Contract NAS8-24296

PORTABLE ASTRONAUTS TEST KIT

VOLUME I
FINAL REPORT

MAY 1970

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Prepared by

MARTIN MARIETTA CORPORATION

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PORTABLE ASTRONAUTS TEST KIT

Volume I
Final Report

May 1970

by

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Prepared Under Contract No. NAS8-24296

for

National Aeronautics and Space Administration
Marshall Space Flight Center
Huntsville, Alabama

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FOREWORD

This report, submitted in accordance with the requirements of Paragraph 6.b and 6.c of Exhibit "A", and Article VII, of Contract NAS8-24296, presents the Martin Marietta Corporation's program completed for development of a demonstration-test mockup of a Portable Astronauts Test Kit. The report is presented in three volumes:

Volume I - Final Report

Volume II - Contract End Item (CEI) Specification

Volume III- Cost Estimate and Schedule

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SUMMARY

A full-scale, demonstration mockup of a Portable Astronaut Test Kit (PATK) was developed and delivered to NASA-MSFC under Contract NAS8-24296. This kit will be used by NASA in demonstrations of a developed capability for astronauts to perform maintenance actions during space missions.

Development and delivery of the PATK was accomplished within a program time span of 39 weeks, ending 27 March 1970. The program basically consisted of:

a. Analysis to determine potential requirements for space maintenance.

b. Definition of tools, test equipment and supplies required to perform space maintenance.

c. Definition and development of a portable kit to contain tools, test equipment and supplies and serve as a work station.

d. Procurement and fabrication of hardware needed to create an assemblage of kit, tools, test equipment and supplies, and a demonstration test panel.

e. Final assembly of the PATK and Demonstration Test Panel and delivery to NASA-MSFC for demonstration.

The PATK is basically a fabricated aluminum housing, approximately 16" x 16" x 22", that contains and provides tools, test equipment, portable lights, work shelves, spare parts, a wall mounting boom, visual maintenance instructions, and an astronaut carrying handle. It weighs approximately 57 pounds, and is

designed to be transported and used by one astronaut for performance of inplace scheduled and unscheduled maintenance requirements. Kit size and configuration are designed for safe, easy handling; passage through a 24" - diameter opening; and effective presentation of kit contents to an astronaut limited to one-handed operations.

The Demonstration Test Panel is a flat mounting plate, approximately $2' \times 3'$, to which are attached a number of integrated electrical and mechanical components, convenience carrying handles, and an attachment plate for mounting of the PATK. The hardware components will facilitate performance of demonstrated maintenance actions using provisions of the PATK.

This program was especially noteworthy in that it elevated an aspect of space maintenance from the conceptual to the reality level. Availability of an integrated set of space tools facilitates subsequent activities such as:

a. Demonstration of tool merits and limitations.

b. Assessment of tool adequacies in space-simulation facilities.

c. Development of improved usage tools.

d. Astronaut assessment of the PATK.

e. Application of the PATK to a specific near-future space program.

It is appropriate to acknowledge the technical direction and support, and cooperation extended to MMC by PATK program personnel of NASA-MSFC:

Mrs. A. Folsom, Technical Monitor, Quality and Reliability Assurance

Elbert Minter, Assistant Technical Monitor, Manufacturing Engineering

S. Peck, Quality and Reliability Assurance

Herman Blaise, Manufacturing Engineering

I. INTRODUCTION

A. Purpose - This report primarily describes the (1) effort performed to develop, and deliver to NASA for demonstration, a mockup of a Portable Astronauts Test Kit (PATK), and (2) physical composition of the basic kit, demonstration test panel, miscellaneous support equipment and supporting documentation. The report also provides conclusions and recommendations, and the results of demonstration tests of the mockup that were performed using MSFC mechanical space-simulation test equipment. Volumes II and III and the appendices of this report contain a proposed end item specification for a space-qualified version of a PATK (Vol. II), and a statement of work, and estimates of cost and delivery time for a space-qualified PATK (Vol. III), and documentation related to the development effort covered herein.

B. Definition of Subject - The PATK is a compact assemblage of tools, test equipment and supplies packaged to enable space crewmen to perform first-level maintenance tasks, e.g., limited inplace repairs, replacements and adjustments; during space operations (see Figure I-1). The maintenance capability represented by this kit would allow electrical and mechanical maintenance tasks to be performed that preserve and extend system reliability, and restore system capability following occurrences of malfunction, failure or damage. The kit has been designed for launch-phase storage, adaptation to a number of specialty tasks, easy translation and handling by one astronaut, and inplace mounting and use at the actual location of space maintenance. The mockup

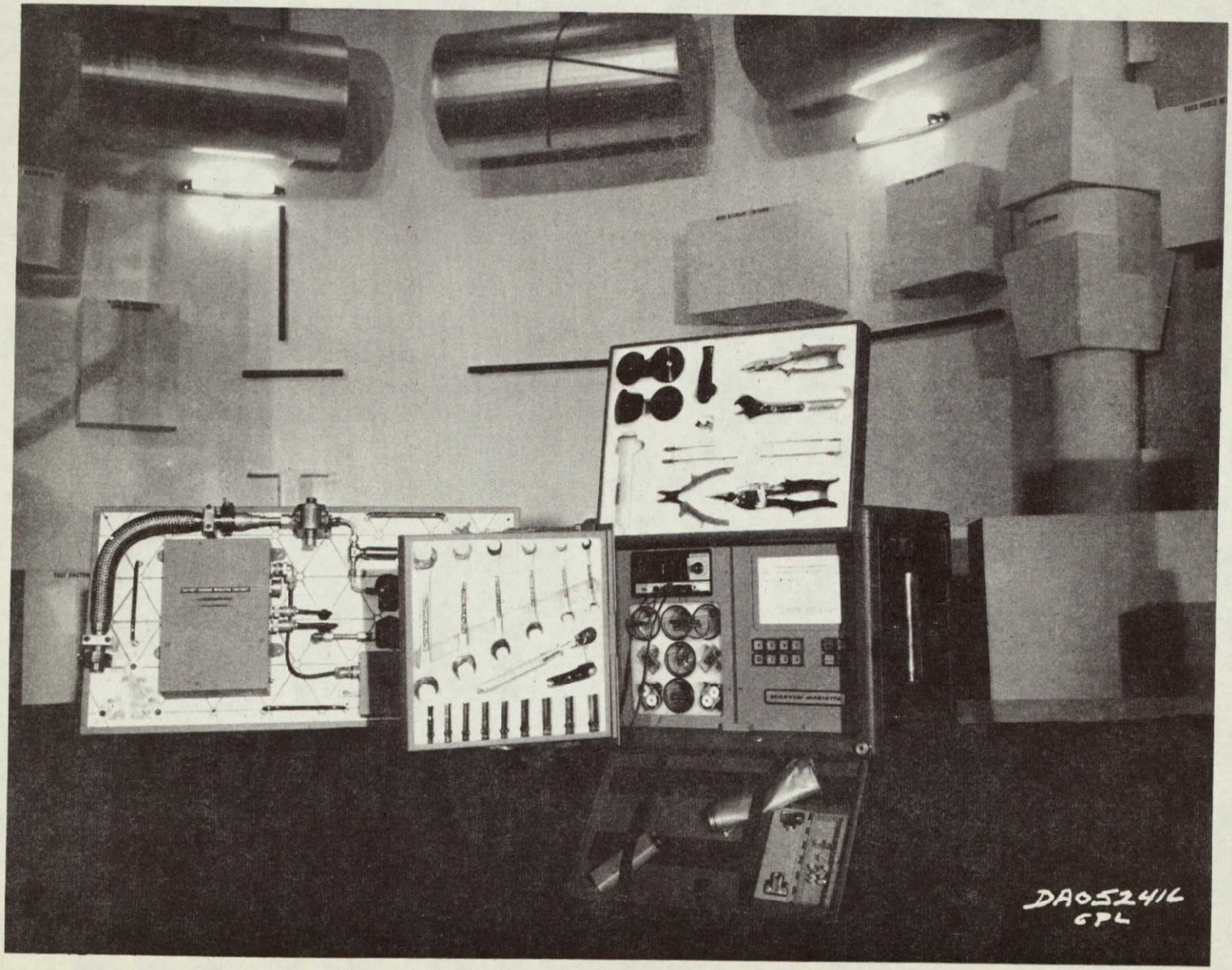

Figure I-1 Portable Astronauts Test Kit

development kit covered herein contains certain features and materials that do not comply with space qualification requirements. Such features and materials are described in detail within Paragraphs III and IV, herein, and signify the need for further research and development of items in order to achieve space-program application of the PATK.

C. Organization of Report - The report, organized into three volumes, presents information in a developing order: first, detailed coverage of the mockup development program; second, recommendations for development of a space-qualified kit; and, third, specification and estimating details that establish a definition baseline for a space-qualified kit.

II. KIT DEVELOPMENT

A. Planning and Control - The PATK program was performed over a period beginning 27 June 1969, and ending 27 March 1970. Delivery of demonstration test hardware and supporting materials was effected 26 January 1970, in consonance with the demonstration test program established by NASA-MSFC. The initial program administrative efforts included development of a project master schedule, issuance of program directives and operating budget, and organization of project team personnel.

The initial implementation project master schedule (see Figure II-1) cited the major program tasks, and established the time-phase requirements for accomplishment of the significant program milestones. Through the course of the program, certain adjustments were made, and mutually agreed to, to

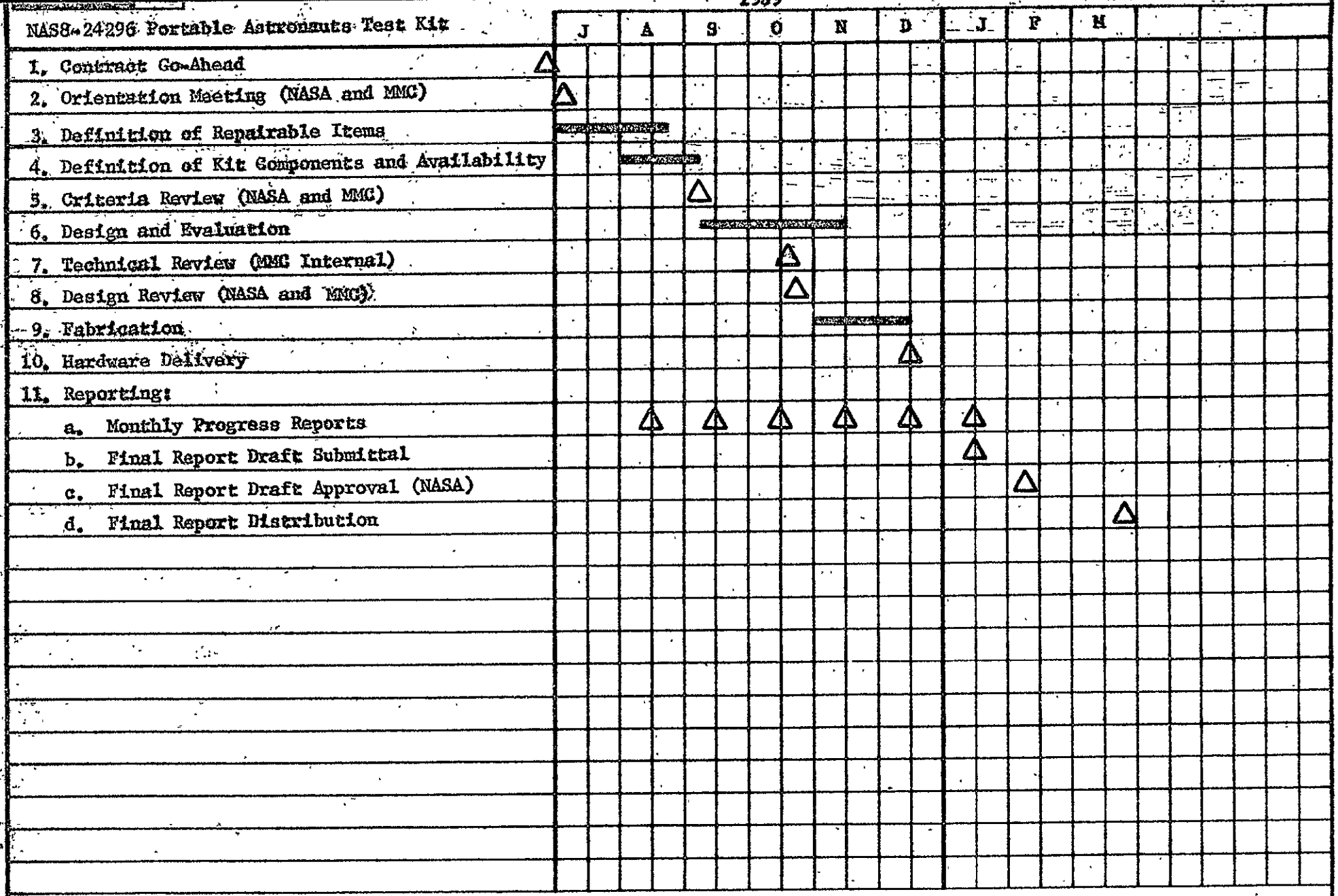

Figure II-1 Project Master Schedule (Original Schedule)

accommodate special design provisions, availability of personnel for interchange meetings, and fabrication lead-time requirements. Figure II-2 cites the actual accomplishment of major program tasks, reflecting discrete adjustments, and accomplishment of major program objectives within the planned time spans. Data requirements attendant to the program, e.g., monthly technical status reports, were administered by establishment of an integrated scheduling program report and periodic status monitoring performed by the Program Control organization. Throughout the program, the Program Control organization was active in establishing and periodically statusing schedule, cost and technical requirements to ensure successful accomplishment of contractual objectives.

The project team complement for this program is shown in Figure II-3. Its relationship to the MMC Denver Division is shown in Figure II-4. The project supervisor, Mr. Joseph C. Spencer, was responsible for lead direction of the program, encompassing planning of tasks, directing all work assignments, and evaluating program progress and results.

On 15 July 1969, a program orientation meeting was held at NASA-MSFC to discuss the general program approach, acquire NASA-supplied reference materials, and establish technical criteria for the initial kit definition analysis. NASA-MSFC representatives provided, and assisted in the

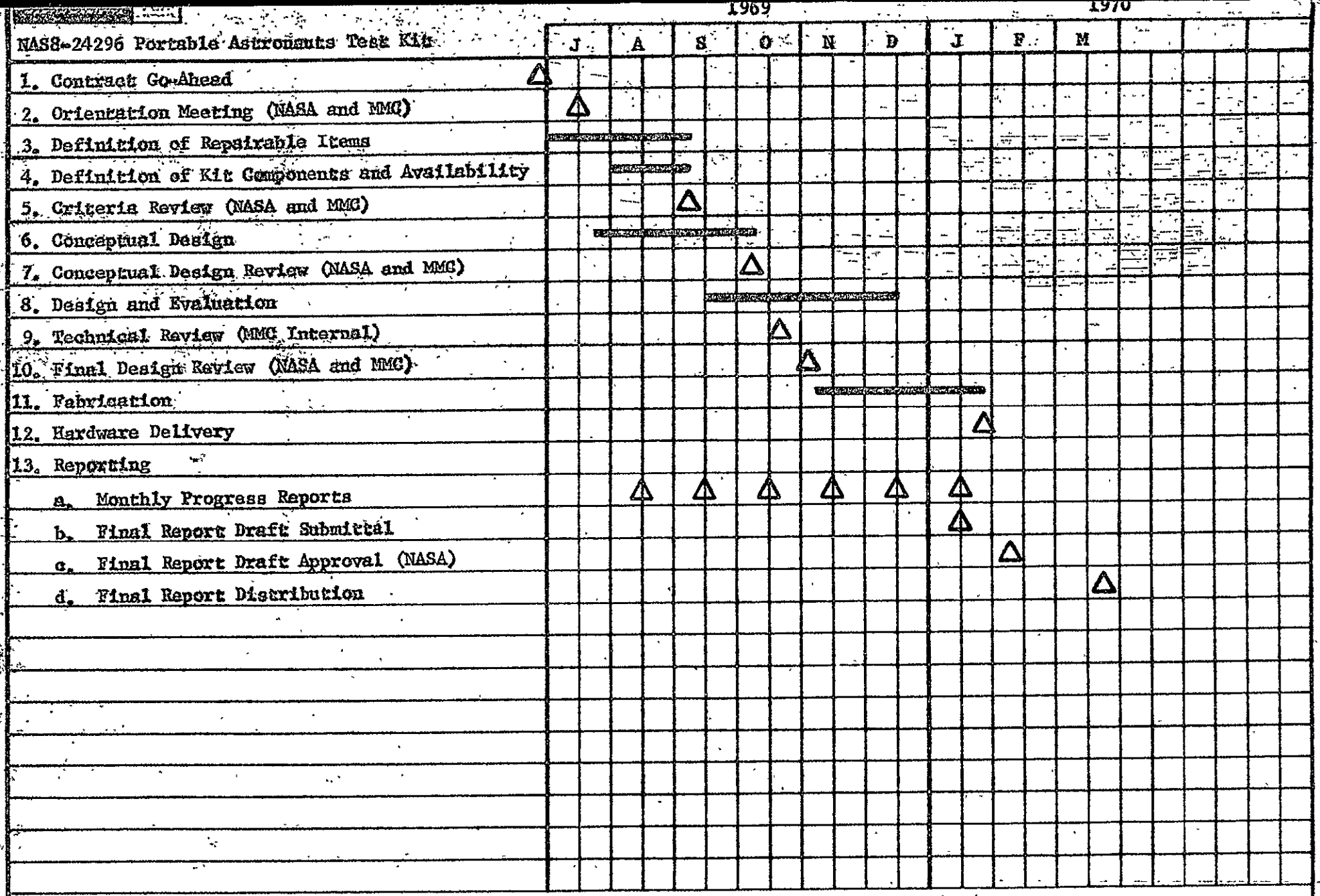

Figure II-2 Project Master Schedule (Actual)

