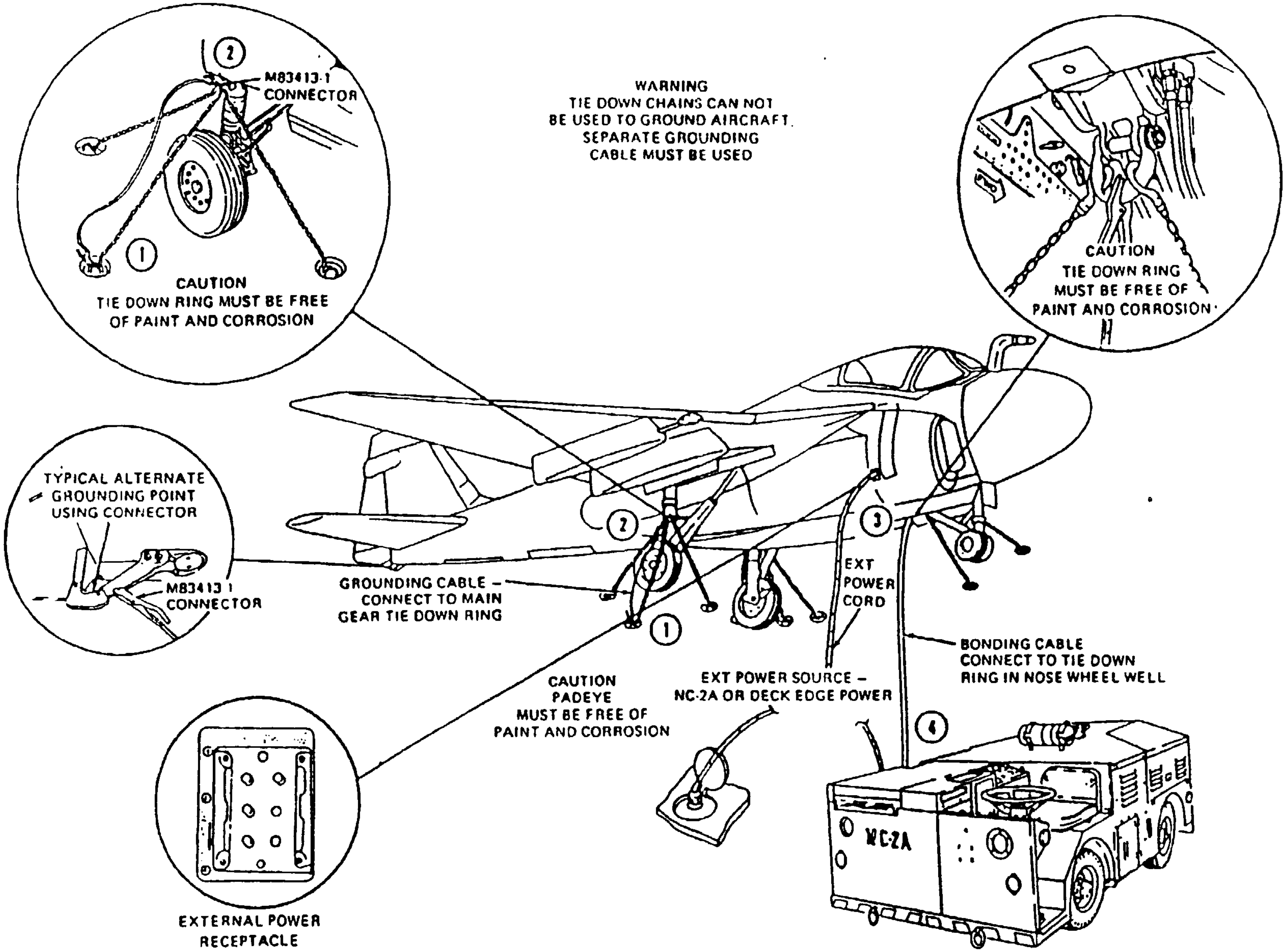

FIGURE 2-115. Carrier-based A-6 aircraft, maintenance evolution.

aircraft when in the parked evolution and stores loading/unloading evolution, proceed as follows (see figure 2-116):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to pylon station grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. To remove grounding cable, reverse above procedures.

2.2.8 Carrier-based A-7 fueling/defueling evolution. To ground carrier-based A-7 aircraft when fueling or defueling, proceed as follows (see figure 2-117):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.9 Carrier-based A-7 maintenance evolution. To ground carrier-based A-7 aircraft when in the maintenance evolution, proceed as follows (see figure 2-118):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to grounding receptacle in left-hand wheelwell (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to nose gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to nose gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.10 Carrier-based AH-1 fueling/defueling evolution. To ground carrier-based AH-1 aircraft when fueling or defueling, proceed as follows (see figure 2-119):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).

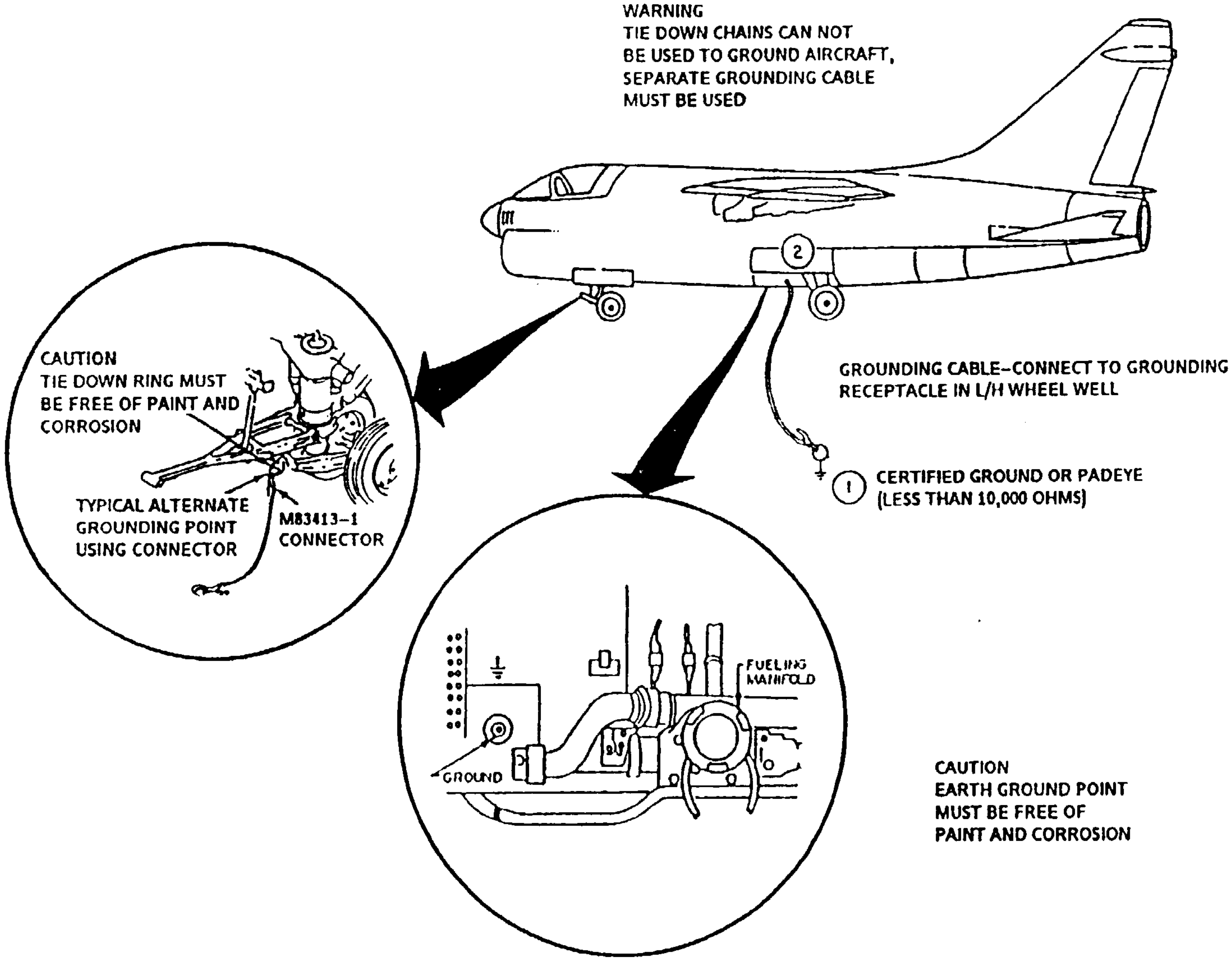

FIGURE 2-116. Carrier-based attack (A-3, A-4, A-6, A-7, AV-8, EA-6) aircraft, parked evolution and stores loading/unloading evolution.

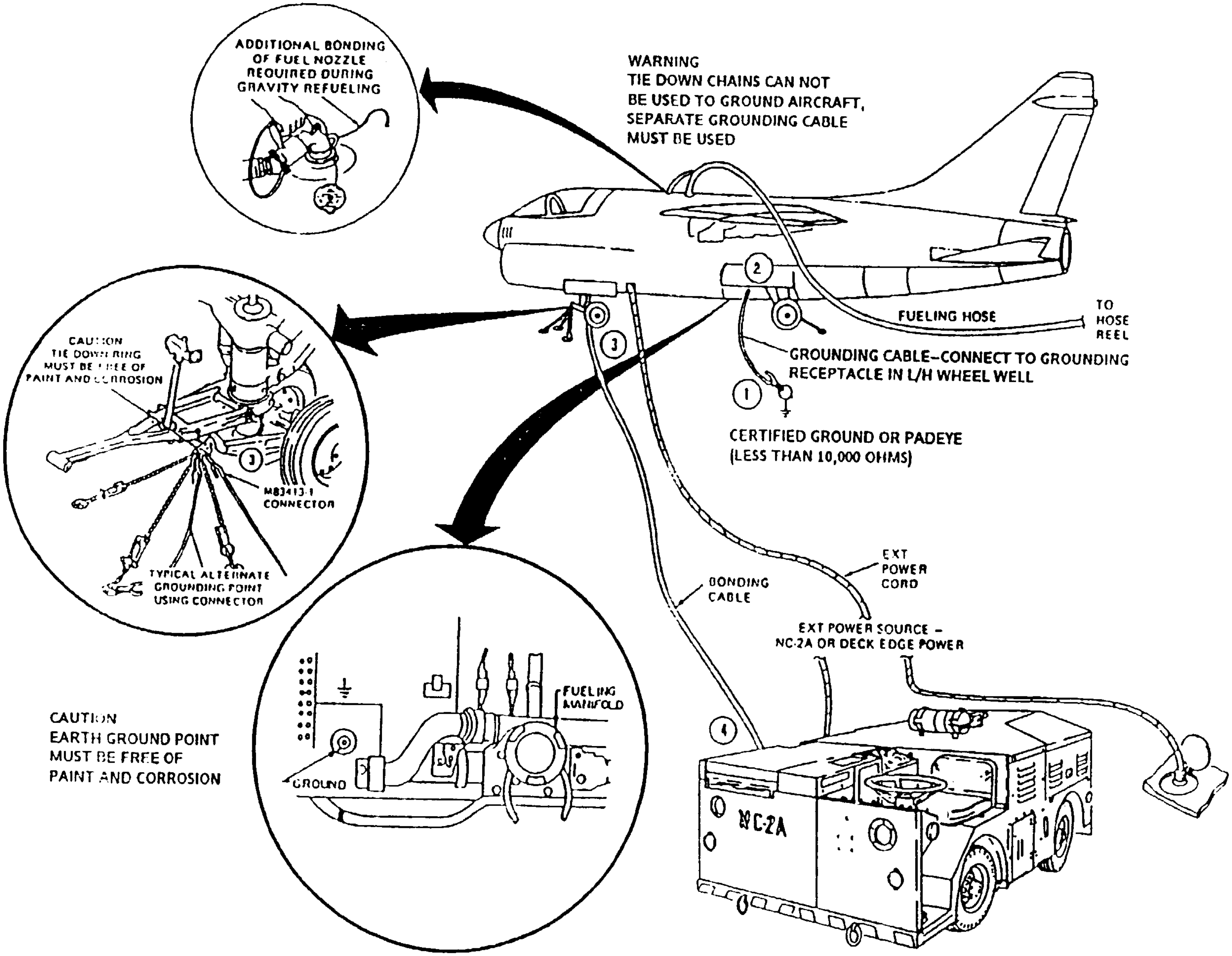

FIGURE 2-117. Carrier-based A-7 aircraft, fueling/defueling evolution.

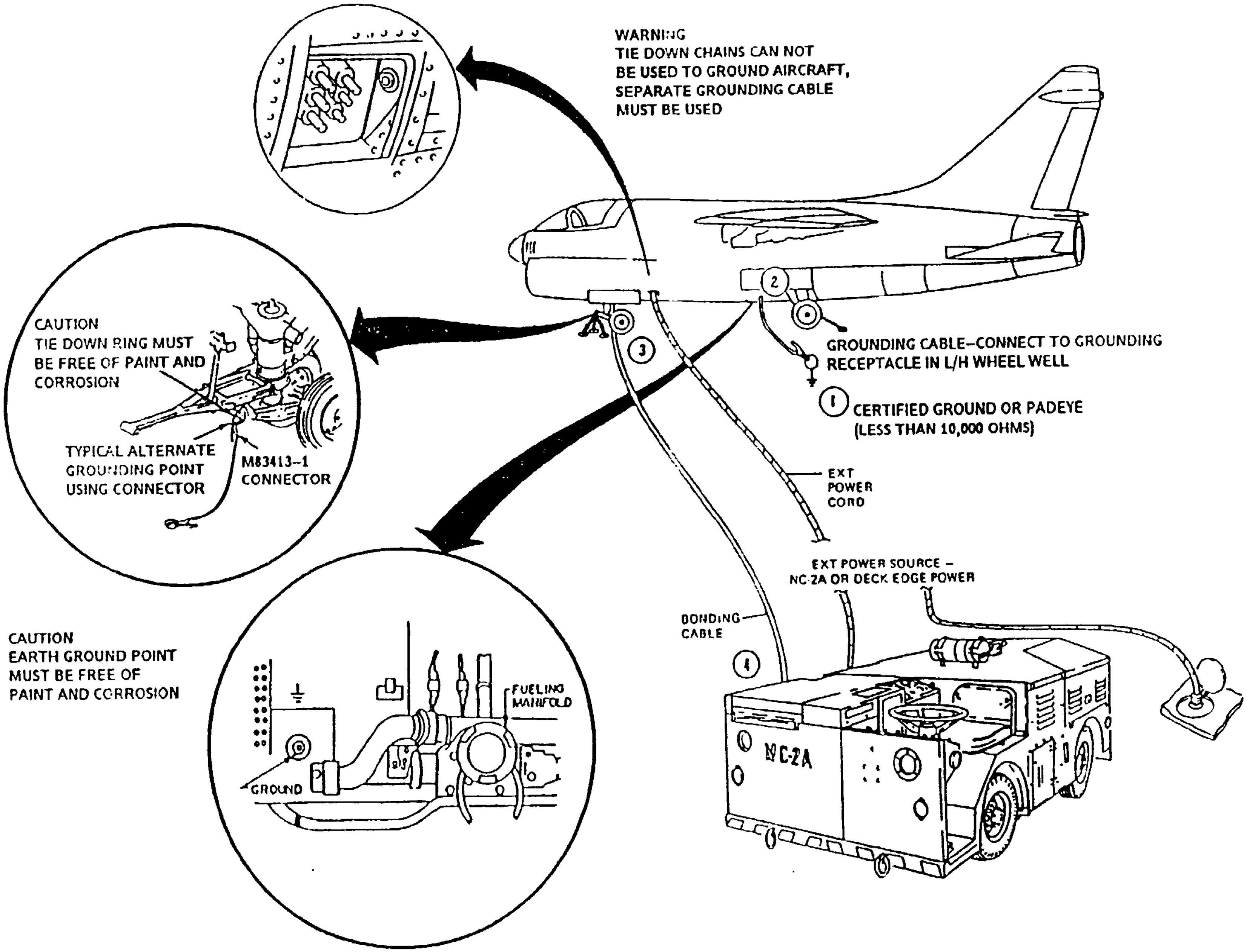

FIGURE 2-118. Carrier-based A-7 aircraft, maintenance evolution.