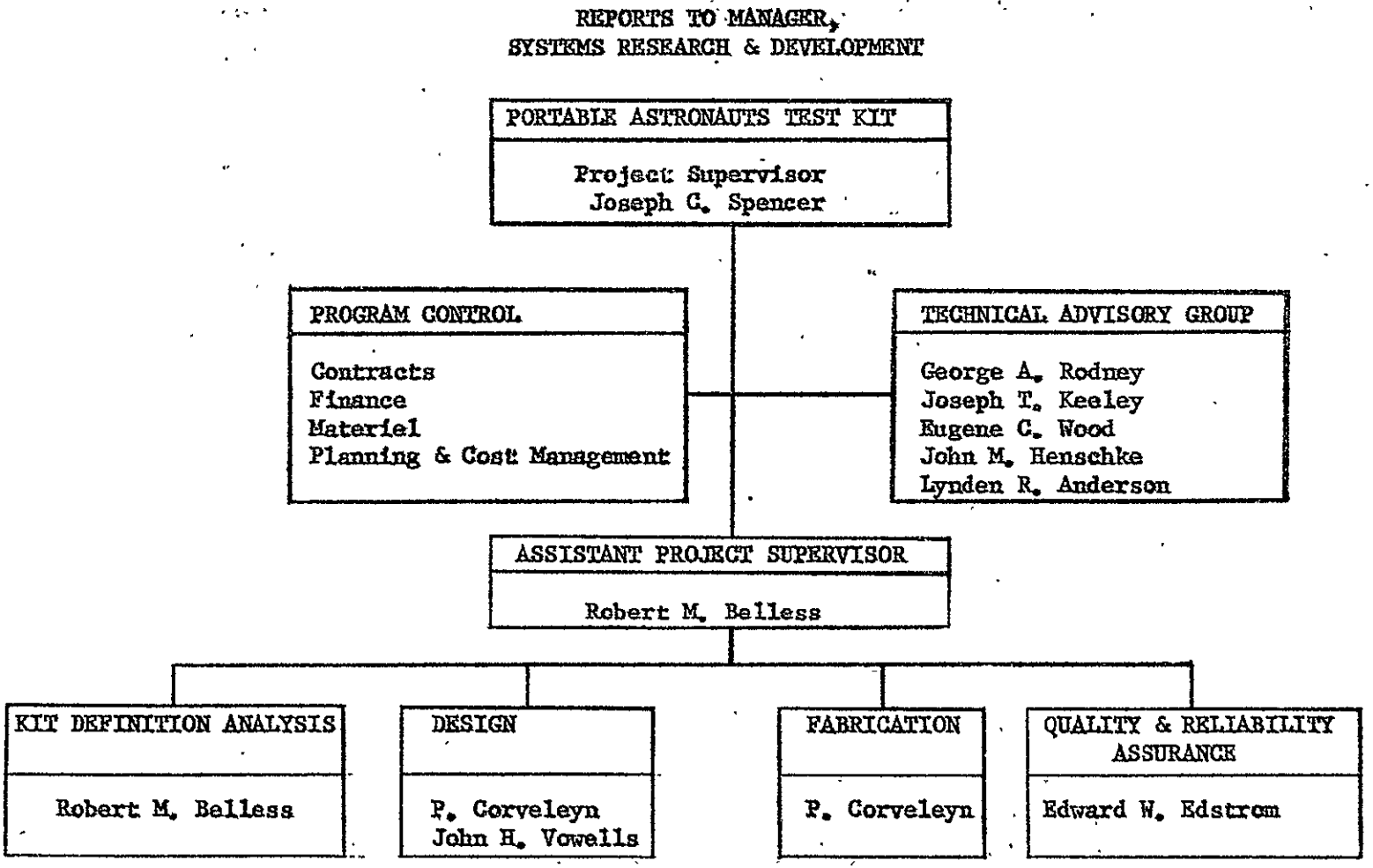

Figure II-3 Project Organization

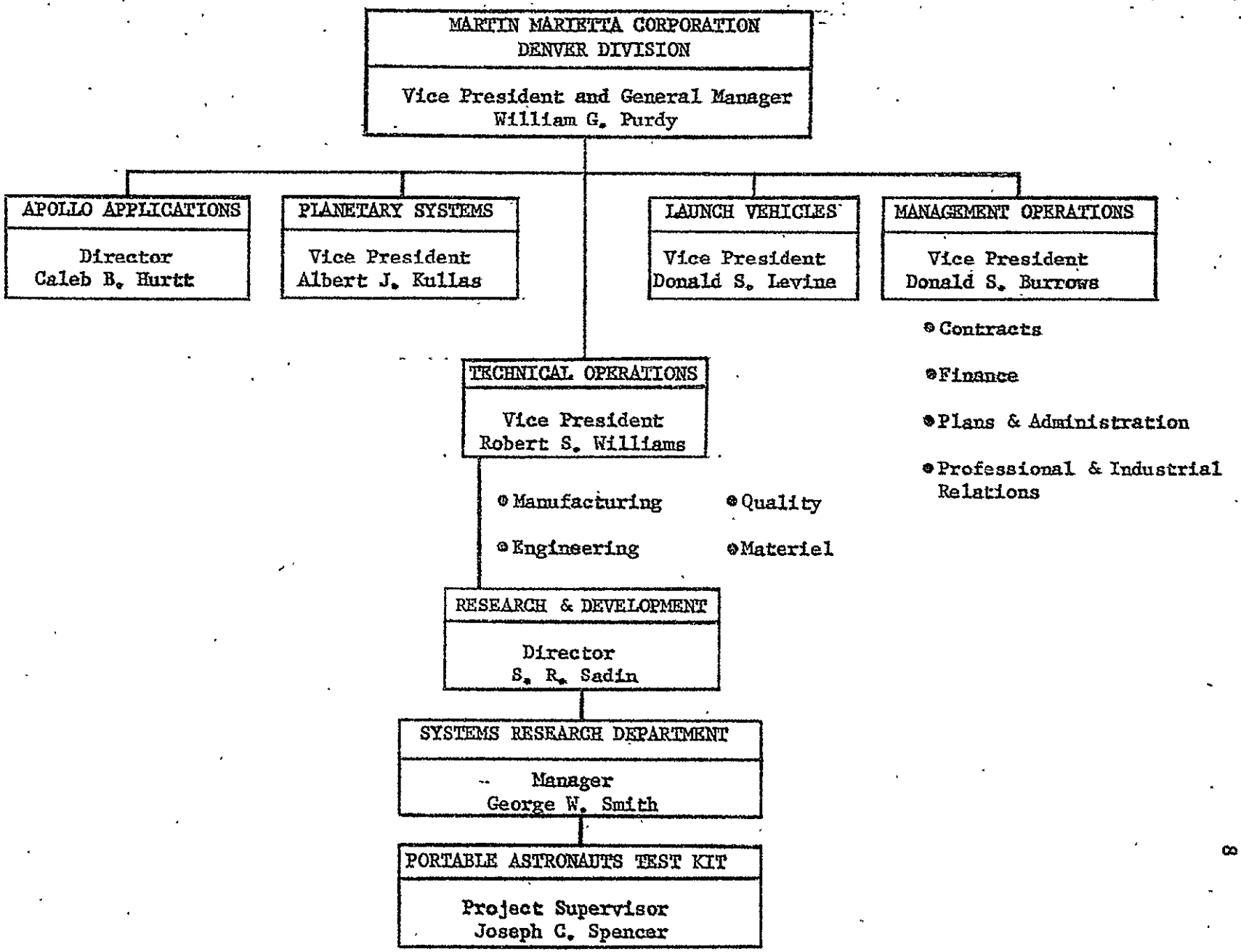

Figure II-4 MMC Denver Division Organization

acquisition of, the following prime-reference documentation:

1. NASA CR-1108, Vols. I, II and III, "Maintainability of Manned Spacecraft for Long-Duration Flights", July 1967 (NASA-Ames Contract NAS2-3705).
2. NASA TM X-53725, Vols. I and II, "Space Tool Development, State-of-the-Art Survey", 15 August 1968.
3. NASA CR-1334, "A Study of Astronauts Extravehicular Work Capabilities in Weightless Conditions", May 1969 (NASA-Langley Contract NAS1-7571).

Analysis criteria established during this meeting to assist and orient the kit definition phase included (these criteria effectively augmented criteria contained within Exhibit "A" of Contract NAS8-24296):

1. Use available Failure, Modes, Effects and Analysis (FMEA) data and other related data from existing spacecraft system programs to establish "most likely" inflight maintenance candidates. The endeavor here was to minimize new and hypothetical analyses, and emphasize use of existing information.
2. Develop an inplace maintenance capability tailored to classes or categories of typical space system hardware (e.g., fluid system valves) rather than to specific and individual hardware items (e.g., Command Module Cooling Circuit, Glycol Diverter Valve No. E-5219).

3. Since the Apollo Applications Program (AAP) offers good "test bed" spacecraft system information, it was agreed that AAP data would serve as a baseline for development of a maintenance kit that would be useful to the AAP and also applicable, in principle at least, to the Space Station Program.

4. Generally assume that spacecraft hardware items that are likely inflight maintenance candidates are, or could be made to be, accessible and convenient for maintenance actions.

5. Plan for development of a maintenance kit core that is supplemented at the time of need with kit elements obtained from stowage that are peculiar for the assigned task.

B. Analysis - The analysis effort was begun by accumulating and reviewing useful reference data. Special emphasis was placed upon use of data that was (1) associated with actual manned spacecraft programs (e.g., Apollo and AAP), (2) relatively current, and (3) readily available. Data typified by the following were obtained and enabled the selection of inflight maintenance candidates:

NASA CR-1108	Cluster Systems Description Document, AAP, May 1969.
MSFC 10M30899, Rev. B	AAP Systems Composite Mechanical Schematics and Index of Finding Numbers, 15 April 1969.

NASA TM X-53725, Vol. I	Space Tool Development, State-of-the-Art Survey, 15 August 1968.
Report No. SS-3414, Vol. II	AAP Environmental Control and Life Support System Reliability Analysis, 10 January 1966.
SD 68-926-15, Vol. 15	AAP FMEA, Electrical Power Subsystem, CSM, 27 January 1969.
Document 1003	Airlock Design Data Book, AAP, 18 October 1968.

The objective of the analysis was to determine likely and representative candidates for inflight maintenance (inclusive of both scheduled and unscheduled maintenance but limited to first-level, or inplace, actions). To determine such candidates, reviews were first made of reference data to isolate potential malfunction, failure and damage occurrences, and specific periodic servicing requirements, considered representative of those to be expected in near-future manned spacecraft systems. Products of these initial reviews were reduced to a final-analysis group by considering only those occurrences or requirements that:

1. Are most likely to occur during the projected mission time due to lower reliability, i.e., those having the highest predicted probability of failure during relative mission periods;
2. Critically affect crew safety and/or mission success as they occur in specific predicted modes and for which system downtime can be tolerated;

3. Are not "backed up" by extensive redundancy or alternative mission operations;
4. Provide a good "sampling level" indication of potential requirements within the more suspect or mission-critical equipment subsystems, e.g., environmental control/life support, electric power and distribution, instrumentation and communication, guidance and controls, and controls and displays;
5. Could be realistically remedied by performance of inflight maintenance actions that are limited to first-level only performance;
6. Can be remedied by performance of maintenance actions that allow, to a 90% level, performance within an intravehicular (IVA) environment.

Potential occurrences and requirements resulting from this analysis were compiled on special analysis sheets typified by Table I. Sheets such as this were prepared for each of the subsystems identified in sub-paragraph II.B.4, above, and were, upon completion, transmitted to the NASA for review and comment. An explanation of columnar footnotes that appear on Table I is provided within Item 1 of Appendix B.

The work sheet package officially transmitted to NASA-MSFC 20 August 1969 is represented by Items 1 and 3 of Appendix B. This analysis phase, by revealing potential requirements for maintenance, developed the logic needed to establish potential tools and a rationale for demonstration of

Table I. In-Flight Maintenance Requirements

Contract: NAS8-24296

Date: 7-30-69

Subsystem/Equipment [5]	Failure Rate (Per 10^6 Hr)	Maint. Crit. Category [1]	Equip. Repair-ability [2]	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time [3]	Complex. Index [4]	Support Provisions	
A. ENVIRONMENTAL CONTROL (ECS) A.1 LIFE SUPPORT									
a. Hydrogen Gas Removal Equip. - CM - Fails to work. Lack of backup equip. to detect level of, and remove, fuel-cell-generated hydrogen gas from crews potable water can lead to serious crew discomfort.	10.0+	Ib	Good	Sch. and Unsch.	Perform periodic task to obtain and chemically analyze samples of potable water supply. Replace, on as-necessary basis, device used to remove hydrogen gas from potable water.	Sch. - 0.5 Hr Unsch-0.3 Hr	1	Water sampling container and analysis tester, built-in valve device to obtain sample, or built-in water filter, e.g., silver palladium, to remove gas as it leaves fuel cell. Spare gas-removal device, e.g., hand-held spinning device, if applicable.	1. Apollo 10 failure report. 2. 10M30899-B
b. Quick disconnect - MDA Find No. E2001 - fails to disconnect.	.5	II	Fair	Unsch.	One crewman must attempt physical disconnection of coupling. MDA docking tunnel must be pressurized. Vented, full pressure IVA suit used. Tunnel entry made from CM side. Assumed failure mode: Fails to disconnect. If physical disconnection cannot be effected, disassembly or replacement actions may be necessary.	.8 Hr or 1.5 Hr	1 or 2	Visual isolation; monitoring not required. System activation provides retest. Tools that may be required incl. open-end wrenches, large crescent wrench, screw drivers, pliers, drift punch, soft face hammer, portable light, parts holder and spare parts stowage provision. One spare E2001 QDIS Assy. Should be spared. Simple instructions needed; no supplies required.	1. 10M30899-B 2. ED2002-850-1
c. O_2 & N_2 Filter - CM Find. No. E5111 - Clogged	.1	III	Fair	Sch.	One crewman performs time scheduled replacement of filter element. Shutoff valves provide system isolation. Performed in press. portion of CM. Access panel removal required.	.8 Hr	1	Tools incl. screw driver, open-end wrenches, portable light, parts holder, and spare parts stowage. One spare element required. No instructions or supplies are needed. Post-maint. test not required.	1. 10M30899-1 2. SS-3414 3. ED2002-756
d. Cabin Press. Transducer - MDA Find No. E2065 - Mech. Failure, Erroneous Output	1.0	III	Good	Unsch.	One crewman replaces transducer. Isolation needed to distinguish between faulty and backup XDCR. Performed in pressurized atmosphere.	1.0 Hr	2	Elect disconnect or short each of two XDCR's to isolate faulty one. Replace using wire cutters, pliers, ratchet & socket set. Parts holder, portable light and spare parts stowage provision. One spare needed, no supplies, and simple instructions.	1. 10M30899-1 2. SS-3414 3. ED2002-756
e. Cabin Ventilation Fan - AM & MDA Find No's. E2016 & E1255 - Fails to Operate	8.3	III	Good	Unsch.	One crewman replaces obviously failed fan. Reactivate elect. circuit to retest. Performed in press. atmosphere.	.8 Hr	1	Tools incl. screw driver, wire cutters, pliers, box-end wrenches, ratchet and socket set, parts holder, portable light, and spare parts stowage. One spare needed. No supplies, and simple instructions.	1. 10M30899-1 2. SS-3414 3. ED2002-756 4. ED2002-850-1 5. Apollo 8 and 9 Failure
f. Flexible Ventilation Duct - MDA Find No's. E2019, E2067 - Accidental tear or puncture	1.0	III	Fair	Unsch.	One crewman effects in-place repair. Equip. shutdown may be unnecessary. Leak isolation effected visually. Performed in press. atmosphere.	.8 Hr	1	Tools incl. glass mending tape, portable light, supplies, stowage provision. No instructions or post maint. test needed.	1. 10M30899-1 2. SS-3414 3. ED2002-756 4. ED2002-850-1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

tool kit capability. Analysts performing this part of the effort were aided in their establishment of support provisions (including tools) through familiarity with this type of analysis and the availability of a tools selection list (see Table II, Appendix B). This list was arbitrarily compiled for reference to reflect a gross cut of tools sufficient or capable of supporting performance of first-level spacecraft maintenance. As the analysis proceeded, tool and supply needs prescribed in the support provisions column (Table I) were transferred to support requirements sheets (Table II) to consolidate and summarize all identified requirements. The Table II sheet was further instrumental in aiding determinations of subsystem support requirements priorities in terms of subsystem need and relative merit. The methodology associated with this analysis process, and typified by the Table II sheet, is essentially the same as that covered within the NASA CR-1108 documentation. Three categories of Table II sheets were compiled, covering standard tools and test equipment, special tools and test equipment, and task support provisions (see Table II, Appendix B, for total summarization).

The Table II sheets revealed a need for a large number of high-volume and, in many instances, unrelated tools and supplies. Further deliberations led to the conclusions that (1) certain tools almost-always used would be reserved for the "core" of the kit, (2) certain function-related, yet less used, tools should be grouped and considered for incorporation into specialty-task sub-kits, (3) certain infrequently used and special-use tools should be reserved

Table II Summary of Maintenance-Support Requirements and Priorities

Contract: NAS8-24296 Date: 7-31-69

	Subsystems					Priority Category		
	Environ. Control	Instrum. & Comm.	Guidance & Control	Controls & Displs.	Power & Distrib.			
Percent of Total System Failures	46%	26%	15%	6%	2%			
Priority Based Upon Above Percent	1	2	3	4	5	I	II	III
Maintenance Support Requirements:								
B. Special Tools & Test Equipment								
1. Leak Detector	X						X	
2. Fluid-Containment Device	X				X	X		
3. Wick-Wetting Water Applicator	X							X
4. Wetness-Level Sensor	X							X
5. Heat Shield (Ablative) Repair Kit		X						X
6. Master Radiation Survey Meter		X						X
7. Ext. Panel Fastener Removal Tool					X	X		
8. Apollo-Type Panel Fastener Removal Tool					X	X		
9. Multimeter					X	X		
10. Test Leads with Heavy-Duty Probes					X	X		
11. Connector-Pin Alignment Tool					X		X	
12. Potable Water Sampler & Tester	X							X

for large spacecraft "tool crib" storage and, therefore, not included in the kit, (4) certain tools may yet require development, or may not be available for near-future demonstration, (5) certain kit items may be satisfied by reapplication of special hardware developed for past spacecraft, and (6) kit tools needed to be resolved as soon as possible to enable kit layout, and determinations of a power supply, electrical interconnections, weight computations, etc.

Efforts were initiated to evaluate in detail each of the above items (excluding Item 6), prepare sketches of conceptual packaging approaches, and solicit responses from commercial and aerospace suppliers for hardware configuration and delivery information, and presentations of hardware capability. Information and materials relevant to this activity phase, including data transmitted to NASA-MSFC 20 August 1969, were accumulated and readied for review with NASA-MSFC program technical representatives in a meeting held at Martin Denver 8-9 September 1969. The meeting produced significant results, the more significant of which were directives for continuing efforts. At this point, the analysis effort was effectively discontinued and emphasis placed upon definition of kit contents, conceptual development of kit configuration, and preliminary design of kit-support aids.

C. Design and Fabrication - Following the 8-9 September 1969 criteria review, program emphasis was placed upon design development of the kit configuration.

Inherent in this development was the need to include the capability to perform and support the maintenance tasks desired by NASA-MSFC for physical demonstration. Using the analysis data, and MMC recommendations supplied during the September meeting, NASA-MSFC advised that demonstration procedures would be based upon performance of the following representative tasks:

1. Removal and replacement of a typical spacecraft mechanical system fluid pump.
2. Inplace fault confirmation, and subsequent removal and replacement, of a battery charger and regulator module.
3. Inplace fault diagnosis of a command-signal type, manually operated, rotary switch.
4. Removal and replacement of a typical spacecraft mechanical system pressure regulator valve.
5. Removal and replacement of a typical spacecraft system, fluid-line installed, pressure transducer.

By 24 September 1969, specific kit contents had been resolved. Certain of the contents required further detail definition, however, before detail development of the kit body could begin, e.g., style and size of the electrical multimeter, type and size of hand-held electrical lights, and type and size of the kit mounting boom assembly. The basic list of resolved contents included:

1. <u>Installed or Incorporated in Kit</u>
   a. Electrical Multimeter (one)

b. Portable lights (two hand-held, extendible with mounting provisions).

c. Task procedures readout device (one, lighted panel).

d. Test probes (compatible with 1.a, above).

e. Kit mounting boom (one, foldaway type).

f. Battery power supply (one, integral, mockup).

g. Small spares stowage compartment (one or more).

h. Large spares mounting panel (one or more).

i. Astronaut carrying and translation handle (one, fixed).

j. Work-shelf-type panel with parts restraint devices (one).

k. Tether connection fixtures (two or more).

l. Astronaut and equipment tethers (two or more).

2. Carried or Stored in Kit

a. Screwdrivers (set; includes panel fastener tool).

b. Pliers (one).

c. Crescent wrench (one).

d. Diagonal wire cutters (one).

e. Metal shears (one).

f. Tape dispensing reels (two).

g. Safety wire dispenser (one).

h. General purpose tie cord dispenser (one).

i. Leak seal material dispenser (one).

j. Fluid containment device (one).

k. Mechanical leak seal plugs (set).

l. General purpose rags (one or more).

m. Velcro tape fastener patches (set).

n. Electrical test leads with clips (two).

3. Carried or Stored in Sub-kits

a. Mechanical

1) Deep-well socket set (3/8" drive)

2) Ratchet for socket set (one)

3) Open-end wrench set

4) Vise grips wrench (one)

5) Allen wrench set

6) Thread cleaning/deburring tool

7) Parts retriever tool

8) Soft face hammer*

9) Drift punch*

10) Torque wrench*

11) Leak detector*

12) Vacuum and pressure sensing and measuring device*

13) Portable N_2 storage and spray container*

14) Window glass cleaner*

15) Decontamination kit*

16) Ablative material kit*

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* These items are reserved for sub-kits that could be formulated, but are not furnished as elements of the mockup kit.

17) Space suit repair kit*

18) Electron beam welder*

19) Portable vacuum cleaner*

20) Small portable power tool kit*

21) Elapsed time indicator*

b. Electrical

1) Pin alignment tool (one)

2) Electrical Connector tool (one)

3) Wire stripper and crimping tool (one)

4) Terminal lugs (set)

Wherever possible, kit elements were selected and obtained from quality commercial sources. In certain instances, commercially-available items were modified to enable use, e.g., ratchet handle, panel fastener tool and the safety wire dispenser. In these instances, services of an engineering model shop were used for modification requirements. In the case of functioning equipment, unique solutions were used to circumvent problems of extremely high unit cost and unavailability of space qualified hardware. Examples are:

1. The multimeter used was selected for its quality, reasonable price, package size, and digital presentation. It is representative of a unit desired for this purpose that is also space qualified. A development contract will probably be

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* These items are reserved for sub-kits that could be formulated, but are not furnished as elements of the mockup kit.

required to acquire a unit compatible with space environment.

2. The two portable lights are mockups of a unit developed by a firm for use on the Apollo Program. This specific light, of those presently available, best satisfies the requirements of this kit. An operational version of this light is very costly.

3. The task procedures readout device recommended for this kit is a microfilm device developed under another NASA contract. Due to unit cost, the version provided under this contract is a mockup, having a lighted panel and identical physical dimensions.

4. A mounting boom that has a telescoping tube capability is highly recommended for use with the PATK. Due to unavailability of an off-the-shelf mounting boom, and prohibitive development costs, a non-telescoping ball-joint type boom assembly was developed for the mockup.

In other instances, conceptual and preliminary designs were accomplished to enable definition of the element to be accommodated by the kit. Examples of this are: portable light mechanical extension rods, battery power supply mockup, and the astronaut carrying and translation handle. When kit elements, location-and-volume critical to kit configuration, were then preliminary defined, full design-phase emphasis was placed upon development of the overall kit configuration.

Design sketches were initially useful to assess various kit shapes, closure openings, handle locations, and mounting boom positions. Composition-material mockups were made of certain elements, particularly those having "deep" dimensions, to better visualize packaging approaches. Attention was given to functional grouping of elements, and desired presentations to an astronaut in a typical spacecraft. Design criteria of special importance to packaging development were carefully re-evaluated at this point. Examples are:

1. 10% of the potential tasks will involve extravehicular activities (EVA).*
2. One astronaut will manually transport the kit from location to location.
3. The kit shall easily pass through a 24-inch diameter opening.
4. The kit shall be suitable for use by an astronaut in the following environmental modes:
   a. IVA, astronaut in "shirt-sleeve" uniform.
   b. IVA, astronaut in unpressurized space suit.
   c. IVA, astronaut in pressurized space suit.
   d. EVA, astronaut in pressurized space suit.
5. Specialty tools may be considered being available in modularized, sub-kits that can be attached to the basic kit.

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* The reservation of 10% EVA capability was later re-evaluated by MMC with a resulting recommendation to NASA-MSFC (see the 30 September 1969

monthly report, MCR-69-439) that the kit and associated supplies be developed for IVA environment only. This approach was mutually agreed to during the 13 November 1969 interchange meeting.

A number of internal, project-team design reviews were next held to review and tradeoff various packaging approaches. To improve the effectiveness of the reviews plastic foam mockups of each major kit element were produced that enabled a third-dimension, visual building block process. These reviews resulted in adoption of a packaging configuration that generally remained unchanged. Technical illustrations of this configuration were next prepared and, in conjunction with tool-elements-selection and design-effort-scheduling information, presented to NASA-MSFC during the formal 7 October 1969 Conceptual Design Review held at MSFC. During this review, MMC also proposed to deliver a demonstration test panel, consisting of a work board on which maintenance-task hardware is mounted in an integrated manner, to facilitate the MSFC-conducted demonstration tests. NASA-MSFC comments were worked both during and after the meeting, and necessary adjustments made to the design configuration. Delivery of the test panel by MMC was formalized, and integrated with overall program schedules.

Upon completion of this review, a full detail design effort was implemented to acquire all hardware elements, finalize kit and sub-kit designs, and prepare for fabrication of "build" items. As the

products of this effort began to materialize, the MMC Program Control Organization established the requirements for a MMC-internal, formal contract technical review. During this review of 23 October, 1969, all aspects of the program were presented and reviewed, e.g., program requirements, program status, budget performance, technical approaches and hardware details. Following this review and resolution of all action items, hardware acquisition and kit design continued at an accomplishment rate compatible with the 14 November 1969 design completion date.

A formal review of the MMC kit and test panel final designs was conducted at NASA-MSFC on 13 November 1969. A number of demonstration-test aspects presented by NASA-MSFC were reviewed and discussed, and resulted in agreements for adjustments to program delivery schedule. A summary of program actions and agreements resulting from this meeting follows:

1. Prior to hardware delivery, MMC would submit copies of kit and test panel electrical schematics for NASA-MSFC safety reviews.
2. Kit design would be oriented toward 100% IVA involvement.
3. MMC solicited NASA-MSFC support in obtaining typical aerospace hardware needed for development and fabrication of the test panel.
4. MMC requested NASA-MSFC review and comments relative to NASA desired paint colors and finishes, nameplates and decals.

5. MMC suggested that the format of the deliverable end item specification be in general accordance with one previously prepared under Contract NAS8-21279 for the "Serpentuator". NASA-MSFC agreed to review this specification and advise MMC of acceptability (the format proved acceptable and was used for the deliverable specification).

6. Plans for reduced-gravity testing of the kit by NASA-MSFC were presented by NASA test representatives, and discussed by the meeting panel. The test program was, in general, acceptable but did introduce a number of additional requirements:

   a. Reduced gravity tests of the kit would be performed at MSFC by NASA, with use of NASA-MSFC facilities.

   b. In support of the NASA-MSFC testing, MMC would provide the following:

      1) Identification of the center of gravity of the deliverable kit.

      2) Kit-incorporated attachment provisions for NASA-furnished helium balancing balloons.

      3) Single-point electrical grounding for the kit and test panel.

      4) Provisions on the test panel to allow test-program attachment of the kit.

5) Flexibility in the design of the test panel to facilitate adaptation of the MMC-furnished test panel to the NASA-furnished test equipment panel.

6) Technical data covering test panel layout and recommended demonstration-test procedures to enable NASA-MSFC preparation of detailed test procedures.

7. Because of the additional work requirements, MMC requested considerations for extension of the 19 December 1969 hardware delivery date. Following discussions, it was agreed that the contractual hardware delivery date would be extended to 23 January 1970. This agreement enabled effective MMC support of the test program while maintaining delivery of hardware within the overall 39-week limitation on total-performance completion of contract.

Immediately following the final design review, program emphasis was placed upon final procurement of outstanding items, fabrication and assembly of the kit, and design and fabrication of the test panel. Generally, fabrication and assembly requirements were accomplished within MMC shop facilities; however, subcontractor services were used where special capabilities and delivery time priorities warranted. Aerospace standards for paint, finishes, fasteners, identification markings and materials were used throughout the kit and exceptions to

this were allowed only where absolutely necessary, e.g., a commercial-standard plastic lenscreen was used in the task instructions readout device to gain the light diffusion desired for easy reading. Extensive use was made of plastic materials, particularly as a material for packaging of hand tools and as a filler in small-parts panel areas. The fabrication flexibility, neatness, and tool-retention capability offered by the plastic materials used significantly enhanced kit packaging.

Test panel development was hampered by difficulties experienced in acquiring typical spacecraft systems hardware. Design of the panel was dependent upon hardware that could be made available from, for the most part, surplus inventories. MMC and NASA-MSFC efforts exerted to acquire suitable hardware specimens consumed considerable time but did culminate in acquisition that was timely for the design and fabrication phases.

D. Delivery - Delivery of hardware to NASA-MSFC was effected 26 January 1970. The major hardware elements included in the delivery were: the basic assembled kit, a functional assembled sub-kit, a non-functional sub-kit (mockup), a full-size mockup of the Apollo Program color-TV camera, the assembled test panel, and carrying cases to accommodate, and provide for safe handling of, the entire set of hardware. Quality reviews of hardware during development and upon completion, and deliverable data products, were performed by members of the project team and

representatives of the MMC Quality Assurance Organization, under jurisdiction of that specific organization.

Certain data products delivered to NASA-MSFC formally and informally in advance of hardware delivery were developed in support of NASA-MSFC planning to develop a demonstration test program. Appendix C, herein, describes the actual procedures used by NASA-MSFC to perform demonstration testing following formal hardware acceptance.

III. DELIVERABLE EQUIPMENT INFORMATION

A. PATK - The deliverable PATK is basically comprised of a core kit, a detachable and functional sub-kit, and a detachable non-functional sub-kit (refer to Figure I-1). A general description of the kit and its elements is provided in Paragraph 3.1.1.2.3 of the CEI specification, Volume II. A set of drawings applicable to the PATK is provided in Appendix A. The drawings reflect actual design of the deliverable mockup-version PATK with the exception of two kit elements: (1) a mounting boom assembly having a telescopic tube provision is recommended for use with the PATK, and is design suggested by drawings included in Appendix A. The mockup-version boom assembly is functionally similar; however, telescoping, lock and arc-movement features are not provided due to cost considerations; and (2) drawings of the special Hoist and Support Harness (Figure III-1), used to hoist and suspend the PATK during test activities, were not prepared since the Harness was subcontractor fabricated in accordance with specification requirements.

Figure III-1 PATK Hoist and Support Harness

The core kit is approximately 16" x 16" x 22", and is comprised of a weld fabricated aluminum structure, to which aluminum front, bottom and top doors are hinged. Mounting provisions are available on the left side fixed panel for attachment of such kits and large spares; storage bags for small spares and the main PATK carrying handle are provided on the right side fixed panel. A mounting boom assembly is located in stored position on the backside of the core. It is both stored and positioned in its work location by one ball-lock pin device that is integral with the boom. Circumferential locking devices are provided on both ends of the boom to facilitate manual positioning and locking of the boom ball-joint mechanisms.

The two sub-kits are approximately 15" x 15" x 3-1/4". The functional sub-kit, containing a slideout drawer and handtools, is an aluminum sheet fabrication, on the external surfaces of which are provision for attachment to the core kit, and attachment of elastic cords used to hold large spares to the PATK. The non-functional sub-kit is a plywood fabrication that incorporates identical exterior attachment provisions. The purpose of this sub-kit is simply to demonstrate add-on capability of the PATK. Elastic cords used in conjunction with large spares are stored within small compartments under the top access cover.

Operation - The PATK is suitable for demonstration with the PATK resting on the boom cover or rear panel, or when the PATK is mounted

to a vertical wall using the mounting boom assembly and counterweight provisions not furnished as a part of the kit (Note: PATK must not be suspended from a wall in 1g atmosphere, with the mounting boom assembly furnished, without use of counterweight provisions). The bottom, front and top covers can be opened without use of tools, using the manually-activated latches that are provided. The sub-kits can be attached or detached at any time, without use of tools, using the mechanical connections provided.

The two mockup portable lights, located on the front panel inside the front cover, are attached to flexible electrical cables that are reel mounted inside the core kit structure. The light units can be manually withdrawn from their stored locations and removed a walking distance of 4-6 feet. Flexible metal rods are located in the two lower corners of the front panel. They will extend approximately 10 inches and connect to the base fittings on the portable lights. This feature allows lights to be mounted, and illumination to be focused on desired locations. The lights used in this kit are mockup versions of a portable electric floodlight developed by Grimes Manufacturing Company for the Apollo Program Lunar Module, ascent stage.

A power supply mockup (red painted, wood block) is located inside the core kit structure to simulate operational-unit installation. Access to the power supply mockup is achieved by opening the top access door. Configuration and size are based upon computations of

needs and a design selection of 28 VDC nickel-cadmium battery cells, all of which is covered on Drawing RES 31664, Appendix A. To convenience mockup demonstrations, all electrically-powered devices are suitable for use with 110-120 V AC 60 Hz source supplied from any convenience outlet. An electrical connection point is provided on the rear side of the core kit. Interconnecting wiring is incorporated within the kit, including common-point grounding, that involves the following kit electrical elements:

1. Digital Readout Multimeter
2. Visual Instructions Readout Device

The mockup PATK incorporates a front-panel mounted digital multimeter. An instruction manual covering operation, maintenance and replacement parts is included as an item of Appendix A. Though this particular meter will not meet space qualification requirements nor service AC systems, it is representative of what is desired of a space qualified unit (as described in Volume II of this report) in the areas of: digital readout, panel size and presentation, volume, weight, rack mounting capability, rotary function/range switch, and convenient location of terminal connection points. This multimeter is designed into the kit for operation from a 110-120 V AC 60 Hz power source.

The visual instructions readout device in the deliverable kit is a mockup version of a microfilm storage and display assembly developed

by the Denver Division of MMC under NASA Contract NAS9-8144. The physical configuration of the mockup is interchangeable with the operational unit; however, the mockup version merely simulates partial operational capability. A typical maintenance task readout frame is permanently installed in the lenscreen opening and can be backlighted by depressing the "POWER" button located on the right side of the control panel. The backlighting is turned off by depressing the "MOTOR-STOP/CLEAR" button located in the same panel area. The "POWER" button switch is also lighted by four No. 327 lamps that are powered by outlet power through an internal stepdown transformer and a latching relay. Two 110-120 V AC 60 Hz 6-watt lamps, having screw thread bases, are located under the lenscreen to provide lighting of the task frame. Access to any of the interior hardware for checks, repairs or replacements is accomplished by removing the top lenscreen cover (or flange). To facilitate demonstration of the operational Microfilm Storage and Display Assembly, MMC has prepared a 16 mm color and sound film for delivery to NASA-MSFC under this contract that provides approximately 4500 frames of film covering operational demonstration (delivered as an item of Appendix A). In addition, the top assembly drawing for the Microfilm Storage and Display Assembly is provided as an item of Appendix A.

The PATK color and paint scheme is primarily based upon use of two colors, medium and dark blue. All exterior painted surfaces,

excluding plastic and commercial-product finishes, were subjected to zinc chromate priming (using MMC Standard MMSK314, Finish Coat 225), and finish coats of blue using the following commercially-available paint:

1. Sherwin-Williams KEM LUSTRAL Industrial Enamel, F68LQ37 (Medium Blue), Blended for 50% gloss level.
2. Sherwin-Williams KEM LUSTRAL Industrial Enamel, F68LQ57 (Dark Blue), blended for 50% gloss level.

The paint used on the front panel of the mockup Microfilm Storage and Display Assembly is Fed-Std-595 No. 26492 Gray, semi-gloss oil base enamel, Finish 648, TTE529B, and is available through commercial paint suppliers.

B. Test Panel - The deliverable test panel is basically comprised of a 24" x 36" x 3/4" plywood mounting board, on which are mounted a number of integrated hardware elements used to demonstrate capability of the PATK, and convenience carrying handles and a mounting plate for attachment of the PATK. A frontal presentation of the test panel is provided by Figure III-1.

The test panel mounting board is surface finished with white oil-base enamel, over which gray paint has been used to simulate wall and floor, spacecraft-type grid plate. A triangularly-shaped doubler plate is located in the lower lefthand corner, with three

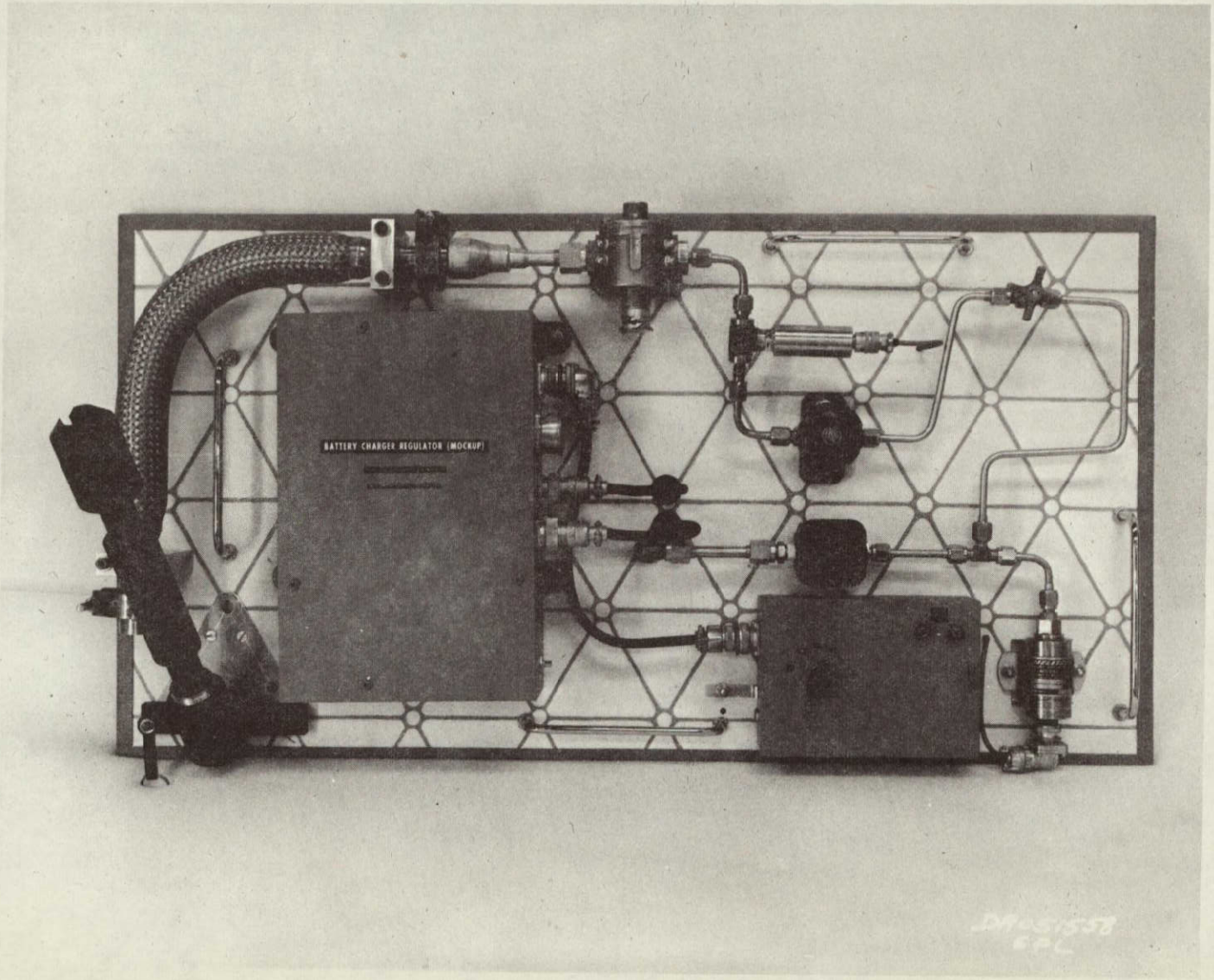


Figure III-2 Demonstration Test Panel

mounting holes, for attachment of the PATK using the mounting boom assembly.

An array of mechanical hardware elements is located on the panel for demonstration purposes. Major elements are: a 1-5/8" O.D. metallic hose with Marman clamp end connections, a sample fluid pump, a pressure transducer, an Imperial shutoff valve, a Republic shutoff valve, a pressure switch, a pressure regulator valve, and interconnecting tubing and fittings. The mechanical subsystem is not active, and has been primarily developed for demonstration of remove-and-replace maintenance tasks using tools and supplies provided by the PATK.

Two electrical components are also located on the panel for demonstration purposes: a simulated battery regulator and charger, and an electrical test panel. Interconnecting cabling is provided between the two components. Some active circuitry exists within these components for task-demonstration purposes and is schematically presented by MMC Drawing RES 31690 (see Appendix A). Within the active circuitry, monitor jacks, a rotary switch containing a built-in malfunctioning part (a resistor), a dry cell battery, a potentiometer, and active interconnecting wiring are available to perform a number of demonstration tasks.

Table III provides a list of suggested demonstration tasks, using this specific test panel and the PATK, that were informally transmitted to NASA-MSFC at an earlier program date.

Table III Suggested Demonstration Task Procedures

1. Removal and Replacement of the Fluid Pump

   a. Test Kit installed on panel at point "A" and both front and bottom doors and sub-kit open.

   b. Remove upper fitting nut from pump (use open end wrench).

   c. Remove lower fitting nut from pump (use open end wrench).

   d. Remove four (4) nuts and lock washer holding pump to mounting pad (use open end wrench). Place nuts and washer on bottom door captive device. Place pump on bottom door.

   e. Reinstall pump using reverse procedure.