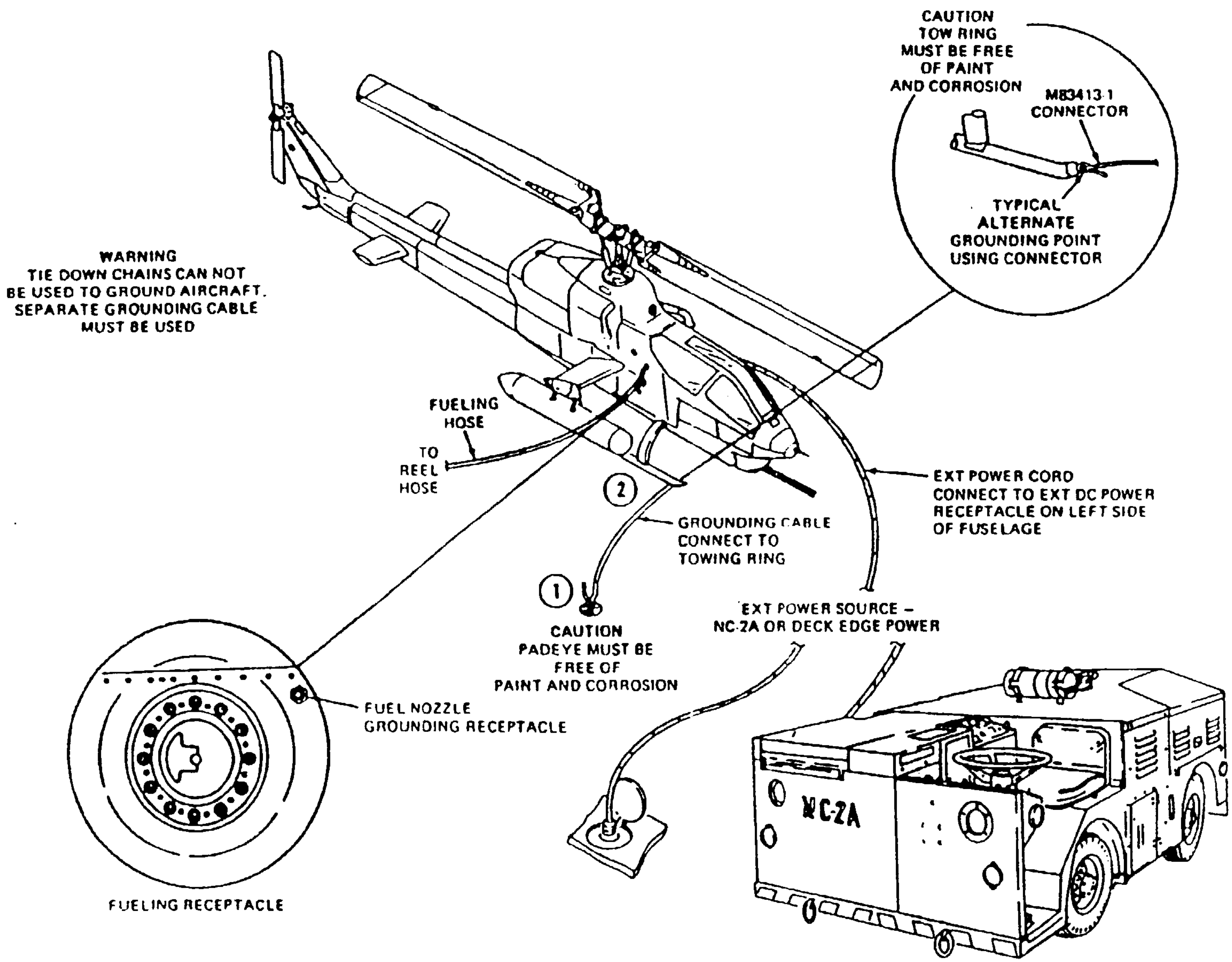

FIGURE 2-119. Carrier-based AH-1 aircraft, fueling/defueling evolution.

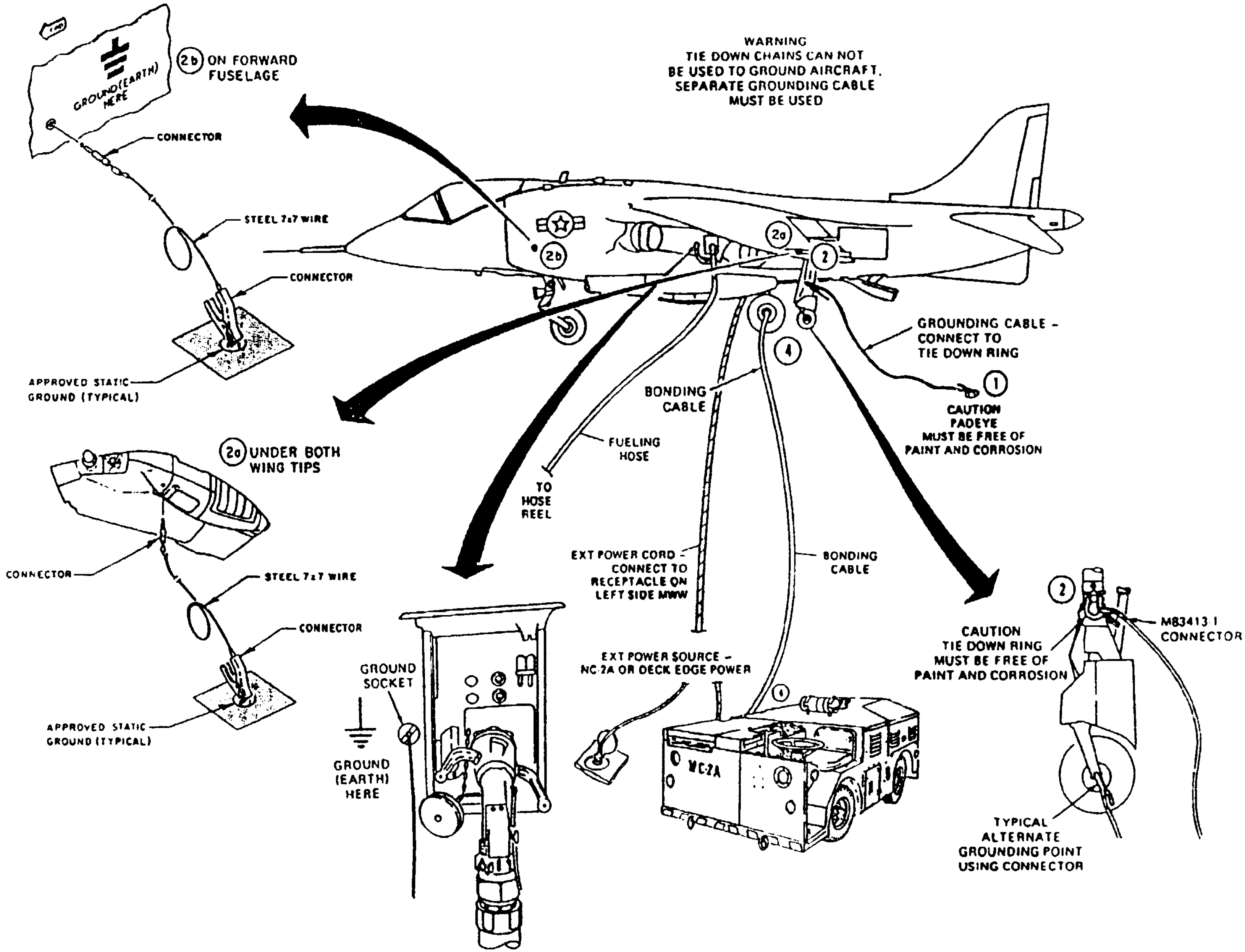

FIGURE 2-121. Carrier-based AV-8 aircraft, fueling/defueling evolution.

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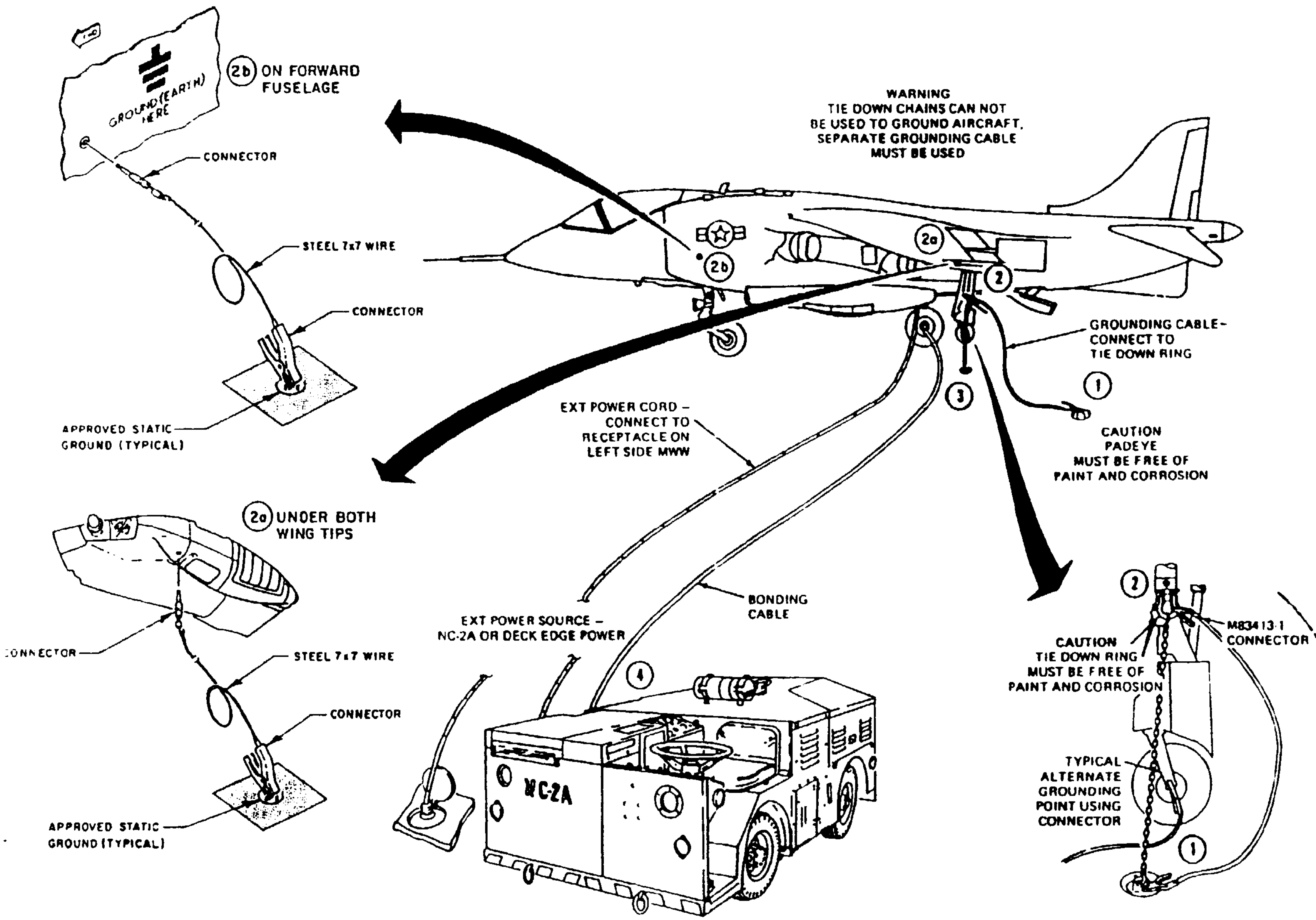

FIGURE 2-122. Carrier-based AV-8 aircraft, maintenance evolution.