2. Removal and Replacement of the Pressure Switch

   a. Remove safety wire with diagonal cutters and place removed wire on bottom panel captive device.

   b. Remove electrical connectors (using connector wrench).

   c. Unscrew switch from tee fitting in line using open end wrenches.

   d. Place switch on bottom panel.

   e. Take spare from small spares storage bag and screw into tee fitting (using open end wrench), re-safety wire (using wire supply and pliers), and re-connect electrical lead (using connector wrench).

   f. Place removed pressure switch in storage bag.

3. Removal and Replacement of a Valve

   a. Remove fitting nuts from valve using open end wrench.

Table III Suggested Demonstration Task Procedures (Cont)

b. Remove two (2) nuts and lock washers holding valve to mounting pad and store on bottom door captive device (use open end wrench).

c. Remove valve and place on bottom door.

d. Take spare valve from storage bag and install on mounting pad using reverse procedure.

e. Place removed valve in storage bag.

4. Inplace Test of Switch (in Test Panel)

a. Connect test probes from multimeter to Test Panel.

b. Use rotary switch to vary voltage to demonstrate multimeter. One bad reading will occur.

c. Use screw driver to open panel.

d. Use test probes to check continuity across switch terminals to find bad circuit.

e. Use jumper wires to remedy circuit and verify by reading multimeter.

f. Restore to normal.

5. Inplace Adjustment and Removal of the Battery Regulator

a. Remove all electrical connectors (using connector wrench).

b. Connect test probes from multimeter to regulator.

c. Adjust voltage with screw driver at test point on regulator.

d. Remove four (4) screws and lock washer using socket and ratchet. Place nuts and washer on bottom cover captive devices. Attach

Table III Suggested Demonstration Task Procedures (Cont)

regulator on large spare storage side of sub-kit using elastic cords.

e. Reinstall regulator using reverse procedure.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions - This program was especially noteworthy in that it elevated an aspect of space maintenance from the conceptual to the reality level. Considerable information is available that covers needs for tools, development of special tools, and testing of specific tools. This program endeavored to span a multitude of studies and specialty development contracts to produce a physical set of tools capable of demonstrating a large number of useful tasks in a spacecraft environment. Availability of an integrated set of space-useful tools paves the way for subsequent activities such as: demonstration of tool merits and limitations, assessment of tool adequacies in space-simulation facilities, practicality of applying such tools to basic system-restore tasks, development of improved usage tools, identification of other tools for first-level maintenance tasks not presently included in the kit, astronaut assessment of the kit and tools, and application of the basic kit to a specific space program.

Analysis, design and fabrication phases of this program were effective in signifying state-of-the-art lag and apparent development areas. Examples are:

1. Space Compatible Materials - Available selection lists seriously handicap design and induce high-cost-level materials procurement. Updated materials information is badly needed, as well as development of new space-compatible materials.

2. Space Design Standards - Standards for materials, finishes, human factors constraints, illumination levels, color coding, fastener hardware, translation aids, tethers and restraint aids, etc., are presently fragmentary, out-of-date, or difficult to obtain.

3. Historical Data - Data of benefit to programs such as this, e.g., FMEA, mission records, crew debriefing, maintenance reports; and that is current and equipment relevant is difficult to obtain, particularly where it is applicable to recent or current programs. If detailed data cannot be made available in a timely manner, statistical-form summary information would be beneficial.

B. Recommendations - A number of program-type and hardware-oriented recommendations have resulted from this program. Recommendations of major importance are:

1. Continued Space Maintenance Work - It is strongly recommended that development work oriented toward achieving a space maintenance acceptance and capability continue. Development work is needed, and program-peculiar capabilities should be defined:

a. Development Work Items

1) Digital Readout Multimeter - A space-qualified version should be considered for development. Studies should

also be performed to determine the most effective multimeter configuration for early-mission use, i.e., perhaps a more standard readout device with lighted panel is an optimum solution. The MMC also recommends that further development of this PATK might consider removal of the multimeter from the core kit and integration of it with an electrical-task sub-kit. This might enhance early space qualification of a basic kit, and also add the multimeter to a smaller-size kit readily adaptable to bench-level maintenance.

2) Visual Instructions Readout Device - Space-qualified versions should be located, if available, and assessed for near-future space applications. If investigation reveals a lack of developed capability, development of suitable readout devices should be considered. This item, like the multimeter above, can present problems in the areas of non-outgassing and non-flammability.

3) Portable Lights - Studies are needed to determine realistic illumination requirements for astronauts performing space maintenance tasks at all applicable levels of maintenance, i.e., first, second and possibly

third. Development of suitable light devices is also needed. As earlier cited, the PATK provides a mockup of a portable light developed for cabin use on the Apollo Program; this light would probably require enlarging for uses projected within this report.

4) Emergency Fluid Containment Device - Techniques and hardware devices are needed to cope with miscellaneous and varying-rate fluid system leaks. A capability to isolate, package and drain off leaking fluids while minimizing or eliminating cabin atmosphere contamination is sought. Hardware developed for this purpose should also enable "fix" of the leak by inplace repair or replacement techniques.

5) Leak Seal Handtool and Puncture Seals - Techniques and hardware devices are also needed to remedy joint leaks in gaseous and fluid systems (e.g., by use of a "contained" sealant applicator), and patch small hole penetrations in pressure vessels, spacecraft hulls, etc. The PATK provides suggested solution methods that require follow-on development.

6) Leak Detection Device - A survey should be performed of available hardware, and current research and

development of techniques, used to sense and provide isolation of fluid and gaseous system leaks. Space qualification and effectiveness of such hardware may necessitate further development.

7) Space Tool Holder - Further research and development are needed to define a holder for tools that will "house" the tools, restrain them through launch environment, and make them readily available for checkout and one-handed operations.

8) Space Work Bench - A survey should be performed to determine status and availability of hardware suitable for use as a space workbench. Programs such as the Space Station suggest a need for second and third-level maintenance capabilities that necessitate use of a special bench.

9) Ablative Material Repair Kit - Materials and techniques to enable space repair or replacement of ablative material regions are deservant of early-development consideration, particularly with the advent of long-term missions and space shuttles.

10) PATK Sub-kits - Sub-kits, as suggested and developed by this program, are ideally suited to packaging of hardware needed to perform specific categories of space

maintenance. A single kit might be developed, for example, to provide total mission capability to sniff, isolate and repair a leaking thermal control system. It is also recommended that space tools developed under NASA Contract NAS8-25067 for space repair of propulsion systems be considered as candidates for an add-on sub-kit that could be demonstrated using the task panel also generated by that contract.

b. Special Study and Development Items

1) PATK for Apollo Program - Investigations should be performed to determine feasibility of applying a smaller configuration of the PATK to the on-going Apollo Program that provides basic tools plus elements oriented to the program's operations, e.g., vacuum cleaning equipment, leak sealing hardware and procedures, and leaking-fluid-containment provisions. A sub-kit approach might be considered to provide support for lunar and orbital operations when in varying space system configurations.

2) PATK for AAP and Space Station - Work should be performed to effect application of a maintenance kit and capability to the second-generation, AAP, cluster configuration, and the Space Station. Definition of a kit should be

accomplished in consonance with developing maintenance concepts for space maintenance at the first, second and third levels, and adoption of system-wide checkout capabilities.

APPENDIX A

DEVELOPMENT PHASE DESIGN DRAWINGS

APPENDIX A

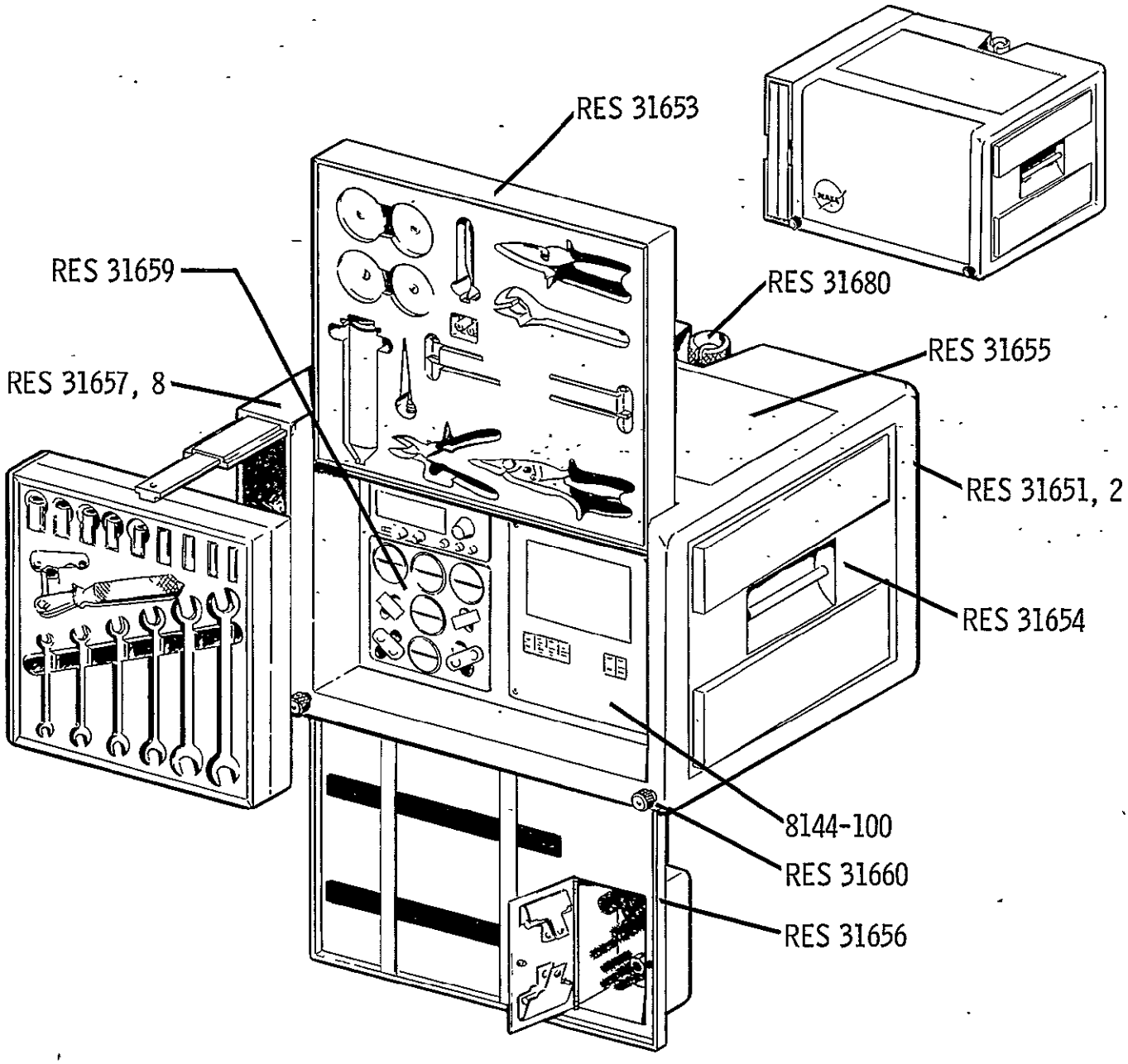
DESIGN DRAWINGS

Martin Marietta Corp. Drawing Number	Sheet	Title
RES 31650		Portable Astronauts Test Kit
RES 31651		Main Frame Isometric
RES 31652	1	Main Frame
	2	Plate, Pivot, Front Door Hinge
RES 31653	1	Front Door Assembly
	2	Tool Installation Front Door
RES 31654		End Panel - Right
RES 31655	1	Top Panel
	2	Top Panel, Hinge Details
	3	Top Panel, Latch Details
RES 31656	1	Bottom Panel
	2	Bottom Panel Details
	3	Bottom Panel Details
RES 31657	1	Tool Installation, Sub. Kit Core
	2	Tool Installation, Sub Kit Core
RES 31658	1	Case Assembly, Sub Kit
	2	Case Assembly, Sub Kit
	3	Case Assembly, Sub Kit
RES 31659	1	Front Panel Assembly
	2	Bracket Assembly
	3	Frame - Retaining

Martin Marietta Corp.
Drawing Number

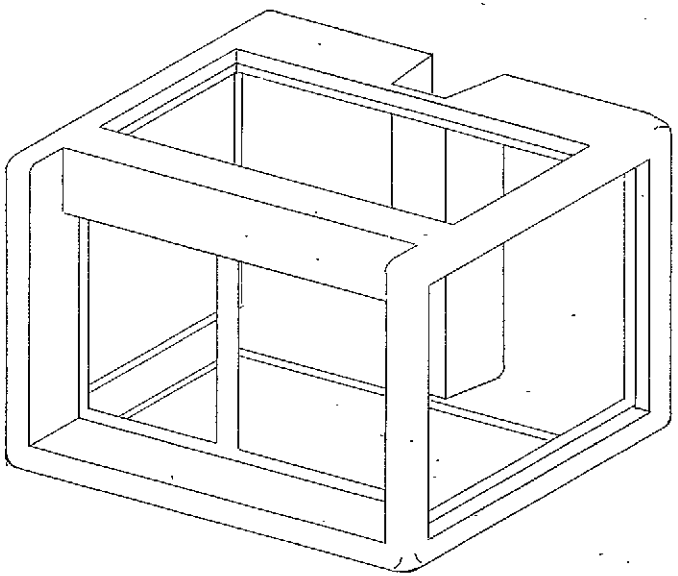
	Sheet	Title
	4	Meter Bezel
	5	Slide Tube Assembly
	6	Front Panel Insert
RES 31660		Portable Light - Flex Arm Assembly
RES 31661		Bottom Plate
RES 31662		End Panel - Left
RES 31663		Tether
RES 31664		Test Kit Battery
RES 31680		Telescopic Boom Assembly
RES 31681		Plate, Mounting, Telescopic Boom
RES 31682		Seat, Locking, Telescopic Boom
RES 31683		Seat, Ball, Telescopic Boom
RES 31684		Tube, Telescopic Boom
RES 31685		Ball, Telescopic Boom
RES 31686		Anchor Plate Assembly, Telescopic Boom
SRD 484013000	2	Boom Assembly
SRD 484013110		Handle, Telescopic Adj.
SRD 484013120		Lever, Telescopic Adj.
SRD 484013130		Locking Pin, Telescopic Adj.
SRD 484013140		Bolt Assy. Special

Martin Marietta Corp. Drawing Number	Sheet	Title
67050971A		Fairchild Instrumentation Instruction Manual for Model 7050 Digital Multimeter (one copy hand delivered to NASA-MSFC under this contract).
No number		One roll of 16mm sound and color movie film covering the MMC Denver Division Microfilm Storage and Display Unit (one film roll hand delivered to NASA-MSFC under this contract). Produced by the MMC Denver Division.
RES31690	1	Test Panel Assembly
RES31690	2	Test Panel Electrical Schematic
RES31665		Test Kit Elect. Schematic



RES31650

PORTABLE ASTRONAUTS TEST KIT



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CHECKED			
DES ENGR		MAIN FRAME ISOMETRIC	
MATL ENGR			
RELIABILITY			
QR ENGR			
PROJECT		SIZE:	CODE IDENT NO: 04236
CUST APPROVAL			RES 31651
		SCALE: None	SHEET 1 of 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

GENERAL NOTES:
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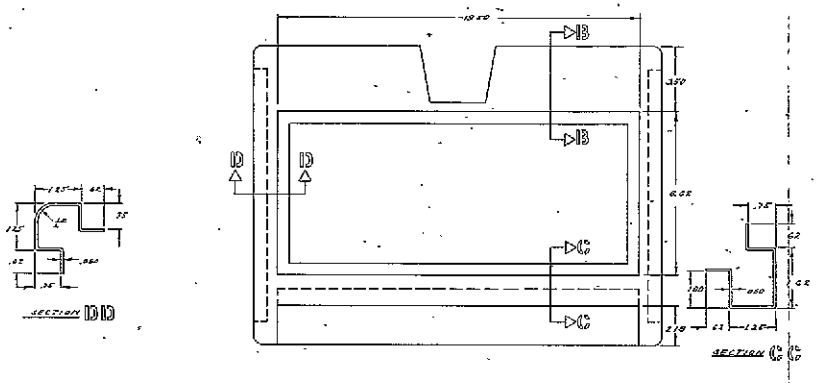
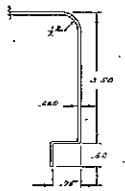
2. 5.18 DIM CHANGED FROM 5.12 12/2/69 RC
3. GRND RADIUS .16 UNLESS NOTED

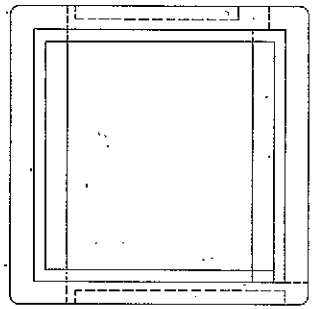


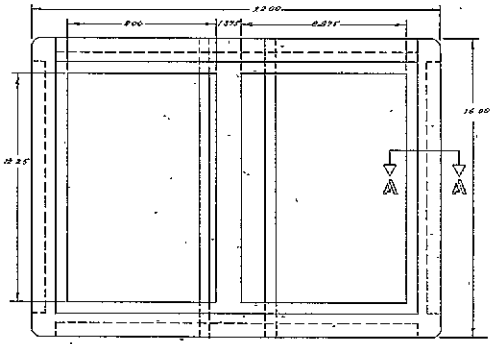
SECTION C C

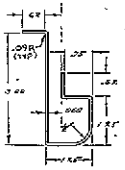


SECTION B B

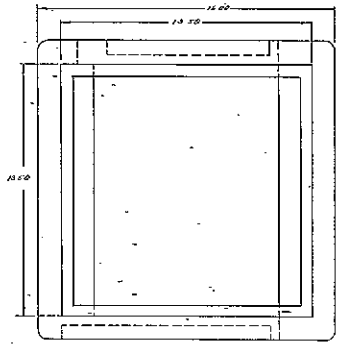
SECTION D D

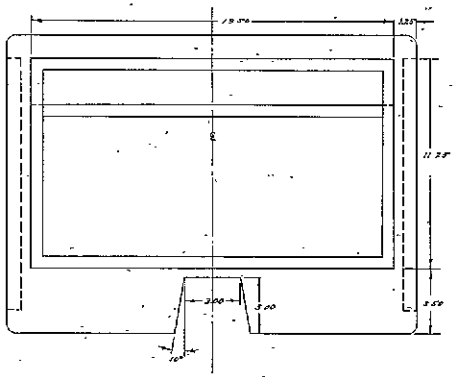






SECTION A A





-001
MATERIAL .063 6061-T4 ALUMINUM
(FIRST ARTICLE MOCK-UP ONLY)

FOLDOUT FRAME 2

FOLDOUT FRAME 1

794-6011
CIT 2736

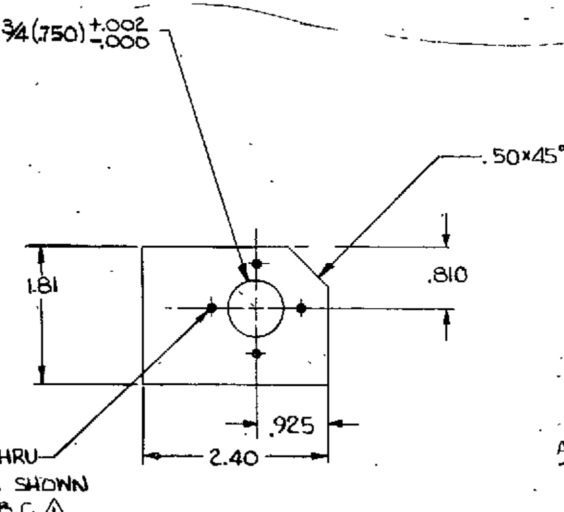
MARTIN MARIETTA CORPORATION

PORTABLE TEST KIT
MAIN FRAME

04236 RES 31458

SHEET 1 OF 2

⚠1 6-32 HOLES TO BE LOCATED AT INSTALLATION IN RES 31652-001 MAIN FRAME



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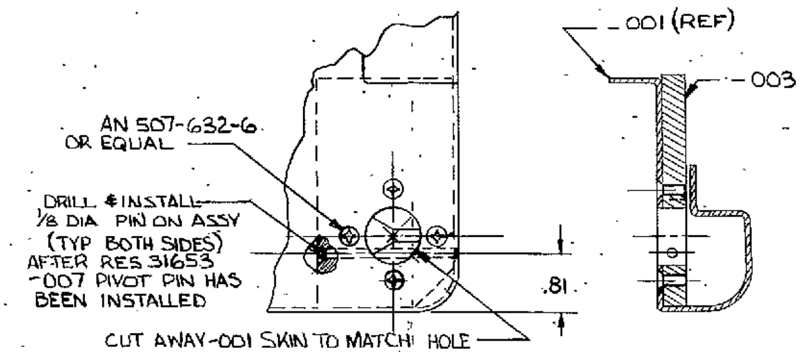


TYPICAL INSTALLATION (2 PLACES)
L.H SHOWN

LIST OF MATERIAL

QUANTITY/DASH NO.	PART NO.	ZONE	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	MATERIAL SPECIFICATION	FINISH OR MFR CODE
	-003		PLATE	1/4 THK BAR	4130 STL		

ODD DASH NO SHOWN — EVEN DASH NO OPP

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING. TOLERANCES ON FRACTIONS ±1/32, DECIMALS .X ±.1, .XX ±.03, .XXX ±.010, ANGLES ±1/2°. MACHINED SURFACES 125

DRAWN BY: J. Vowells 1640 DATE 1-10-69

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

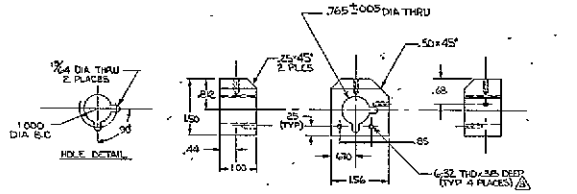
PLATE, PIVOT
FRONT DOOR HINGE
ASTRONAUT TOOL KIT

SIZE C | CODE IDENT NO. 04236 | RES 31652

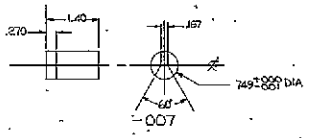
SCALE 1/1 | SHEET 2 OF 2

FOLDOUT FRAME 1

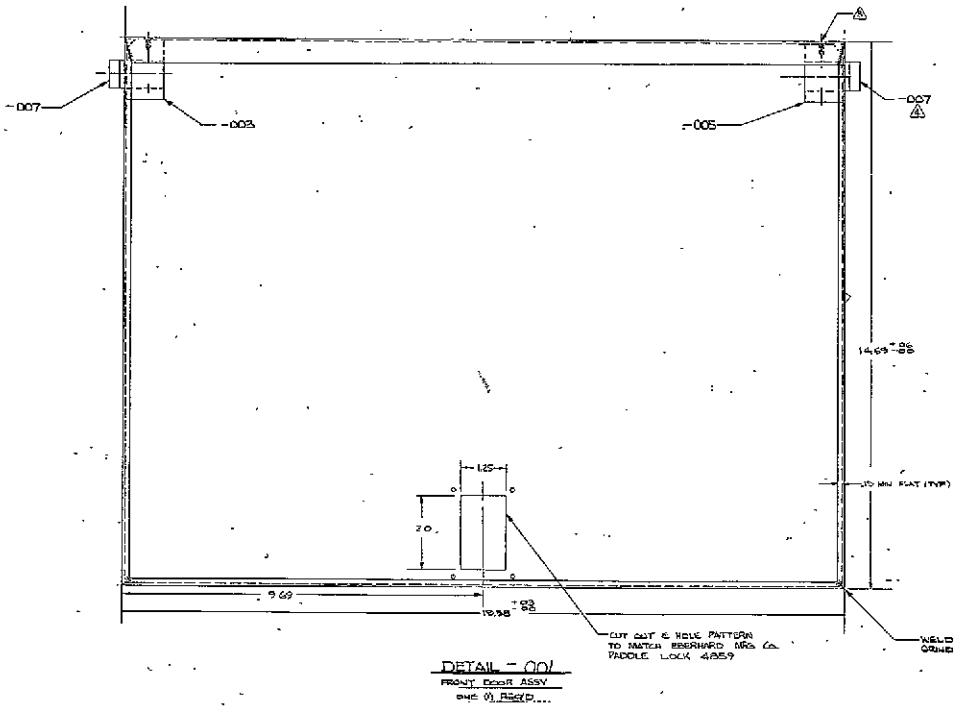
FOLDOUT FRAME 2



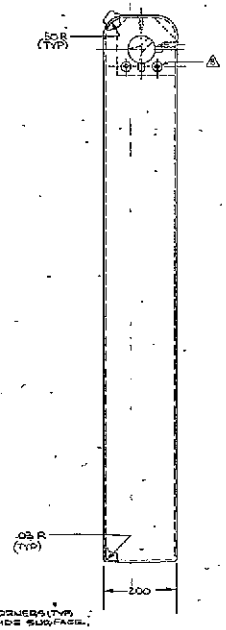
PIVOT BLOCK 2024-T4
1 REQD LH (-003) 1 REQD RH (-005 NOT SHOWN)



PIVOT PIN (304 CRES)
2 REQD



DETAIL - 001
FRONT DOOR ASSY
(ONE (1) REQD)



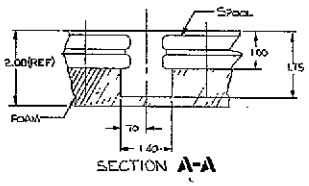
NOTES:
1. MATL .0601 AL ALLOY ASTM B918A .064 THK.
2. REMOVE ALL BURRS & SHARP EDGES
⚠ 6-32 THREADED HOLES MAY BE LOCATED AFTER BLOCKS ARE INSTALLED
⚠ -007 PIVOT PIN TO BE INSTALLED AFTER DOOR IS LOCATED IN MAIN FRAME

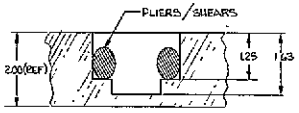
		FRONT DOOR ASSY, ASTRONAUTS PORT. TEST KIT
		SIZE 04236 RES 31695

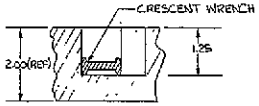
M. GLOSSA

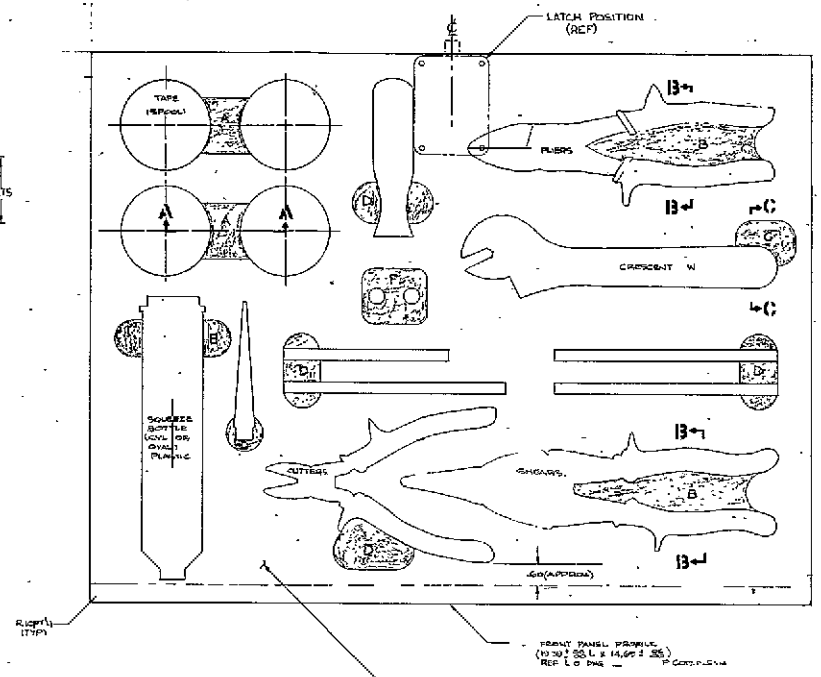
FOLDOUT FRAME

FOLDOUT FRAME 2

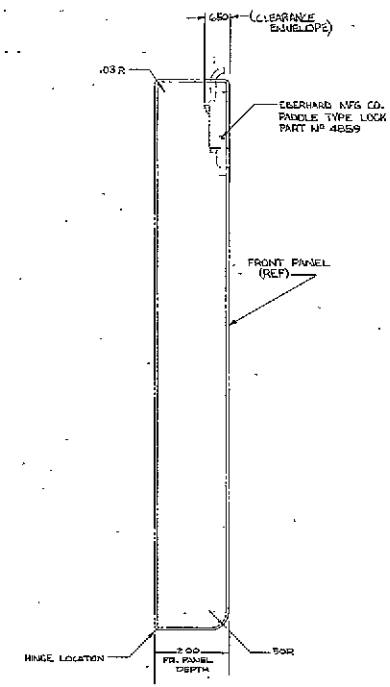








CAVITY	DEPTH
D	1⅜ INS.
E	1¾ INS.
F	1 IN.



1. UNLESS OTHERWISE NOTED ALL TOOLS TO BE FLUSH (+0-.05") WITH TOP SURFACE OF FOAM CORE.
2. ALL TOOLS TO BE RETAINED BY CONTROLLING INTERFERENCE FIT OF FOAM ON TOOL PROFILE.
3. ALL TOOLS SHOWN WILL BE PROVIDED FOR CUT OUT PROFILES DURING PROTOTYPE MANUFACTURE.

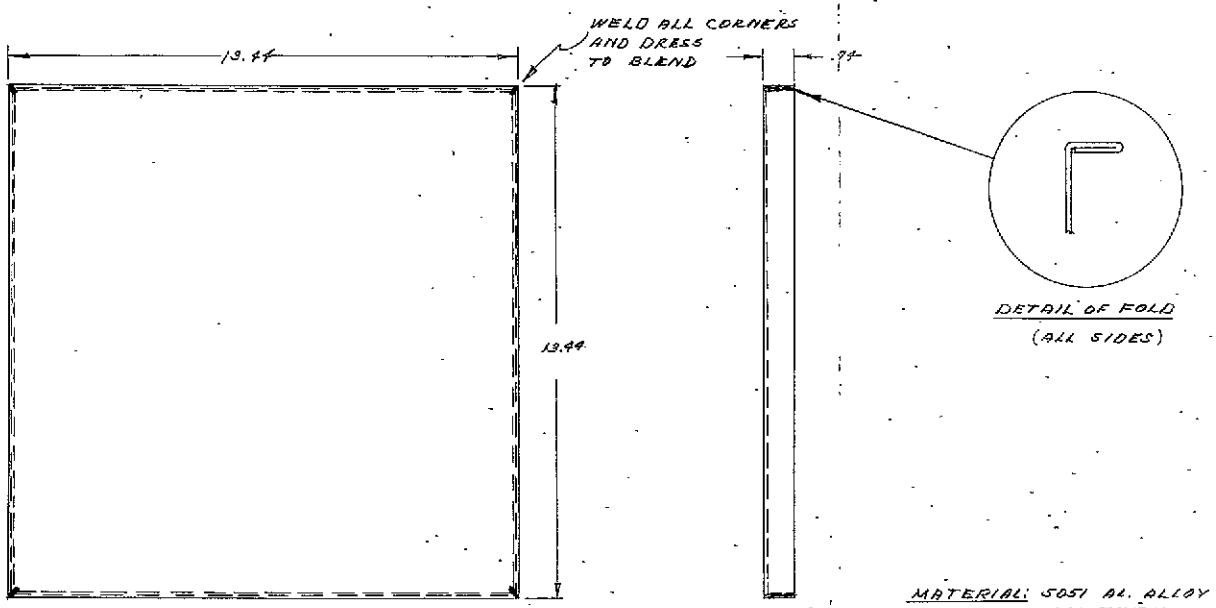
FOLDOUT FRAME 2

FOLDOUT FRAME 1

		TOOL INST. - FR DOOR ASTRONAUTS PORT. TEST KIT
	04236	RES 31695

GENERAL NOTES:

1- ALL DIMENSIONS $^{+.00}_{-.03}$



MATERIAL: 5051 AL. ALLOY .060 THICK

P. CORVELEYN, 11/28/69

MARTIN MARIETTA CORPORATION

END PANEL -RIGHT

04236

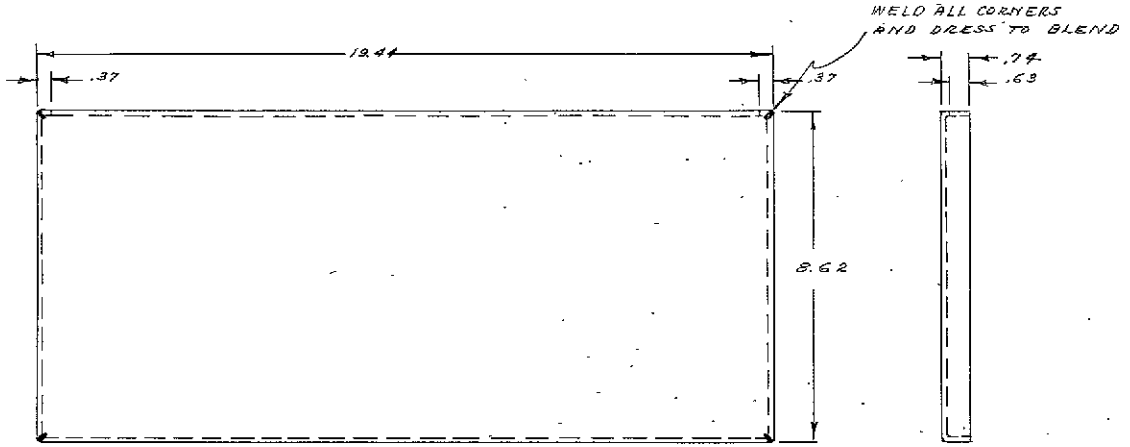
RES 31654

FOLDOUT FRAME 1

FOLDOUT FRAME 2

GENERAL NOTES:

1- ALL DIMENSIONS $^{+.00}_{-.03}$



MATERIAL: 5051 AL ALLOY .063 THICK

DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
AND ARE AFTER PLATING
TOLERANCES ON DECIMALS
FRACTIONS ANGLES
.X .XX .XXX
±1/32 ±.1 ±.03 ±.010 ±1/2°
MACHINED SURFACES
REF MIL-STD-10
MIL-I-8500 STATUS
INTERCHANGEABLE
REPLACEABLE
UNCONTROLLED
DER 061626 (10-68)

DRAWN P CORVELEYN 11/24/67
CHECKER
STRESS ENGR
WT ENGR
MATL ENGR
RELIABILITY
QA ENGR
PROJECT
CUST REQUIRMT

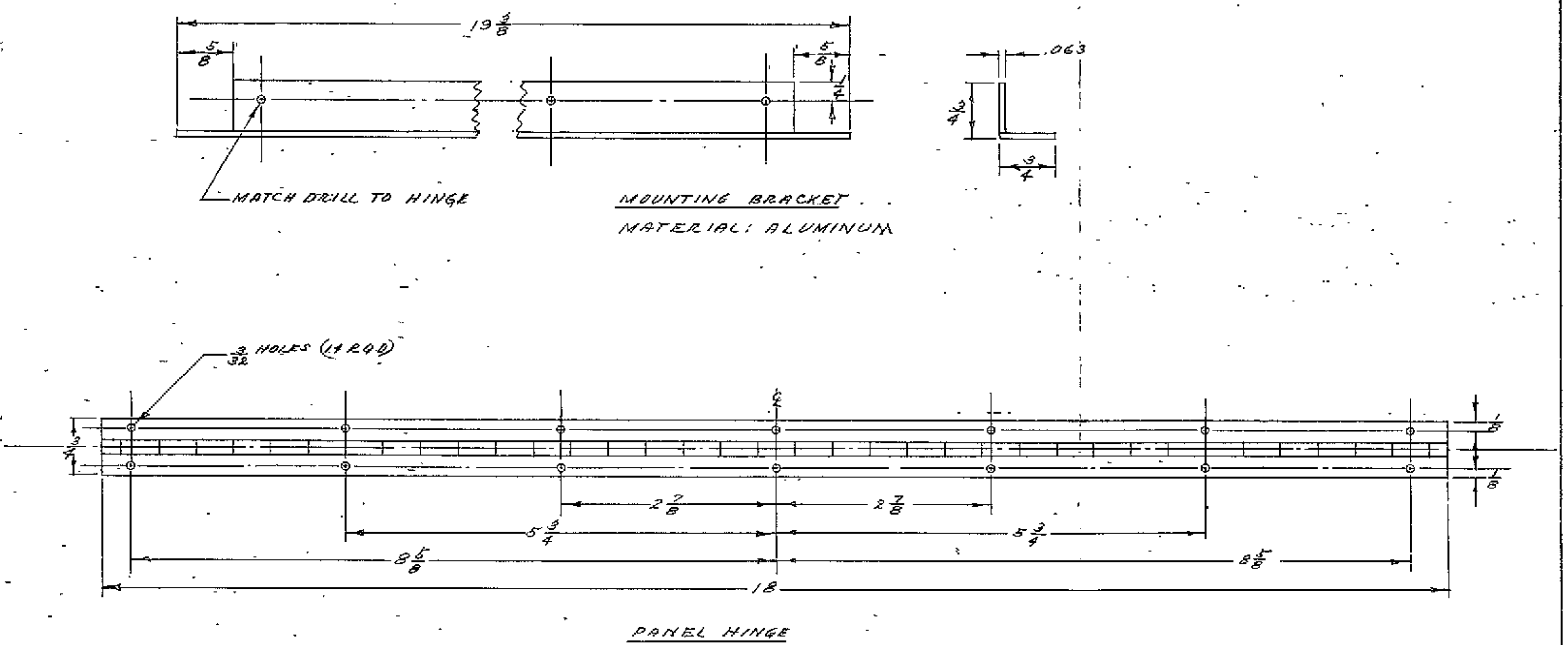
MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

TOP PANEL

SIZE CODE IDENT NO 04236 RES 31655
SCALE 1/2 SHEET 10

FOLDOUT FRAME

FOLDOUT FRAME 2



DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
AND ARE AFTER PLATING
TOLERANCES ON DECIMALS

MACHINED SURFACES
REF MIL-STD-10

MIL-I-8500 STATUS
INTERCHANGEABLE
REPLACEABLE
UNCONTROLLED

DRAWN: R CORVELEYN 1/8/70
CHECKED
STRESS ENGR
WT ENGR
MATL ENGR
RELIABILITY
CR ENGR
PROJECT
CUST APPROVAL

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER COLORADO

TOP PANEL
HINGE DETAILS

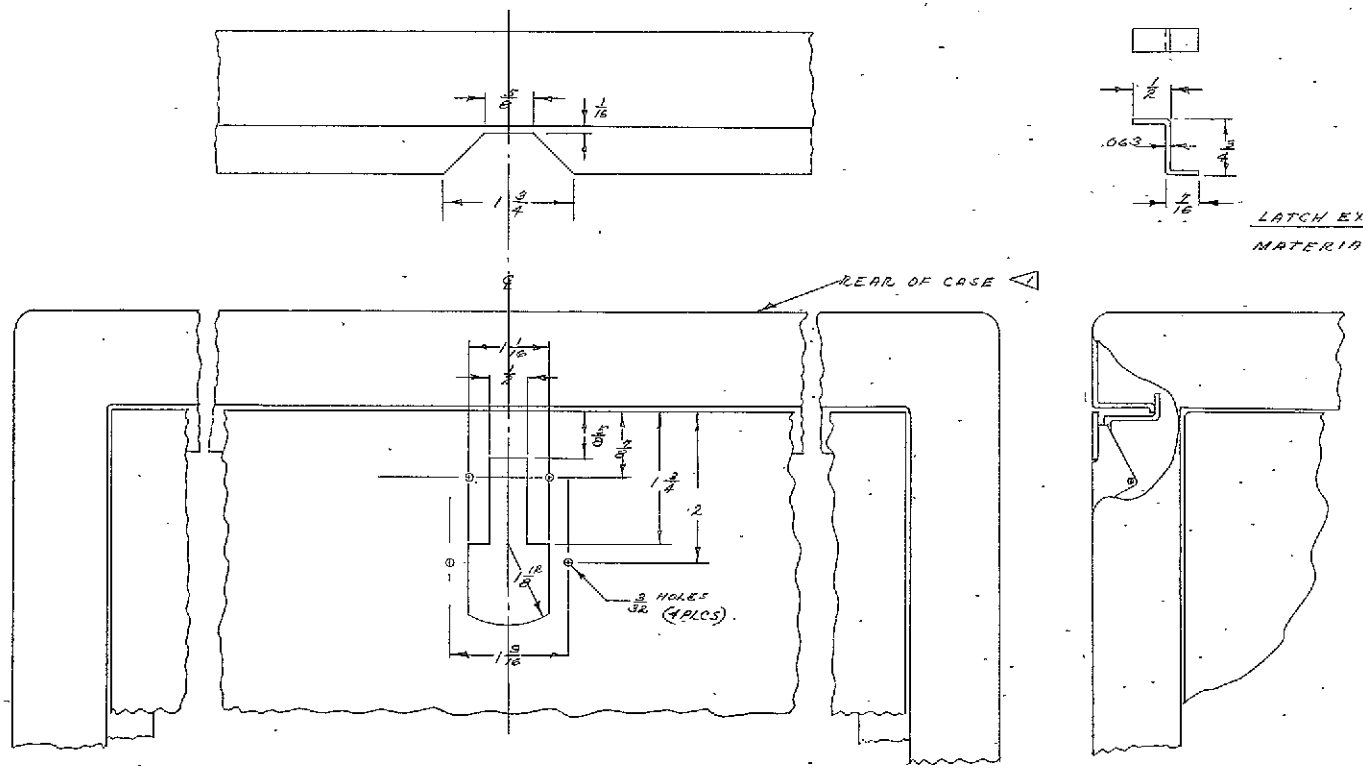
SIZE | CODE IDENT NO 04236 | RES 31655
SCALE | SHEET 2/3

FOLDOUT FRAME 1

FOLDOUT FRAME 2

GENERAL NOTES

1 - PANEL TO BE INSTALLED 180° FROM THAT SHOWN FOR EASIER ENTRY.