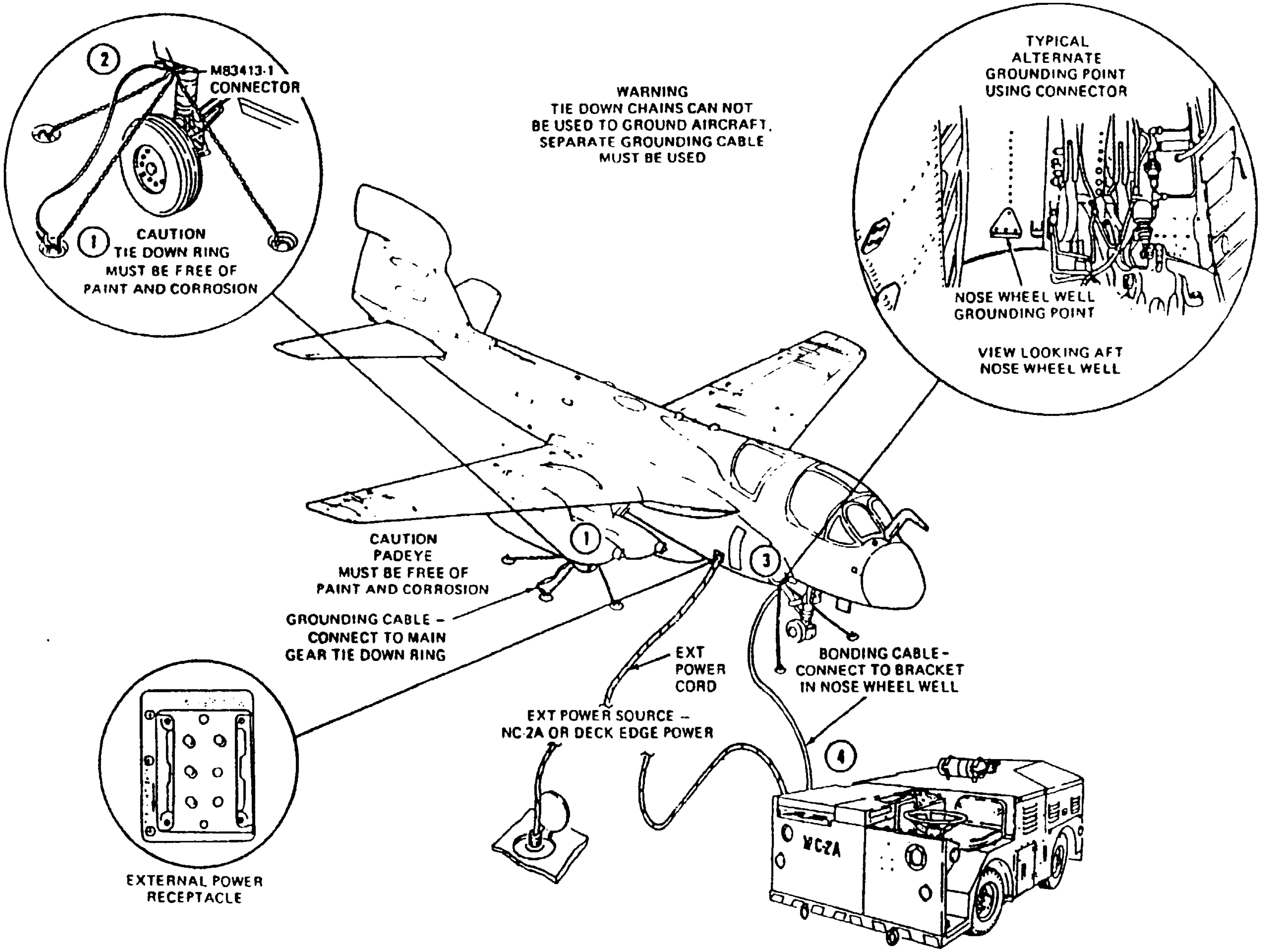

FIGURE 2-131. Carrier-based EA-6 aircraft, maintenance evolution.

b. Connect free end of grounding cable to main gear tiedown ring (2). If this location is not accessible, then connect grounding cable to bracket inside nose wheel well (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to bracket inside nose wheel well (3).
d. Connect free end of bonding cable to a bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.23 Carrier-based F-4 fueling/defueling evolution. To ground carrier-based F-4 aircraft when fueling or defueling, proceed as follows (see figure 2-132):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.24 Carrier-based F-4 maintenance evolution. To ground carrier-based F-4 aircraft when in the maintenance evolution, proceed as follows (see figure 2-133):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to engine nacelle grounding receptacle (typical) (2) or to grounding receptacles on main wings (2a) (as applicable).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).
d. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to main gear tiedown ring (3).
e. Connect free end of bonding cable to a bare metal area on the MEPP (4).
f. To remove grounding or bonding cable, reverse above procedures.

2.2.25 Carrier-based fighter aircraft (F-4, F-14, F-18) parked evolution and stores loading/unloading evolution. To ground carrier-based fighter (F-4, F-14, F-18) aircraft when in the parked evolution and stores loading/unloading evolution, proceed as follows (see figure 2-134):

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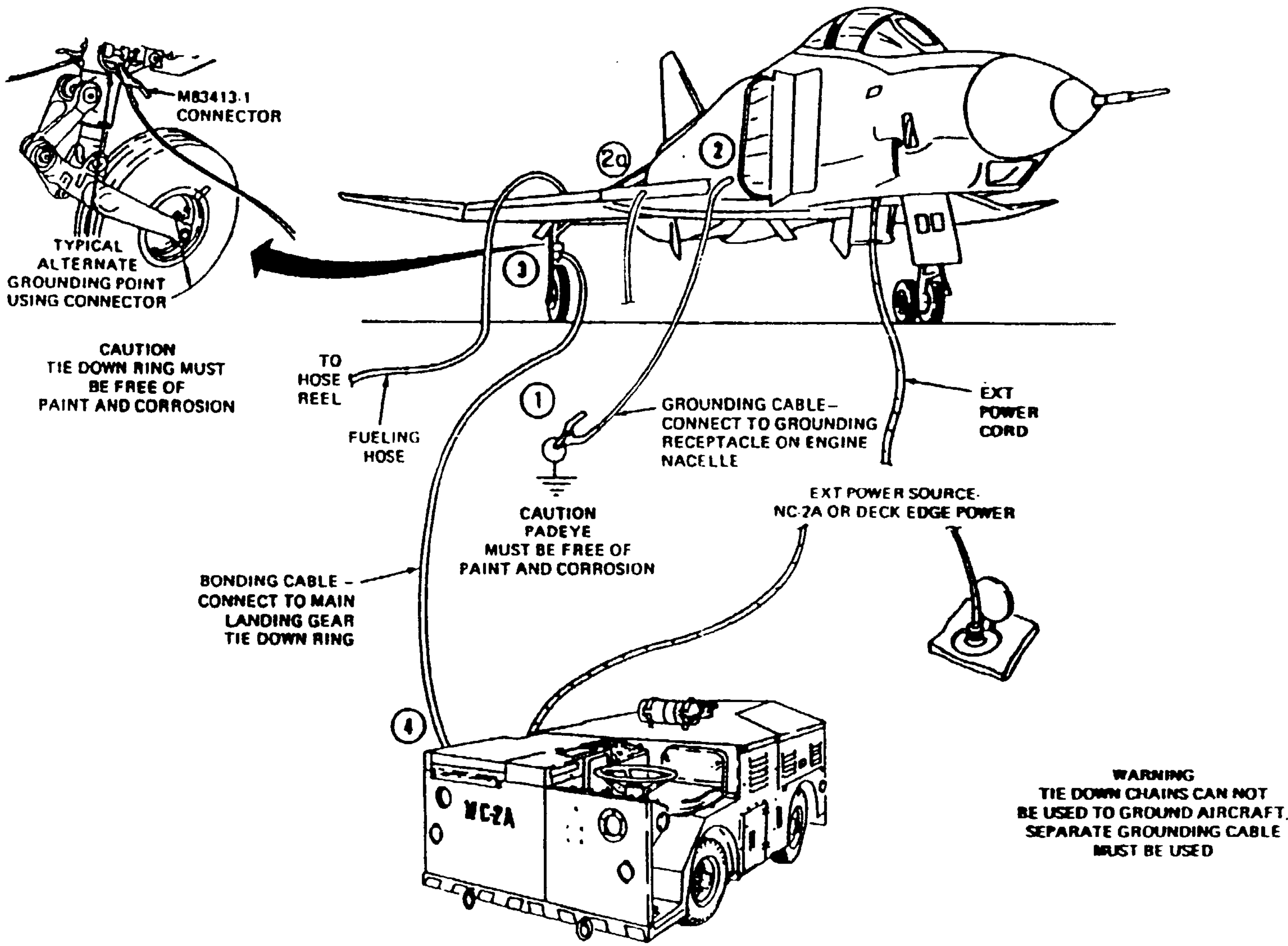

FIGURE 2-132. Carrier-based F-4 aircraft, fueling/defueling evolution.