LATCH EXTENSION

MATERIAL: STAINLESS STEEL 302

DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING

TOLERANCES ON DECIMALS

FRACTIONS	X	.XX	.XXX	ANGLES
±1/32	±.1	±.03	±.010	±1/2°

MACHINED SURFACES REF MIL-STD-10 ✓

NIL-1-8500 STATUS

INTERCHANGEABLE

RE-LACEABLE

UNCONTROLLED

DRAWN BY R. CORVELEYN 1/8/70

CHECKED

STRESS ENGR

WT ENGR

MATL ENGR

RELIABIL

QR EI QI

PROJ

CUST & DUTY

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER, COLORADO

TOP PANEL
LATCH DETAILS

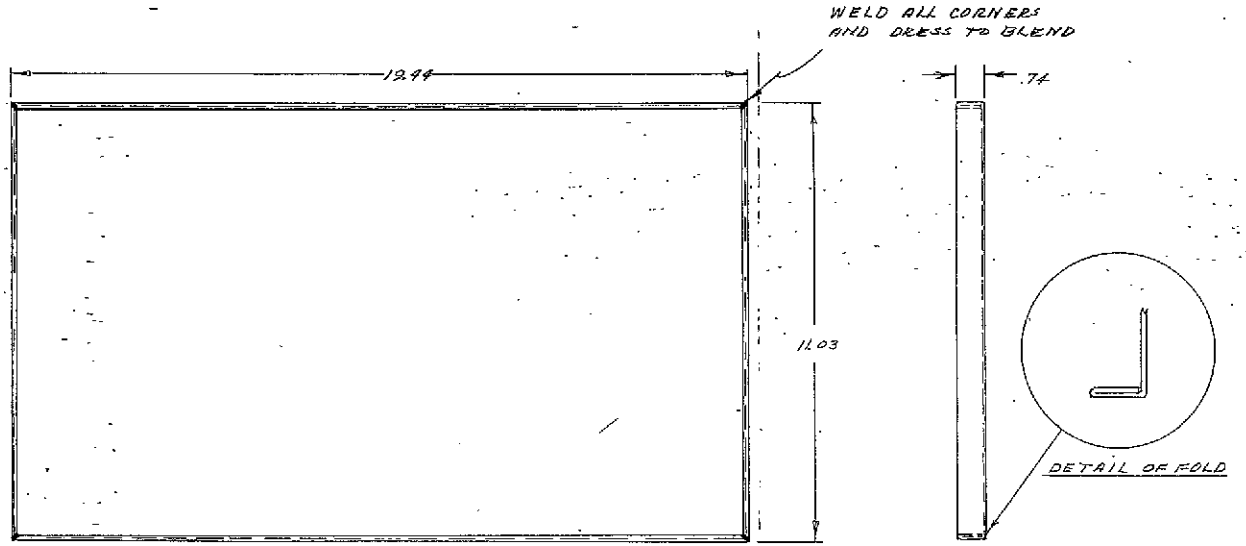
SIZE: —
CODE IDENT NO: 04236
RES 31655
SCALE: FULL
SHEET 3/3

FOLDOUT FRAME 1

FOLDOUT FRAME 2

GENERAL NOTES:

1-ALL DIMENSIONS $\pm .00$ $.03$



MATERIAL: 5051 AL. ALLOY
.063 THICK

P. CORVELEYN 11/25/69

MARTIN MARIETTA CORPORATION

BOTTOM PANEL

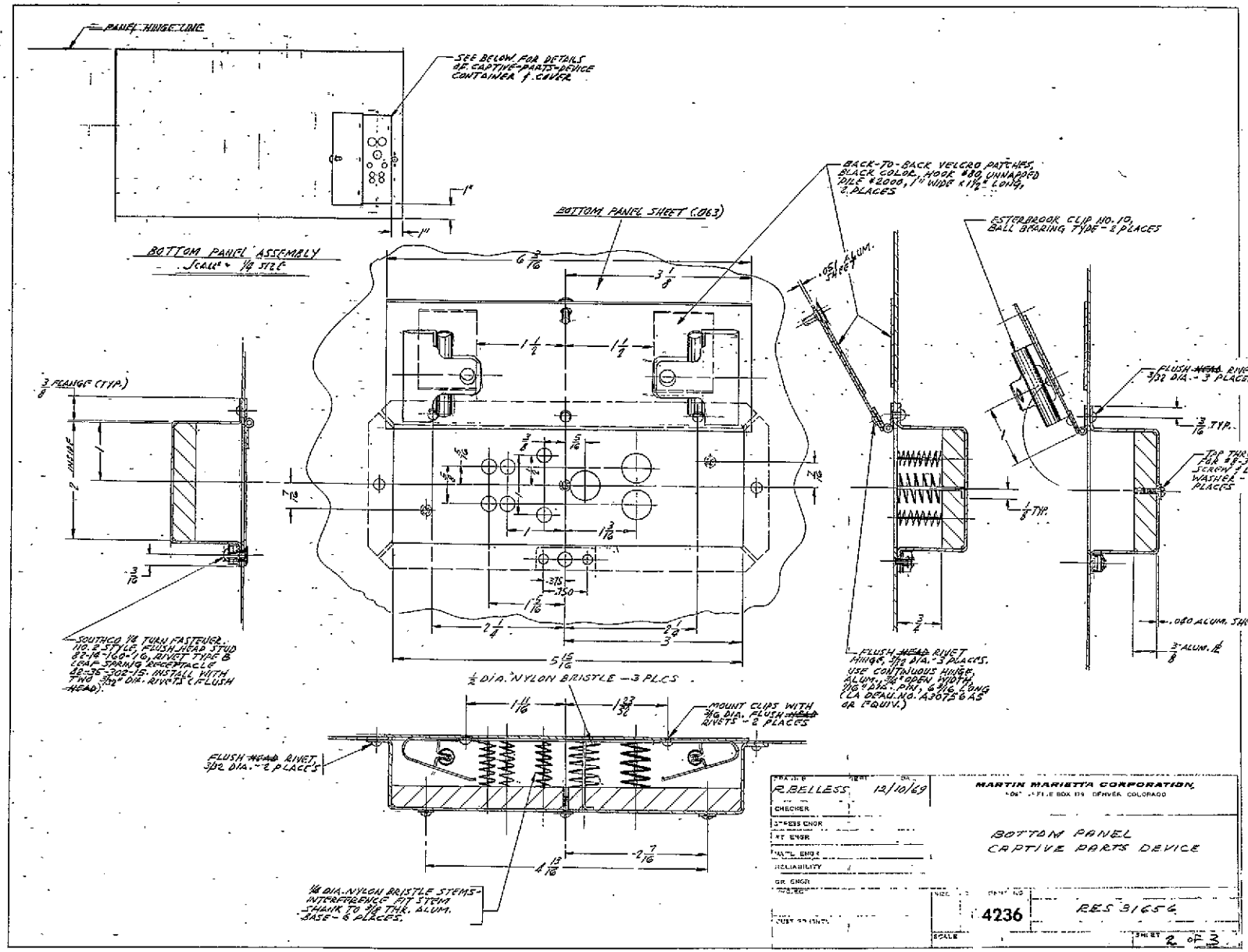
04236

RES 3/656

SHEET 1 OF 3

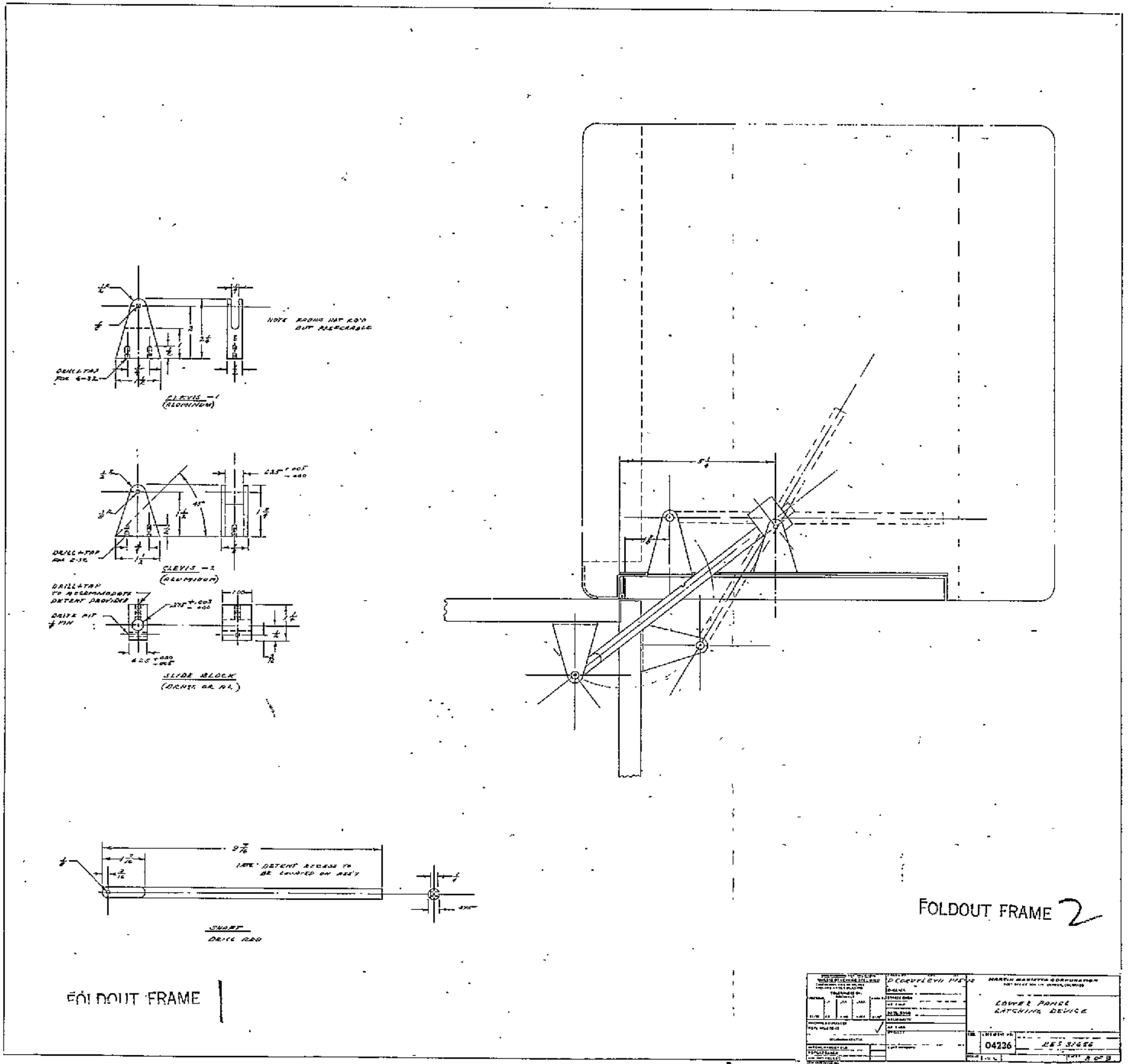
FOLDOUT FRAME 1

FOLDOUT FRAME 2



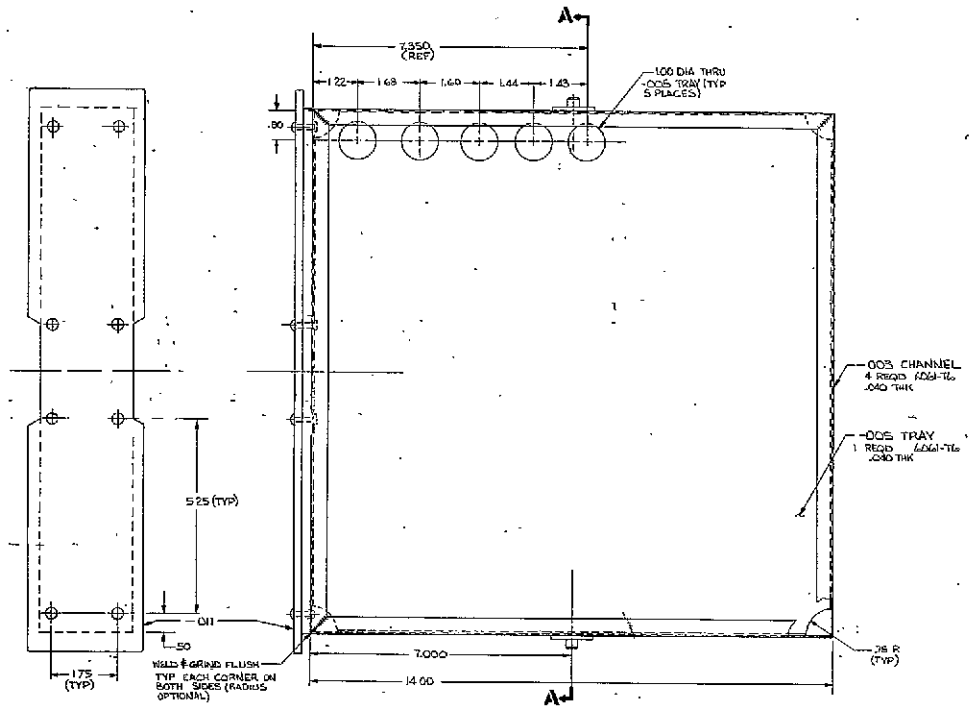
FOLDOUT FRAME 1

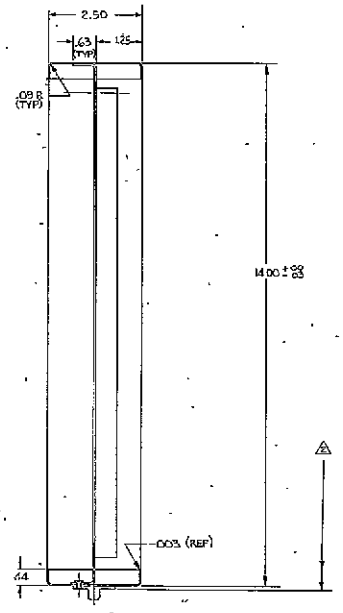
FOLDOUT FRAME 2



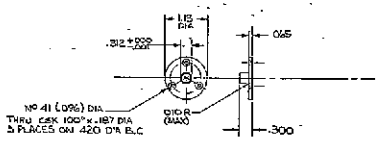
FOLDOUT FRAME 2

FOLDOUT FRAME 1



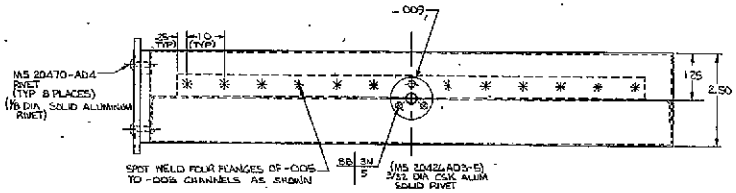


SECTION A-A

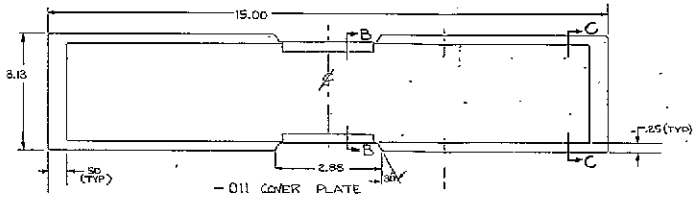


-009 PINTLE
2 REQD 2024-T3 OR EQUAL

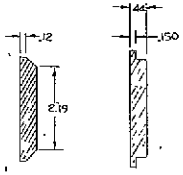
FOLDOUT FRAME 2



-001 CORE FRAME ASSY



-011 COVER PLATE
1 REQD 2024-T3 OR EQUAL



SECTION B-B SECTION C-C

FOLDOUT FRAME 1

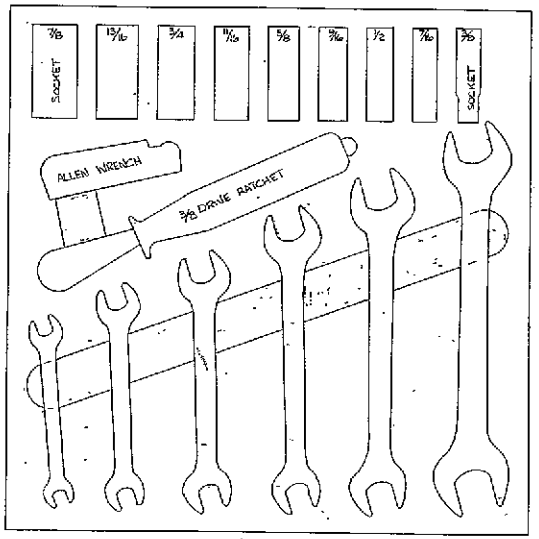
⚠ THIS DIMENSION NOT TO EXCEED 14.130 INS
1-009 PINTLES TO BE IN LINE SO THAT THE FRAME ROTATES CONCENTRICALLY & SQUARELY BETWEEN THEM

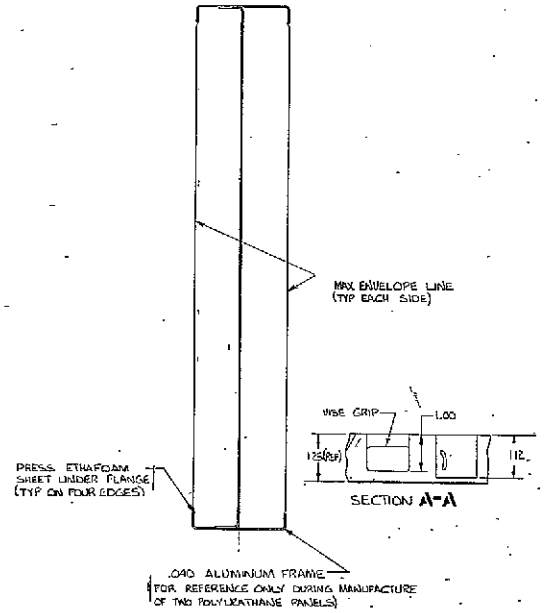
MARTIN MARIETTA CORPORATION

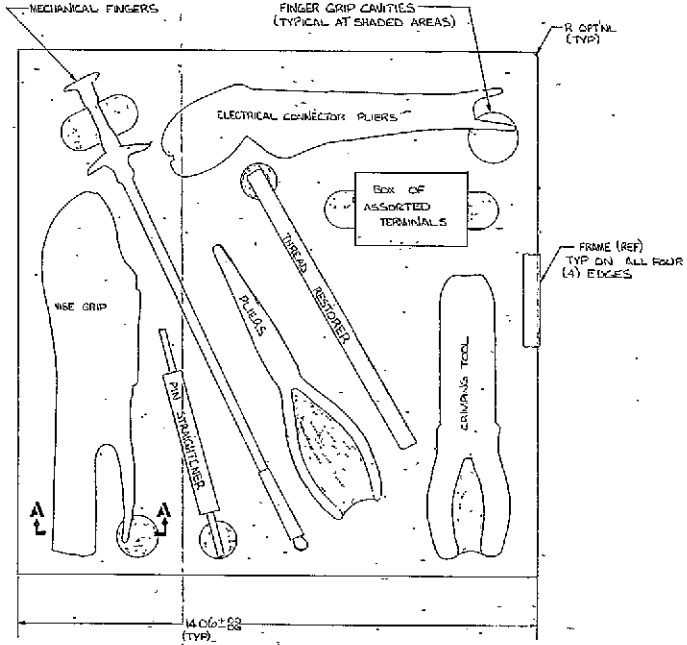
TOOL INSTALLATION SUB-KIT CORE ASTRONAUTES TOOL KIT

04236 RES 316757

SCALE FULL SHEET 1 OF 2





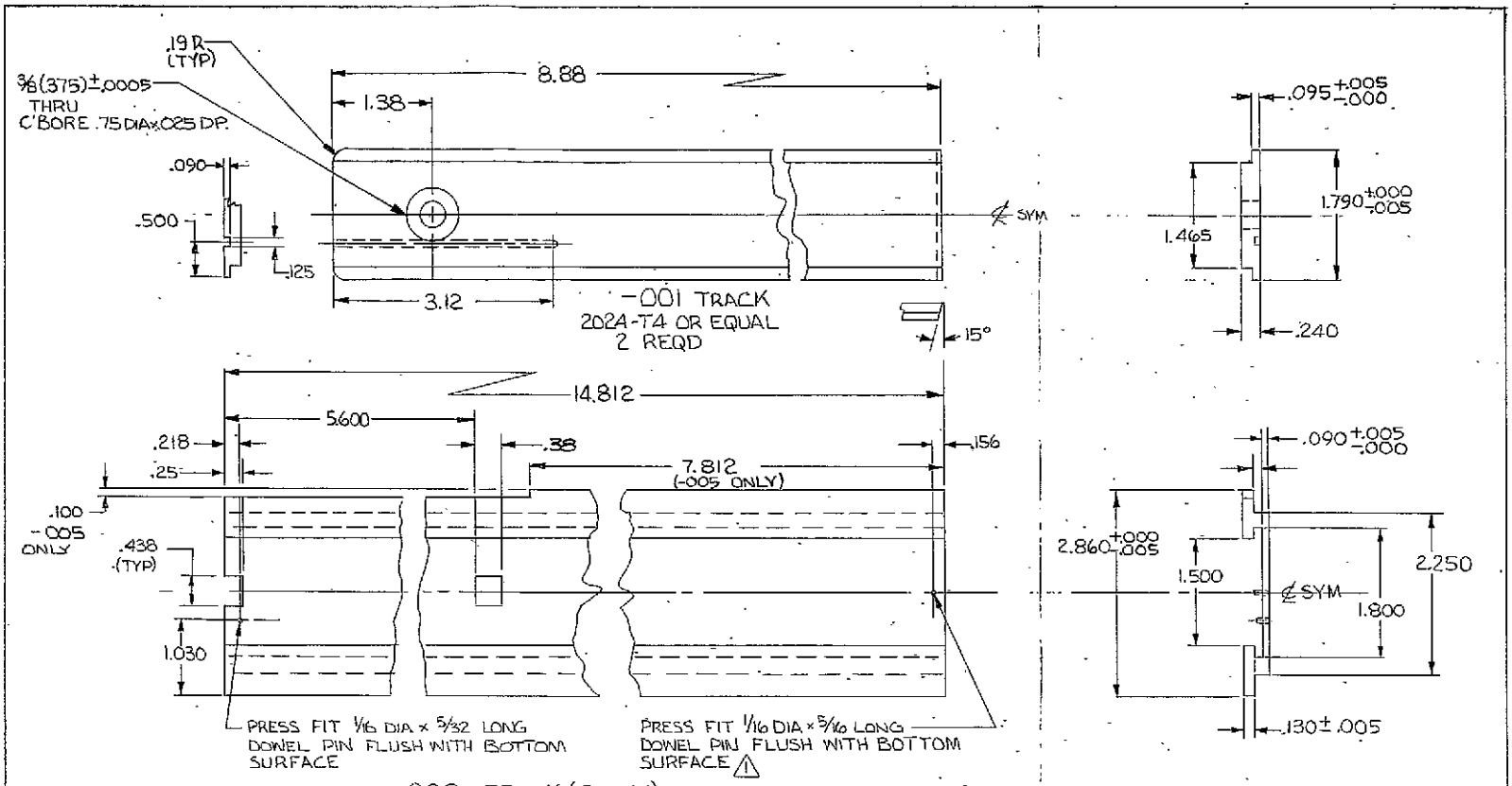


NOTES
1. ALL TOOLS & FRAME ASSY TO BE PROVIDED FOR MOLDING OR CUT OUT TEMPLATES
2. ALL TOOLS TO BE FLUSH WITH UPPER SURFACE OF FOAM UNLESS OTHERWISE NOTED.
3. ALL TOOLS ARE TO BE RETAINED BY CONTROL OF CAVITY PROFILE ONLY I.E. NO CLIPS, STRAPS ETC.
4. FINGER CAVITY DEPTH TO EXCEED TOOL DEPTH BY 3B WHERE POSSIBLE.
5. COLOR OF FOAM ~ WHITE

		TOOL INSTALLATION SUB KIT CORE ASTRONAUTS TOOL KIT
		04236 RES 3657

FOLDOUT FRAME 1

FOLDOUT FRAME 2



NOTES

4. HARD COAT ANODIZE BOTH -001 & -003
3. -001 TRACK TO SLIDE FREELY ON -003 TRACK
2. ALL CORNER & FILLET RADII .010
⚠ INSTALL PIN AFTER -001 TRACK HAS BEEN MOUNTED IN GROOVES

J Jewett 1640 12-5-69

MARTIN MARIETTA CORPORATION

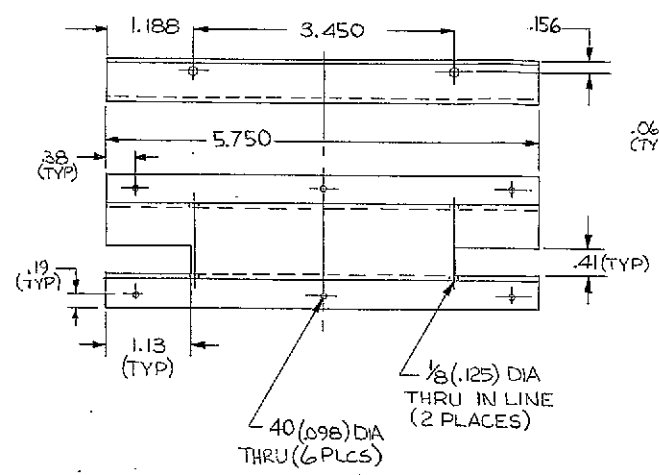
TRACK ASSY.
SUB KIT CORE
ASTRONAUTS TOOL KIT

04236 RES 31658

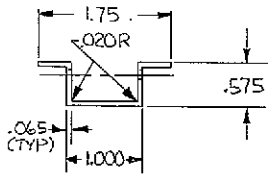
SCALE FULL SHEET 1 OF 3

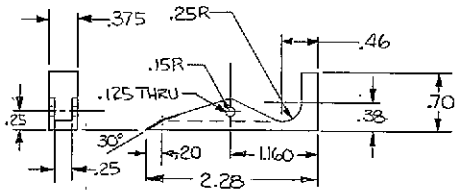
FOLDOUT FRAME 1

FOLDOUT FRAME 2

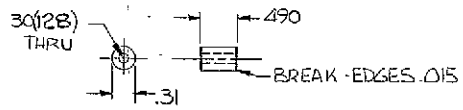


-015 CHANNEL 1 REQD
2024-T3 OR EQUAL

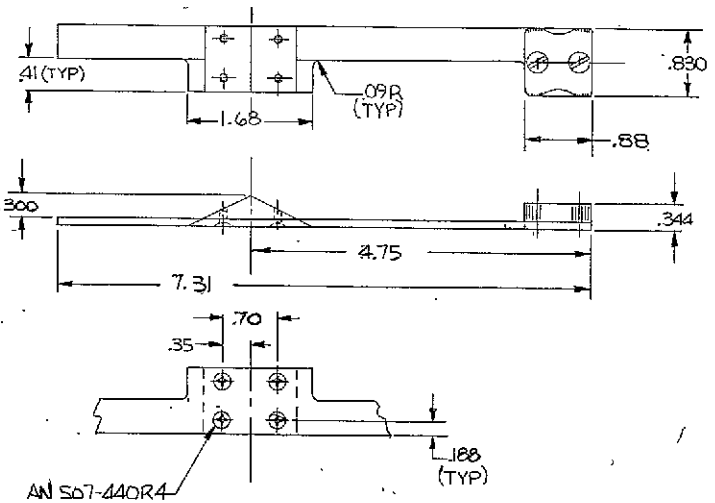




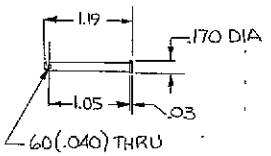
-007 PAWL 2 REQD
2024-T4 OR EQUAL



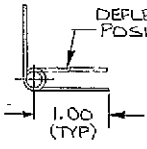
-009 SPACER 2 REQD
ANY ALUMINUM



-017 SLIDE ASSY. 1 REQD
2024-T3 OR EQUAL .094 THK



-011 PIN 2 REQD
CRES STEEL



TORSION SPRING SPEC.
.030 DIA MUSIC WIRE
.270 O.D
.70 IN/LB TORQUE
7 COILS
COIL DIRECTION OPTIONAL
2 REQ'D

DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING
TOLERANCES ON: DECIMALS
FRACTIONS ±1/32 | X ±.1 | .XX ±.03 | .XXX ±.010 | ANGLES ±1/2°
MACHINED SURFACES REF MIL-STD-10 ✓
MIL-I-8500 STATUS
INTERCHANGEABLE
REPLACEABLE
UNCONTROLLED

DRAWN BY d Dewells DEPT 1640 DATE 12-8-69
CHECKER
STRESS ENGR
WT ENGR
MATL ENGR
RELIABILITY
QR ENGR
PROJECT
CUST RPRSNTV

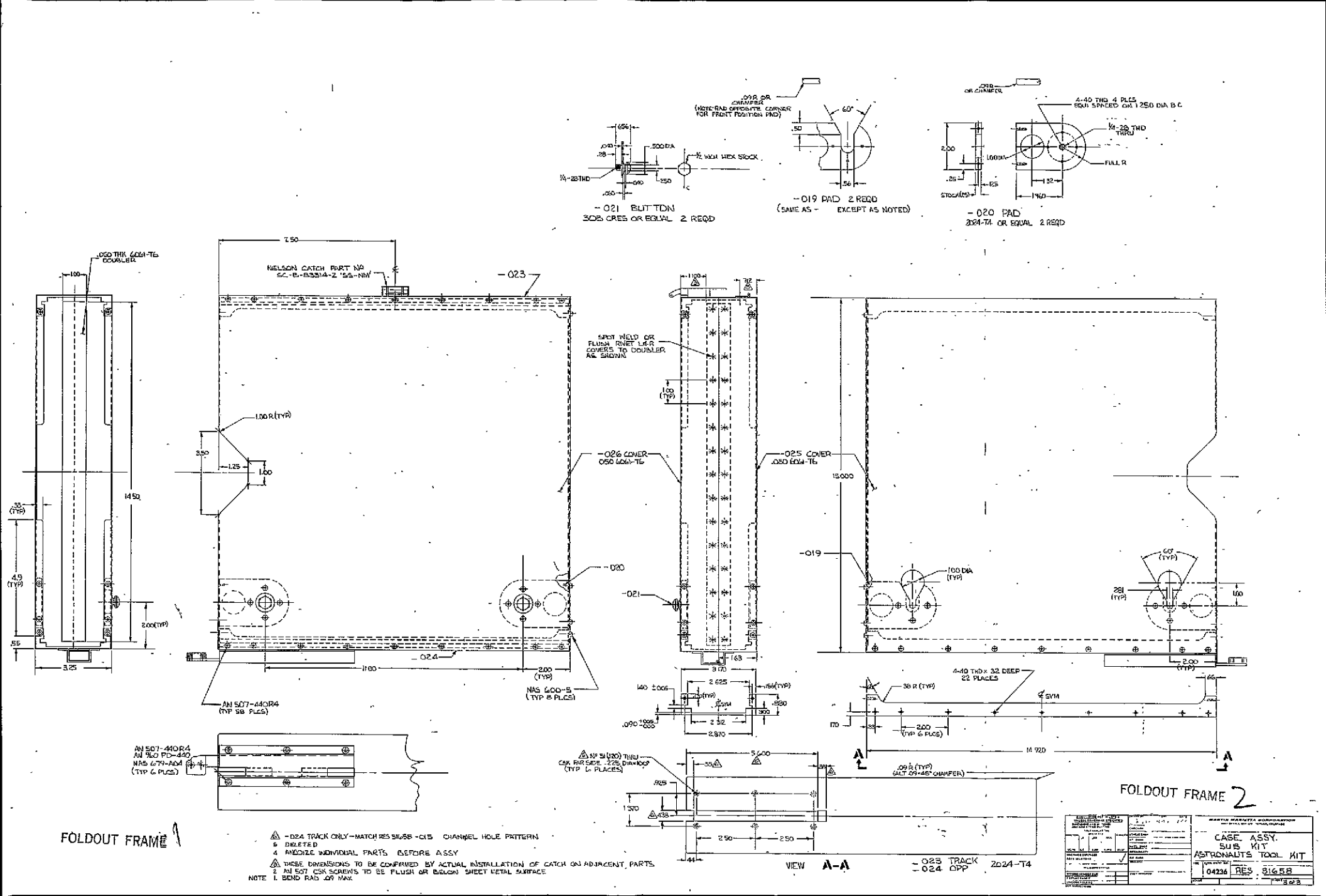
MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

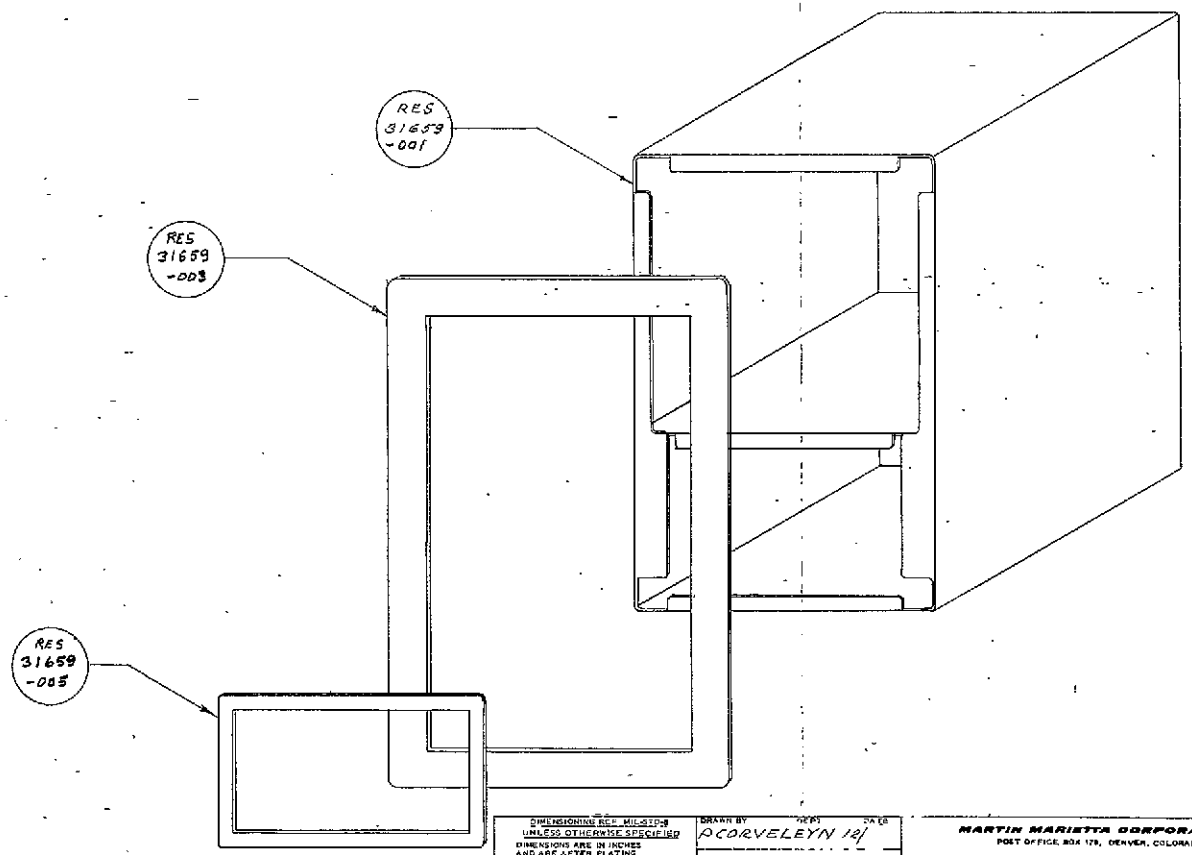
DETAILS TRACK LATCH ASSY ASTRONAUTS TOOL KIT

SIZE | CODE IDENT NO 04236 | RES 31658
SCALE FULL | SHEET 2 OF 3

FOLDOUT FRAME 1

FOLDOUT FRAME 2


-021 BUTTON
303S CRES OR EQUAL 2 REQD
-019 PAD 2 REQD
(SAME AS - EXCEPT AS NOTED)
-020 PAD
2024-T4 OR EQUAL 2 REQD
.050 THK 6061-T6 DOUBLER
NELSON CATCH PART NO
SC-6-83314-2 'SS-NW'
-023
SPOT WELD OR FLUSH RIVET L&R COVERS TO DOUBLER AS SHOWN
-026 COVER .050 6061-T6
-025 COVER .050 6061-T6
-024
-020
-021
-019
AN 507-440R4 (TYP 58 PLCS)
NAS 600-5 (TYP 8 PLCS)
AN 507-440R4 AN 960 PD-440 NAS 679-A04 (TYP 6 PLCS)
4-40 THD x 32 DEEP 22 PLACES
.09 R (TYP) (ALT 09-45° CHAMFER)
VIEW A-A
-023 TRACK -024 OPP 2024-T4
FOLDOUT FRAME 1
FOLDOUT FRAME 2
-024 TRACK ONLY—MATCH RES 31658 -015 CHANNEL HOLE PATTERN
DELETED
ANODIZE INDIVIDUAL PARTS BEFORE ASSY
THESE DIMENSIONS TO BE CONFIRMED BY ACTUAL INSTALLATION OF CATCH ON ADJACENT PARTS.
AN 507 CSK SCREWS TO BE FLUSH OR BELOW SHEET METAL SURFACE
NOTE 1. BEND RAD .09 MAX
CASE ASSY. SUB KIT ASTRONAUTS TOOL KIT
04236 RES 31658



DIMENSIONING REF MIL-STD-8 UNLESS OTHERWISE SPECIFIED	DRAWN BY (NEW) DATE: P CORVELEYN 12/
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING	CHECKER
* TOLERANCES ON DECIMALS: FRACTIONS ±1/32; .X ±.1; .XX ±.03; .XXX ± .010; ANGLES ±1/2°	STRESS ENGR
	WT ENGR
	MATL ENGR
	RELIABILITY
MACHINED SURFACES REF MIL-STD-10 ✓	QK ENGR
	PROJECT
MIL-1-8800 STATUS	
INTERCHANGEABLE	CUST PRPRTY
REPLACEABLE	
UNCONTROLLED	

DEN 66165 (10-68)

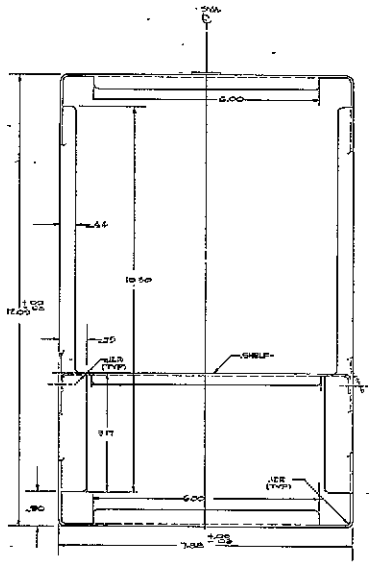
MARTIN MARIETTA CORPORATION
POST OFFICE, BOX 179, DENVER, COLORADO

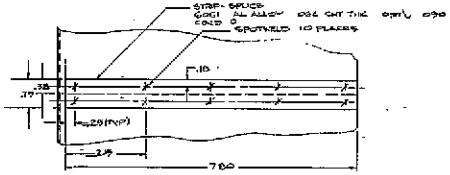
FRONT PANEL ASS'Y

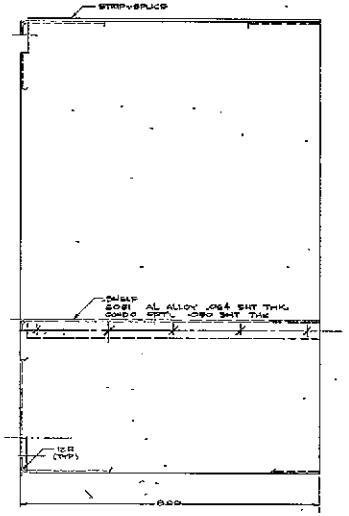
SIZE	CODE IDENT NO	
	04236	RES 31659
SCALE		SHEET 1 OF 6

FOLDOUT FRAME 1

FOLDOUT FRAME 2







-001 BRACKET ASSY.