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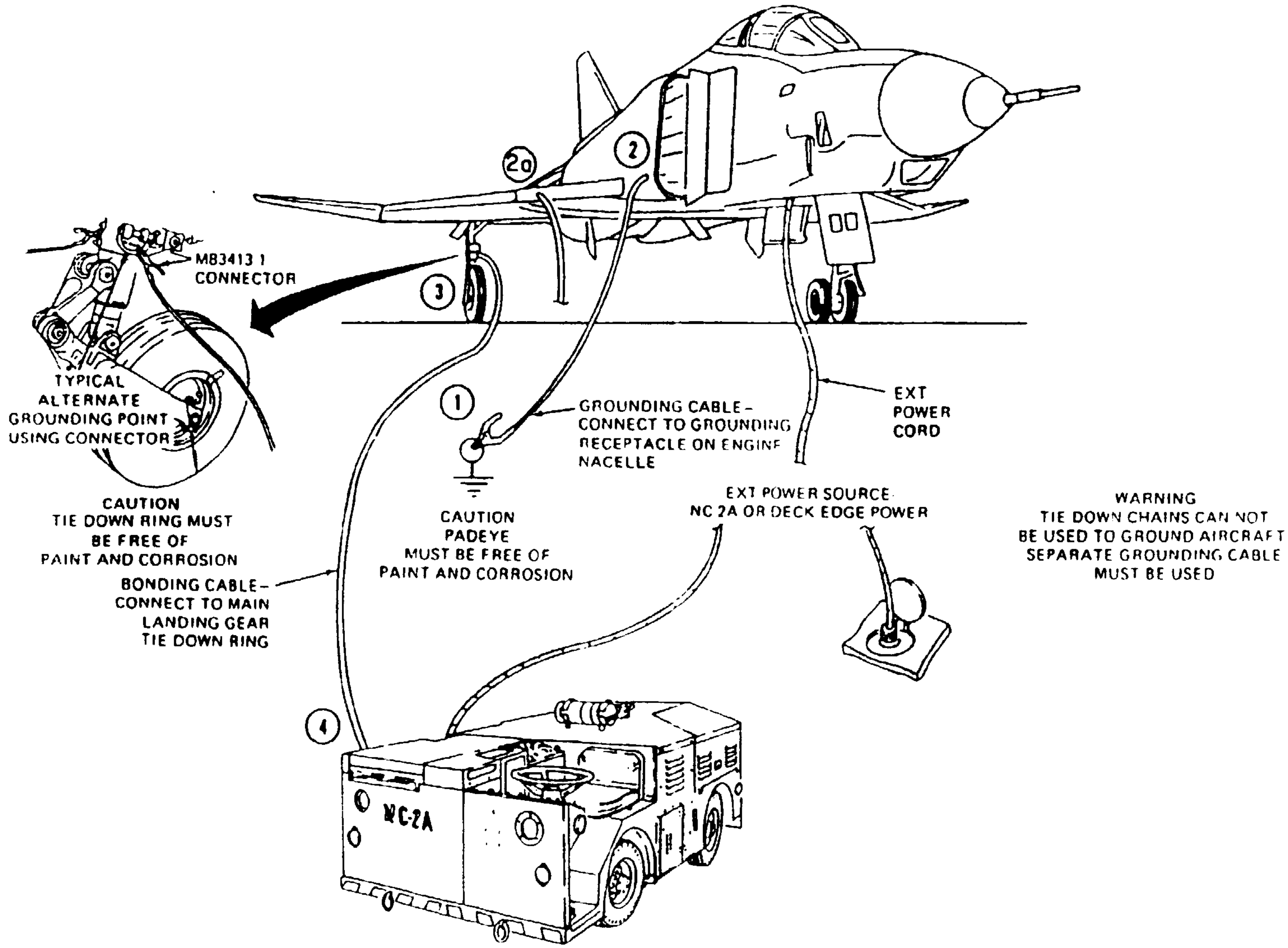

FIGURE 2-133. Carrier-based F-4 aircraft, maintenance evolution.

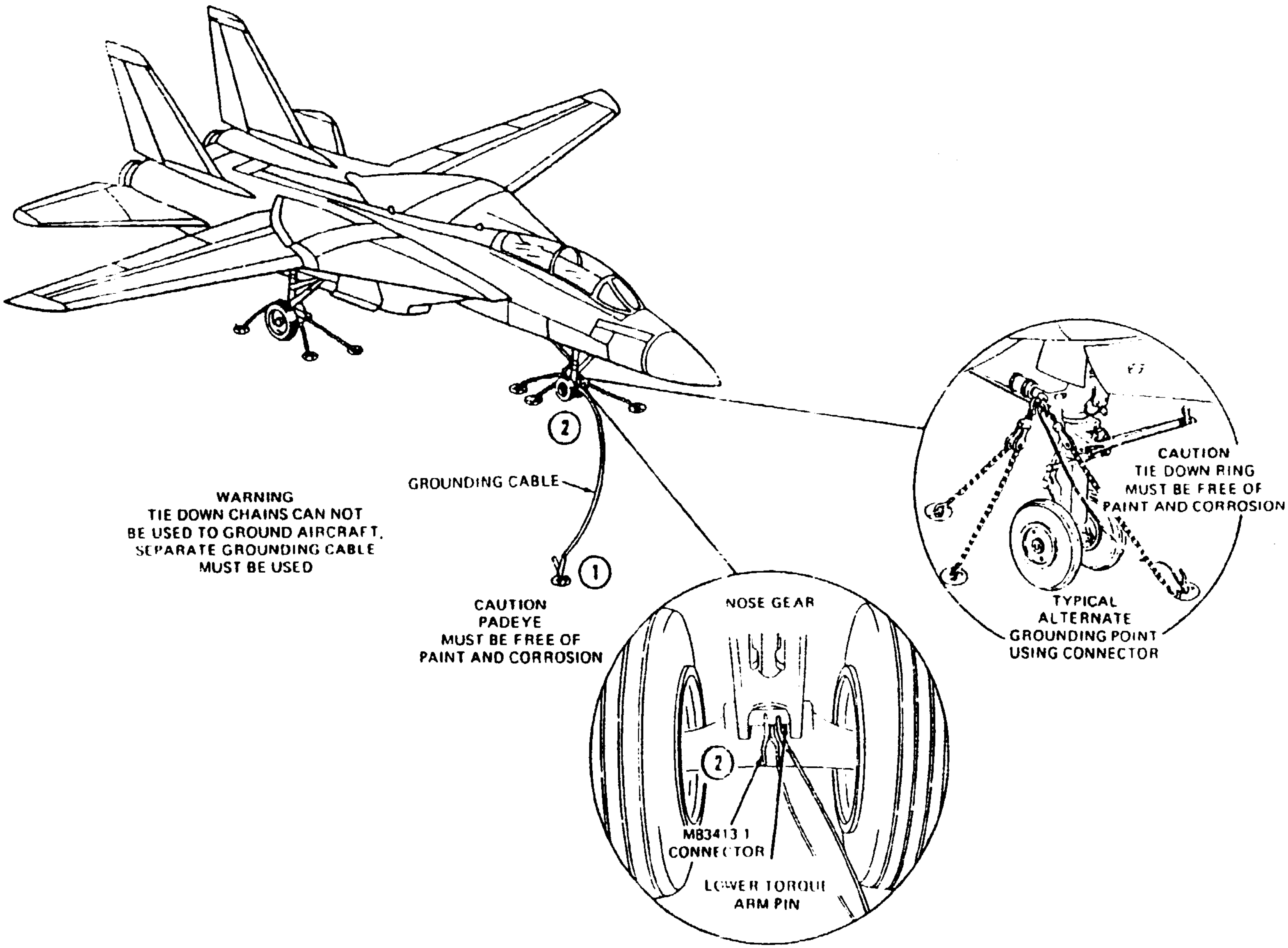

FIGURE 2-134. Carrier-based fighter (F-4, F-14, F-18) aircraft, parked evolution and stores loading/unloading evolution.

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. To remove grounding cable, reverse above procedures.

2.2.26 Carrier-based F-14 fueling/defueling evolution. To ground carrier-based F-14 aircraft when fueling or defueling, proceed as follows (see figure 2-135):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to lower torque arm pin (3).
d. Connect free end of bonding cable to bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.27 Carrier-based F-14 maintenance evolution. To ground carrier-based F-14 aircraft when in the maintenance evolution, proceed as follows (see figure 2-136):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to lower torque arm pin on nose gear (2). If this location is not accessible, then connect grounding cable to nose gear tiedown ring (typical alternate grounding point).
c. If using MEPP, attach bonding cable with M83413-1 electrical ground connector to lower torque arm pin (3).
d. Connect free end of bonding cable to bare metal area on the MEPP (4).
e. To remove grounding or bonding cable, reverse above procedures.

2.2.28 Carrier-based F-18 fueling/defueling evolution. To ground carrier-based F-18 aircraft when fueling or defueling, proceed as follows (see figure 2-137):

a. Attach grounding cable with M83413-1 electrical ground connector (clamp type) to a padeye (1).
b. Connect free end of grounding cable to nose wheel well grounding receptacle (typical) (2).
c. If grounding receptacles are not accessible, then using a grounding cable with M83413-1 electrical ground connector at each end, follow step a, and connect free end of grounding cable to main gear tiedown ring (typical alternate grounding point).

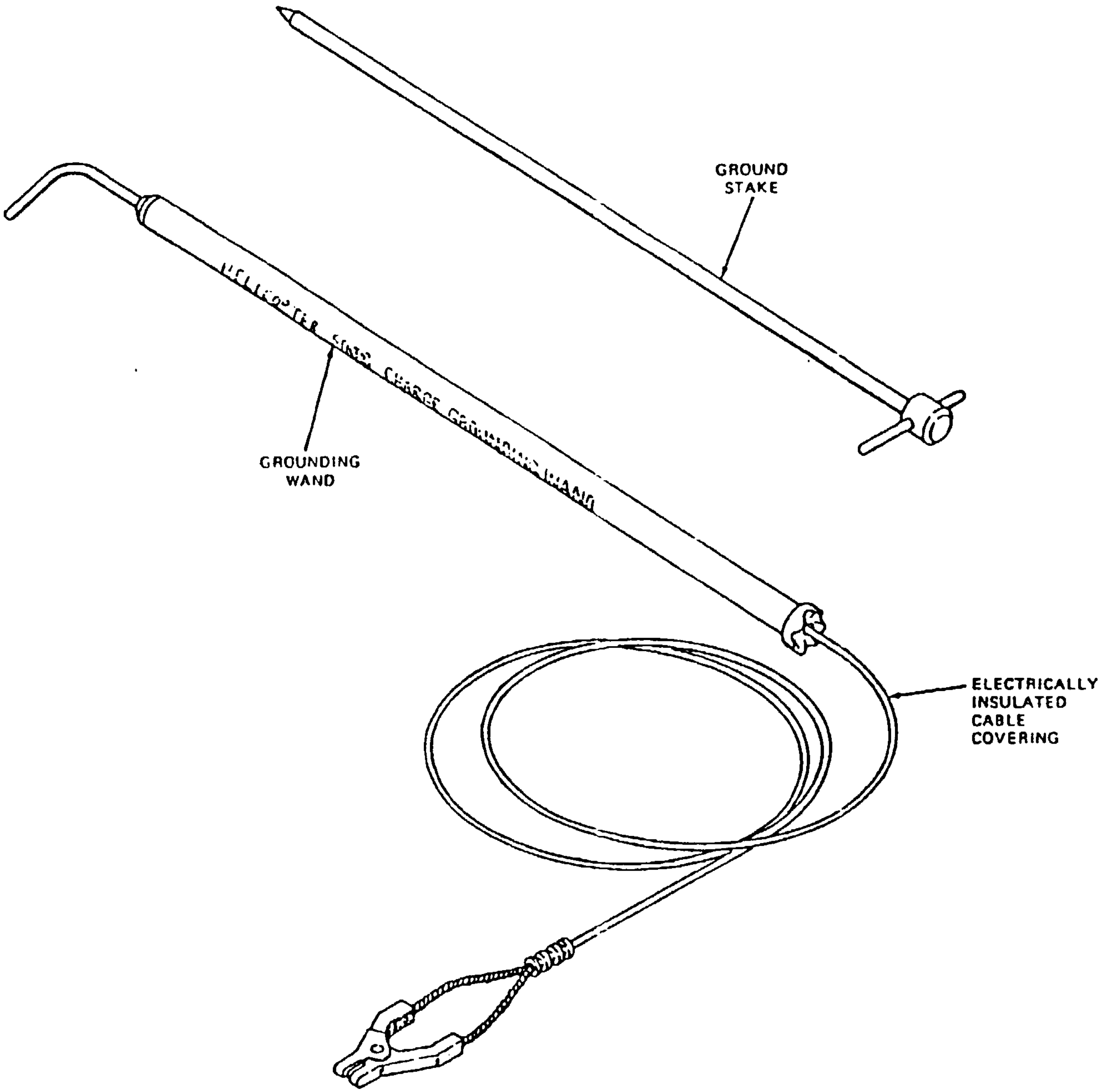

FIGURE 3-4. Helicopter grounding wand.

3.4.4 Servicing aircraft with water, oxygen, and hydraulic carts. Similar precautions are required to ground and bond the aircraft during water, oxygen, and hydraulic services. Where metal hoses are used between oxygen or nitrogen cart and aircraft, bonding is unnecessary.

3.4.5 Temporary grounding. In areas where no approved static or power grounds exist, metal rods may be driven into the ground at suitable points adjacent to the proposed aircraft parking position. For temporary grounds that may be used for some period of time, these rods should be approximately 8 ft. long and 0.875 in. in diameter. Care must be taken that the rod is not driven into a place where it will damage underground services.

3.4.5.1 For aircraft operating in the field, a temporary ground may be obtained by driving a metal rod approximately 3 to 4 ft long and 0.5 in. in diameter into the ground adjacent to the parked aircraft. This usually provides an adequate static ground. The quality of the ground depends on the type of soil and the amount of moisture available. The ground resistance can be improved by saturating the area with water.

3.4.5.2 A temporary ground rod that is in use for some time should have its ground resistance measured on a frequent basis. The resistance should be less than 10,000 ohms. If it is not, consideration should be given to driving additional or longer rods in order to reduce ground resistance.

3.4.5.3 In geographical areas covered by deep ice, such as Antarctica, establish a temporary ground(s) as follows:

a. Drive a metal rod approximately two feet long and 0.5 inches in diameter into the ice.

b. During fueling operations, follow the triangulation bonding and grounding procedures outlined in the handbook using the temporary grounding rod (see paragraph 3.4).

3.5 Actual grounding problems. The following are excerpts from the Naval Safety Center files. These narrative sections are reproduced here only to demonstrate the actual types of problems that are encountered in daily fleet operations.

3.5.1 Narrative: "WHEN A.C. AND D.C. POWER WAS APPLIED TO ACFT, THE MAINT PERS RECEIVED A SHOCK FROM THE SKIN OF THE ACFT. TROUBLESHOOTING OF THE ELECT SYS REVLD THAT EXTERNAL A.C. D.C. POWER RECEPTACLE COMMON GROUND WIRE NR P 49AON HAD MELTED INSULATION. OXIDIZATION AND CORROSION VISIBLE AT THE TERMINAL ON THE ACFT SKIN WAS THE ONLY APPARENT REASON FOR OVERHEATING. ALL CONNECTIONS WERE SECURE."

Comment: Prior to any maintenance action, aircraft must be appropriately grounded.

3.5.2 Narrative: "DURING TURN AROUND INSP PLANE CAPTAIN APPLIED ELECT POWER UTILIZING THE FLIGHT LINE ELECT DISTRIBUTION SYSTEM. UPON CONTACTING AIRCRAFT, PLANE CAPTAIN RECEIVED MILD BUT DEFINITE ELECT SHOCK. ELECT POWER WAS SECURED. WATER WAS STANDING ON RAMP AS A RESULT OF WEATHER CONDITIONS

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CONSISTING OF LOW OVERCAST AND RAIN. INVEST BY PUBLIC WORKS ELECT SHOP PERS REVEALED BROKEN GROUNDING PLUG WHICH PREVENTED THE CABLE FROM ACHIEVING PROPER GROUND. THIS INCIDENT REEMPHASIZED THE NECESSITY FOR PROPER HANDLING AND MAINTENANCE OF FLIGHT LINE ELECT POWER DISTRIBUTION SYSTEM IN ORDER TO AVOID SERIOUS PERSONNEL INJURY, ESPECIALLY UNDER ADVERSE RAMP CONDITIONS."

Comment: Emphasizes need to inspect grounding hardware.

3.5.3 Narrative: "AFTER SHUTDOWN FM FLT, ORD MAN BEGAN PROCED FOR LOADING MK82 PRACTICE BOMBS ON UTBD RACKS. AFTER COMPLETION OF JETTISON REL CKS, JETTISON CART WAS BEING INSTLD IN PORT OUTBD STA. AS CAP AND CART WERE BEING INSERTED INTO BREECH, CART EXPLODED. INJURY TO ORD MAN INVOLVED WAS SUPERFICIAL AND THERE WAS NO DAM TO ACFT. IMMED AFET INCDT, ORD INVOLVED CKED BOTH CKPTS TO ASCERTAIN JETTISON ASCERTAIN JETTISON SW POSITION, AND STATED BOTH WERE IN THE OFF/SAFE POSIT. HOWEVER, ACFT WAS UNGROUNDED. THE MOST LIKELY CAUSE OF INCDT WAS THE FAIL OF ORDNANCEMAN TO GROUND ACFT PRIOR TO EXECUTING LOADING PROCEDURES."

Comment: The next ordnance man may not be so lucky.

3.5.4 Narrative: "ACFT WOULD NOT ACCEPT EXT DC POWER FOR START. UPON REMOVAL OF DECKING PLT SIDE, DISCOVERED DC EXT POWER RECEPTACLE GROUND LEAD WAS NOT ATTACHED. FURTHER INVEST REVLD GROUND LEAD HAD BURNED A HOLE IN MOUNTING AREA, THUS FREEING THE LEAD. BELIEVE ATTACHING BOLT WORKED LOOSE OVER A PERIOD OF TIME AND CAUSED POOR CONNECTION. ANY LOOSENESS COUPLED WITH EXCESSIVE HEAT GEN BY HIGH CURRENT CAN RESULT IN THIS SIT."

3.5.5 Narrative: "WHILE PERFORMING BEFORE START CHECKLIST WITH EXT D.C. PWR APPLIED, CREW NOTICED SMOKE COMING FROM BENEATH PLTS DECKING. EXTERNAL PWR IMMED SECURED. T/S REVLD LOOSE GROND WIRE FOR DC EXT PWR RECEPTACLE. REPLACED GROUNDING WIRE."

3.5.6 Narrative: "JUST BEFORE LIGHT OFF, ON START OF NO. 2 ENG, PLT SMELLED ELECTRICAL FUMES AND NOTICED SMOKE COMING FROM UNDER HIS DECKING. HE SHUTDOWN BOTH ENG AND SECURED ACFT. TROUBLESHOOTING REVLD DC EXT PWR RECPT GROUND WIRE LOOSE, BURNING THRUGH ATTACHING STRINGER."

Comment: Para 3.5.4, 3.5.5 and 3.5.6 are typical of many reports and illustrate not only the need for constant vigilance but the serious consequences that poor maintenance will cause. Any aircraft fire, especially onboard a carrier, can be disastrous.

3.5.7 Narrative: "WHILE DEFUELING, VAPOR WAS OBSERVED IN THE STBD WHEEL WELL. INVEST REVLD ALL FOUR ENG HRD BOTTLES HAD DISCHARGED. THE FOUR PRIMARY CARTRIDGES WERE EXPENDED. STATIC ELECTRICITY BUILD-UP CAUSED BY IMPROPER GRND OF FUEL TRUCK TO ACFT. THE FUEL TRUCK TO ACFT GROUNDING WIRE WAS CONNECTED TO THE LANDING GEAR SCISSORS STRUT, VICE THE GROUNDING KNOBS PROVIDED ON THE FORWARD SIDE OF THE LANDING GEAR. THIS SCISSORS STRUT IS PAINTED AND POSSIBLY COULD HAVE CAUSED AN INPROPER GRND. PROPER GROUNDING PROCEDURES HAVE BEEN STRESSED IN THE CMD. MAINT ERROR SQD."

Comment: This illustrates not only the need to make sure that the bonding cable is attached to a clean metallic surface but the need to do an even better job of stressing these important requirements.

3.5.8 Narrative: "WHILE TROUBLESHOOTING A FUEL QUANTITY DISCREP, ELECTRICIAN, AE2 SOUCHAK, RECEIVED AN ELECTRICAL SHOCK WHILE HANDLING A CANNON PLUG IN FLAP WELL. INVESTIGATION REVLD THAT ACFT WAS NOT GROUNDED (NOR REQUIRED TO BE)."

Comment: Cannot agree with the comment "(nor required to be)." The local requirements should be rewritten.

3.5.9 Narrative: "WHILE FUELING FOR TRAINING FLIGHT, LIGHTNING STRUCK IN CLOSE PROXIMITY TO AIRCRAFT AND FUEL TRUCK. OF THE TWO CREWMEMBERS FUELING THE AIRCRAFT, ONE WAS KNOCKED TO THE GROUND AND THE OTHER LEFT DAZED BUT STILL ON HIS FEET. THE DRIVER OF THE FUEL TRUCK WAS APPARENTLY UNAFFECTED. THE FUELING OPERATION WAS SECURED AND THE CREWMEMBERS WERE TAKEN TO THE HANGAR AREA WHERE CORPSMEN CONDUCTED AND INITIAL EXAMINATION. THE CREWMEMBERS WERE SUBSEQUENTLY TRANSPORTED TO THE MEDICAL CENTER AND LATER RELEASED WITH NO APPARENT INJURIES. BECAUSE ACCEPTED AND PROVEN SAFETY PROCEDURES WERE FOLLOWED, A TRAGEDY OF IMMENSE PROPORTIONS WAS UNDOUBTEDLY AVERTED. ALTHOUGH THE SKY WAS OVERCAST WITH SOME CUMULUS CLOUDS IN THE AREAS, THERE WAS NO RAIN OR LIGHTNING ACTIVITY IN THE AREA. AS A RESULT, THE DRIVER AND CREWMEMBERS ALL WERE SATISFIED THAT CONDITIONS WERE SAFE FOR REFUELING. AT FIRST, IT WAS BELIEVED THAT THE AIRCRAFT HAD BEEN STRUCK BY THE LIGHTNING; HOWEVER, A THOROUGH INSPECTION BY QA PERSONNEL REVEALED NO DAMAGE OR OTHER INDICATION THAT THE AIRCRAFT SUSTAINED A DIRECT HIT OR CONDUCTED ANY PORTION OF THE CHARGE. NO DAMAGE TO THE FUEL TRUCK WAS IN EVIDENCE OR LATER REPORTED BY THE FUEL FARM. FOLLOWING THE LIGHTNING STRIKE, IT WAS NOTED THAT THE GROUNDING WIRE HAD NUMEROUS BURN SPOTS AND WAS SMOKING. FURTHER INSPECTION OF THE GROUNDING WIRE REVEALED THAT IT CONDUCTED A SUBSTANTIAL ELECTRICAL CHARGE AS EVIDENCED BY DISCOLORED WIRE, CRYSTALIZED METAL, AND MELTED POLYMER COATING. DURING THE INITIAL EXAMINATION BY CORPSMEN, ONE OF THE CREWMEMBERS COMPLAINED OF A TINGLING SENSATION IN HIS RIGHT ARM. SUBSEQUENT INVESTIGATION REVEALED THAT HE WAS HOLDING ON TO THE FUELING NOZZLE AT THE TIME OF THE STRIKE. THE OTHER CREWMEMBER INITIALLY HAD BLURRED VISION FOLLOWING THE STRIKE. IT IS BELIEVED THAT THIS WAS PROBABLY CAUSED BY HIM HITTING HIS HEAD ON THE UNDERSIDE OF THE WING ROOT AT THE TIME OF THE INCIDENT. AFTER THOROUGH INVESTIGATION BY THE AVIATION AND GROUND SAFETY OFFICER, IT WAS DETERMINED THAT ALL APPLICABLE DIRECTIVES AND REGULATIONS WERE STRICTLY ADHERED TO BY ALL PERSONNEL AND COMMANDS CONCERNED AND AS A RESULT, FURTHER SUBSTANTIATES THE VALUE OF PROPERLY GROUNDING THE AIRCRAFT AND FUEL TRUCK DURING FUELING OPERATIONS." This says it all - it is up to you to READ AND HEED!"

Comment: None required.

3.6 Measurement of static ground and electrical power ground points. Ground resistance measurements should be taken at periodic intervals to ensure that these measurements are made during different seasons over a period of years. A 15-month interval is recommended, although local site conditions may dictate other measurement intervals.

3.7 Grounding hardware/receptacle considerations. In all of the previously mentioned grounding procedures and considerations the receptacle is the preferred method of connection. Care must be taken to ensure that the receptacle is in good condition. Any evidence that the mating connection is loose indicates that the receptacle is defective and it must be replaced.

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Periodically, all receptacles must be inspected and their resistance to the aircraft structure should be measured and found to be less than 0.1 ohm. An MS 3493 plug should be inserted in the receptacle and found to be firmly seated. The pull required to withdraw the plug should be between 8 and 14 lb. A pull of less than 8 lb indicates a weak or damaged receptacle; a pull exceeding 14 lb may indicate a corroded receptacle. In either case, the receptacle must be replaced. Additionally, the complete cable must be maintained in good electrical condition.

CAUTION: Use of alligator clips or braided panel strap to ground or bond aircraft and support equipment is prohibited.

3.7.1 If a grounding receptacle is not available, an approved grounding cable constructed in accordance with MIL-C-83413/1 or /3 (with MIL-C-83413/7 clamps, as applicable) must be used. Care must be taken that the clamp-type connector, if used, conforms to MIL-C-83413 and must be checked for weak spring, deformed or rusty jaws, or any other defect which would prevent a good connection.

3.8 Grounding hardware military specification reference list. Grounding hardware military specification sheets are listed in Section 1, paragraph 1.2.

SECTION 4

4.0 THEORETICAL BASIS FOR AIRCRAFT GROUNDING

This section provides theory, background, and information necessary to understand the rationale behind the requirements for aircraft grounding and bonding. Theory and equations associated with both electrostatic charge generation in aircraft and grounding effects are discussed. The different aircraft scenarios or servicing situations are introduced with emphasis on the hazards that can be encountered.

4.1 Electrostatic theory. Static electricity, by definition "electricity at rest," consists of opposite electrical charges that are usually kept apart by insulators. Potential differences involved may amount to thousands of volts. However, the flow of electricity during generation and accumulation is small, in the range of millionths of an ampere. A primary manifestation of static electricity is the discharge or sparking of the accumulated charges. Static electricity is generated by the separation of like or unlike bodies. Electrostatic charges, positive and negative, always occur in pairs. They become evident when these pairs, having been in contact with each other, are separated. For significant potential to be developed, the bodies holding the charges must become, and remain, insulated from each other. Insulation may occur through complete physical separation of the bodies or because at least one of the bodies is an insulator.

4.2 Scenarios. The following aircraft evolutions or scenarios are considered in this manual:

a. Stores handling (including ordnance)
b. Maintenance (flight line and hangar)
c. Fueling
d. Parked

Potential hazards considered during each scenario are:

a. Static electrical shock to personnel
b. Power system electrical shock to personnel
c. Ordnance misfire and/or inadvertent ordnance or stores release
d. Fuel vapor ignition
e. Damage or upset to electronic subsystems

4.3 Energy sources. The source mechanism and source magnitude of the electrical energy is critical in assessing the possible occurrence of a hazardous situation. The following energy sources are to be considered during the aircraft evolutions of stores handling, maintenance, fueling, and aircraft parked:

a. Static
   - Triboelectric
   - Induced
   - Friction
b. Power
   - Ground fault
   - RF electromagnetic energy
   - Lightning

4.6.1.5 These values exceed the threshold hazard values for ignition for fuel vapor. Therefore, fuel vapor ignition should be considered during fuel transfer. For the electrically isolated aircraft, fuel vapor ignition, equipment upset, and reflex shock reaction by personnel must be considered.

4.6.1.6 The source level has been established as due to charge induced by storm activity. Energy levels may then reach

$$U = 1/2CV^2 = 1/2\ (0.005\ \mu F)(60\ kV)^2 = 9\ J.$$

These levels exceed threshold values for all hazards:

4.6.2 Time duration considerations. Some of the phenomena cited in paragraph 4.6.1 are transient in nature. Knowledge of their duration is necessary to assess them as realistic hazards. Induced voltages, friction voltages, and voltage buildups following fueling are considered transients.

4.6.2.1 Using the ungrounded aircraft resistance of 40 MΩ, an aircraft capacitance to ground of 0.005 μF, and a safe voltage limit of less than 30V, the following time durations were computed from:

$$t = RC \ln \left(\frac{E_i}{E_s} \right)$$

where t = time to reach E_s after removal of source

R = aircraft resistance to ground

C = aircraft capacitance to ground

E_i = initial (source) voltage

E_s = safe voltage level

Transient Source	E_i Source Magnitude	Time to E_s
Friction	27.0 kV	1.36 sec
After-fueling potential	2.5 kV	0.88 sec
Induced	60.0 kV	1.52 sec

4.6.2.2 Any transient is objectionable from a safety standpoint. As stated earlier, heart action discoordination (fibrillation) threshold levels have time durations as low as 0.2 sec. Thus, the duration of even the shortest of the three transients considered is unacceptably long.

4.6.3 Hazards. Ungrounded aircraft must be considered to be in jeopardy from the indicated energy source, since at least one (and generally more than one) hazard threshold level is exceeded during each scenario. These results are summarized in table 4-V below. The possibility of these hazardous events occurring is ensured by the physical data available. However, each is dependent on a number of factors which may occur simultaneously only very rarely (for example, the refueling of an aircraft with 40 M impedance to earth, a fuel spill, and an electrical spark located at the right point in the volume of fuel vapor or misted fuel to cause ignition). In any single one-time event, such as an aircraft repair or refueling operation, consideration could be given to the fact that hazardous combinations appear so seldom that they may be neglected. However, when consideration is given to the number of naval aircraft involved, the rapid tempo of operations, the fact that these are military operations (not always conducted under ideal conditions), the high cost of equipment, and the threat to personnel safety, electrical grounding for safety becomes an imperative requirement. Electrical airframe grounding, like safety belts in automobiles, is statistically indicated by, among other things, the vast numbers involved.

TABLE 4-V. Potential hazard relationship to energy sources and scenarios.

Scenario	Energy Source					
	Tribo	Friction	Fuel trans	Atmospheric induced fields	External power system	Lightning
Maintenance	AD	ADE	-	ADE	BD	BCDE
Fuel	AD	ADE	ACDE	ACDE	BCDE	BCDE
Stores Handling	AD	ACE	-	ACE	-	BDCE
Park	AD	ACDE	-	ACDE	-	BCDE

where: A = Static shock to personnel
B = Power shock to personnel
C = Ordnance EED/stores misfire/release
D = Fuel vapor ignition
E = Electronic equipment damage

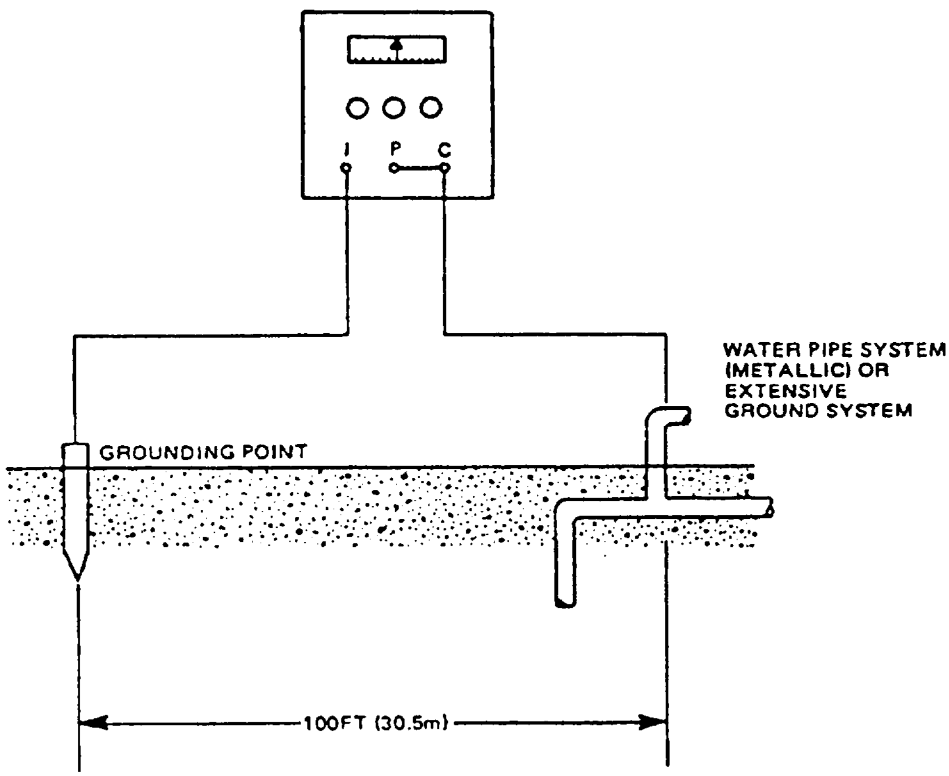

FIGURE 5-6. Two-terminal method test setup.

c. Locate a large, unpainted, metal water pipe at least 100 ft (30.5 m) from the ground point being evaluated and connect test lead C from the tester to this water pipe.

d. Adjust the resistance dials on the tester until the indicator dial is centered (zeroed) on the scale. When the dial is centered, the resistance value (in ohms) of the ground point being evaluated can be read on the tester's digital readout.

5.4 Schedule for resistance testing of ground points. It is recommended that resistance measurements of a facility's ground points be performed periodically in order to determine if there has been any degradation of the grounding system. It is important to verify that the resistances of the ground points are below recommended maximum values in order to minimize likelihood of injury or damage. The recommended maximum resistance values are: less than 10 ohms for a power ground point and less than 10,000 ohms for a static ground point.

5.4.1 The recommended time interval between resistance testing is 14 months. This ensures that over a 6-year period the ground points will be tested during all seasons, thereby providing a profile of seasonal resistance variations. Depending on the number of ground points to be measured, it might be more feasible to employ a rotational method, rather than measure all of the points in a single time span. For example, if the facility were divided into seven sections, the measurement task would be initiated every two months in a different section.

5.4.2 The task of measuring ground points normally comes under jurisdiction of the public works department of the facility. Additionally, their responsibilities will include setting up and carrying out the test schedule.

5.5 Identification of ground points. It is recommended that ground points already measured should be identified in the manner indicated in figure 5-7. This identification indicates to personnel that the ground point is satisfactory.

5.6 The use of mooring eyes as static ground points. Mooring eyes (also referred to as padeyes) may be used as static ground points provided that they have been measured and identified in a proper manner (see paragraphs 5.3 and 5.5). Surveys (AIR-5181-1000) have indicated that samplings of the resistance values of mooring eyes showed them to be under 10,000 ohms and therefore acceptable as static ground points. Mooring eyes selected for use as static grounds must have their resistance measured and verified at intervals specified in paragraph 5.4.1.

5.6.1 Figure 5-8 shows typical mooring eye installation details. Additional information is available in NAVFACENGCOM Technical Specification TS-02614. At some facilities, a stainless steel bead has been welded to the upper exposed area of the mooring eye. This prevents corrosion buildup on the mooring eye and reduces its likelihood of providing a poor ground.

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SECTION 6

6.0 INFORMATION FOR GUIDANCE ONLY.

6.1 Changes from previous issue. Vertical lines or asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

6.2 Subject term (keyword) listing.

Aircraft
Airframe
Cable
Electrical bonding
Electrical grounding
Electrical resistance
Maintenance
Procedures
Safety

Custodian:
Navy - AS

Preparing Activity:
Navy - AS
(Project EMCS-N105)

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