ONE (1) REQ'D.

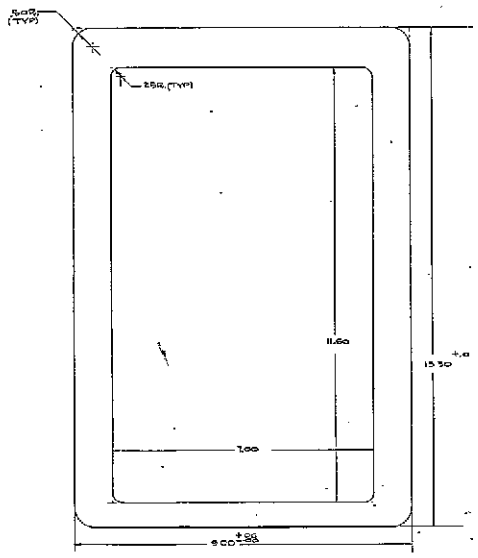
NOTES:
1. REMOVE ALL BURRS & SHARP EDGES
2. CERTIFIED MATL NOT REQD
3. BRAKELET DIMENSIONS MUST BE HELD

		BRACKET ASSY. ASTRONAUTS PORT. TEST KIT
		04236 RES 51659
		SHT 2 OF 2

M. GLOSSA

FOLDOUT FRAME 1

FOLDOUT FRAME 2

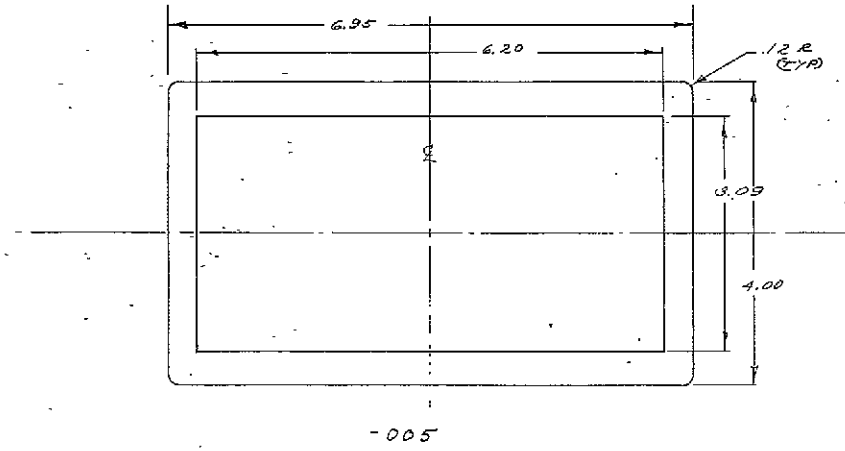


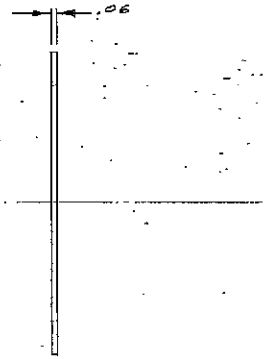
-003 DETAIL -
FRAME, TRAINER, FULL

NOTES.
1. MAT'L: SHEET AL ALLOY ASTM B209A .10 SHT THK.
2. REMOVE ALL SHARP EDGES & BURRS.
3. CERTIFIED MAT'L TEST REQ'D.
4. MOUNTING HOLES TO BE FIXTURED, LATER.
5.

		MARTIN MARIETTA CORPORATION
		FRAME ASTRONAUTS' PORT TEST KIT
		04236 RES 31659
		SHT 3 of 6

GLOSSA





MATERIAL: 5051 AL. ALLOY
.06 THICK

DCORVELEYN 12/2/92

MARTIN MARIETTA CORPORATION

METER BEZEL

04236

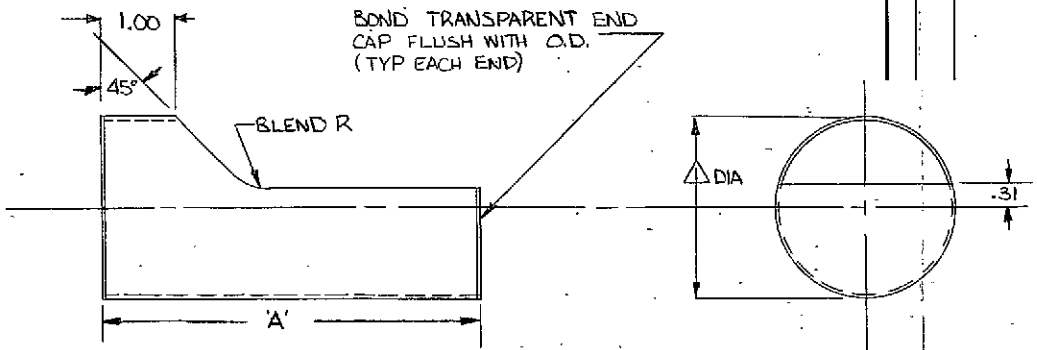
RES 31659

SCALE FULL

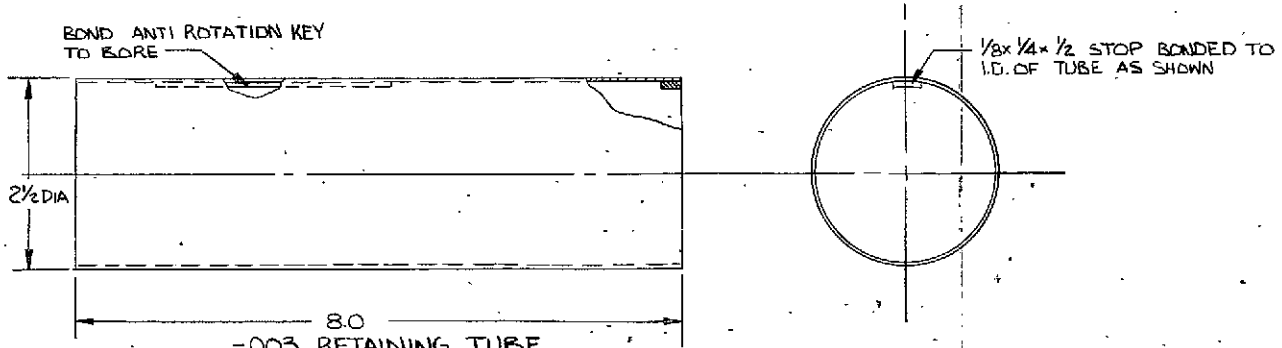
SHEET 4 of 6

FOLDOUT FRAME 1

FOLDOUT FRAME 2



No. REQ'D	DIM 'A'
2	8.0 IN
1	6.0 IN
2	5.0 IN



NOTE ⚠ THIS DIA TO SLIDE INSIDE BORE OF -003 RETAINING TUBE

QUANTITY/BASIC NO.	PART NO	ZONE	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	MATERIAL SPECIFICATION
	-003		DRAWER		PLASTIC	
	-001		TUBE		PLASTIC	

LIST OF MATERIAL

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED

J. Jones 1040 DATE 1-11-69

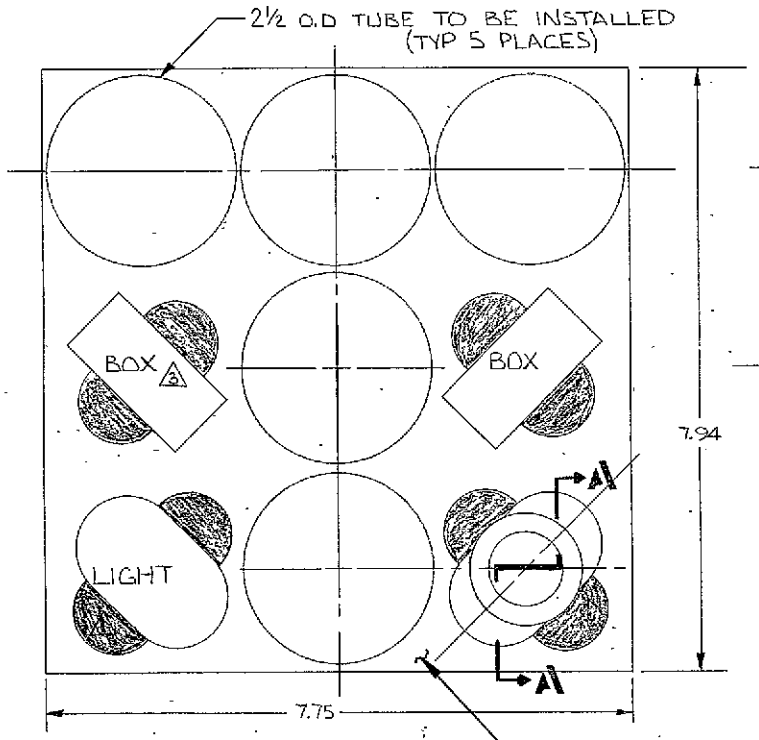
RAYTHEON COMPANY
FOUR OFFICE BOX 179, DENVER, COLORADO

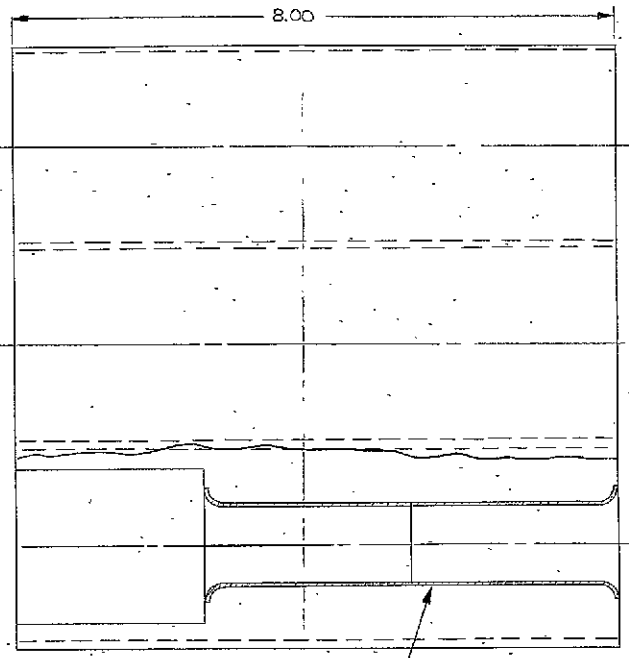
SLIDE TUBE ASSY
ASTRONAUT TOOL KIT

SIZE	CODE IDENT NO.	RES 31659
C	04236	
SCALE 1/1		SHEET 5 OF 6

FOLDOUT FRAME 1

FOLDOUT FRAME 2





4 ALL ITEMS RETAINED BY ETHAFOAM TO BE FLUSH.

3 BOX DIMENSIONS 1×2×3 IN

2 HOLE MAY BE SEARED TO FORM RIGID TUNNEL REPLACING TUBE

NOTE 1 SHADED AREAS DENOTE 2.00 IN DEEP FINGER CAVITIES

DIMENSIONING PER MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
AND ARE AFTER PLATING
TOLERANCES ON:
FRACTIONS ±1/32 | DECIMALS .X ±.1 | .XX ±.03 | .XXX ±.010 | ANGLES ±1/2°
MACHINED SURFACES
REF MIL-STD-10
MIL-1-8700 STATUS
INTERCHANGEABLE
REPLACEABLE
UNCONTROLLED
DRAWN BY | DEPT | DATE
CHECKER
STRESS ENGR
RT ENGR
MATL ENGR
RELIABILITY
QR ENGR
PROJECT
CUST APPRVTV

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

FRONT PANEL INSERT
ASTRONAUT TOOL KIT

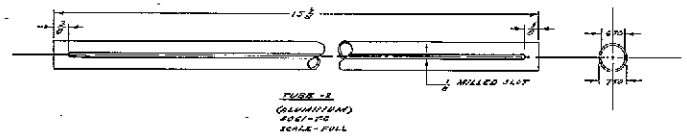
SIZE 04236 | CODE IDENT NO | RES 31659
SCALE 1/1 | SHEET 6 OF 6

FOLDOUT FRAME 1

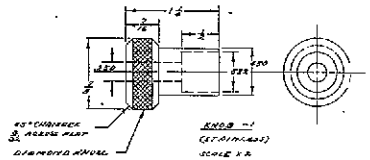
FOLDOUT FRAME 2

GENERAL NOTES

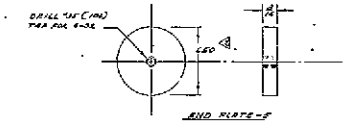
1. LOCATION OF ASSEMBLY MOVED FROM UPPER FRONT CORNER TO LOWER FRONT CORNER OF CABINET
2. MEASURE TUBE 10 AND ADJUST DIA FOR PRESS FIT



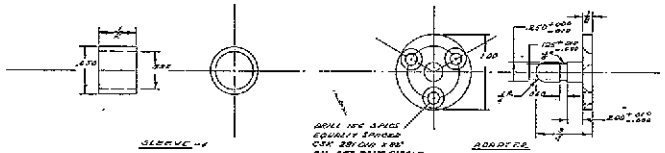
TUBE -8
(ALUMINUM)
6061-T6
SCALE - FULL



KNOB -1
(STAINLESS)
SCALE 1:1

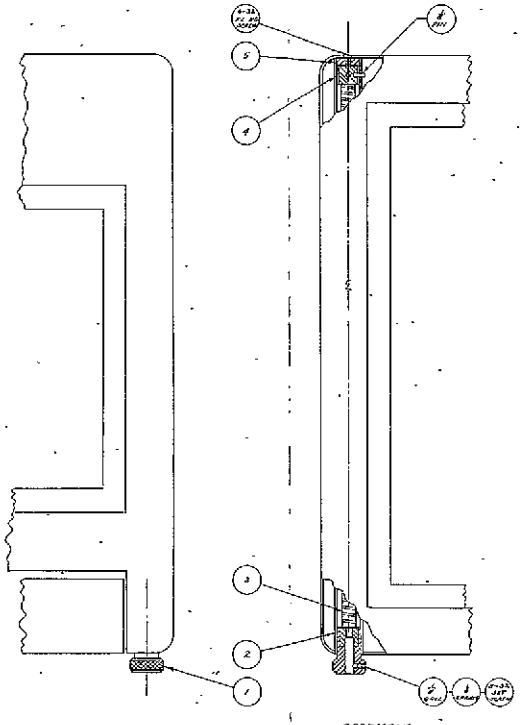


END PLATE -F
(ALUMINUM)
6061-T6
SCALE 1:1

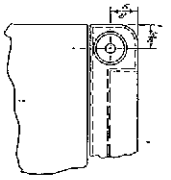


SLEEVE -4
ALUMINUM
SCALE 1:1

BODY CAP
STAINLESS STEEL 303
SCALE 1:1



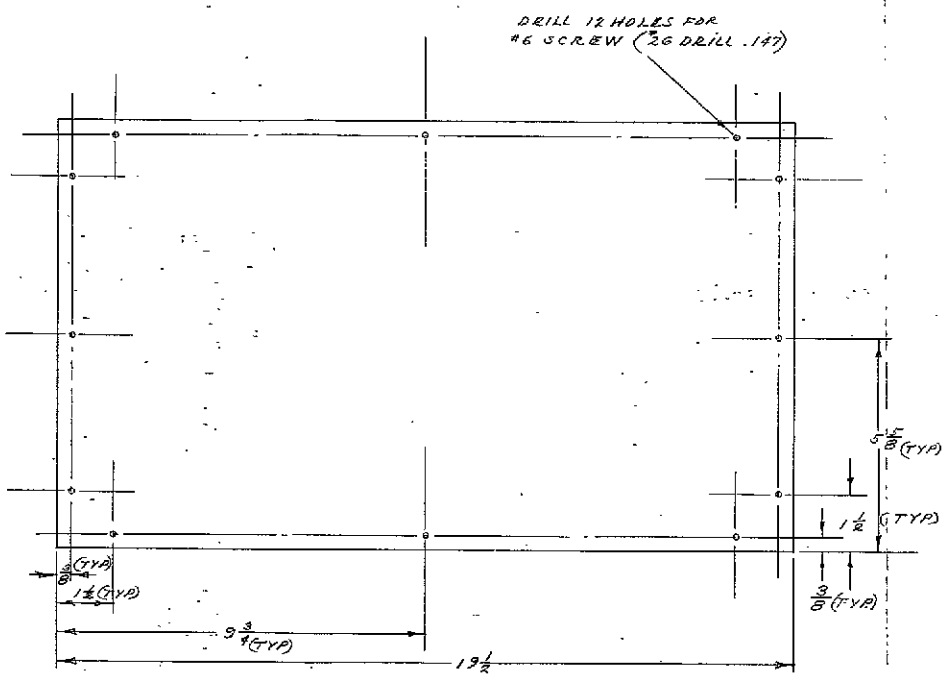
ASSEMBLY
FULL SCALE



FOLDOUT FRAME 2

FOLDOUT FRAME 1

			MARTIN MARIETTA CORPORATION
			PORTABLE LIGHT FLEXIBLE HOSE (ASSEMBLY OF "A" DETAILS)
			84236



MATERIAL: 2024 ALUMINUM

DIMENSIONING REF. MIL-STD-8 UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING TOLERANCES ON: FRACTIONS .X .XX .XXX ANGLES 31/32 .8 .03 .010 31/2° MACHINED SURFACES REF MIL-STD-10 ✓ MIL-I-8500 STATUS INTERCHANGEABLE REPLACEABLE UNCONTROLLED DRN 081658 (10-66)	DRAWN BY DEPT. DATE R CORVELEYN 11/6/69 CHECKER STRESS ENGR WT ENGR MATL ENGR RELIABILITY DR ENGR PROJECT CUST REPRSNTV	MARTIN MARIETTA CORPORATION POST OFFICE BOX 179, DENVER, COLORADO BOTTOM PLATE SIZE CODE IDENT NO. 04236 RES 3.1 661 SCALE 1/2 SHEET	

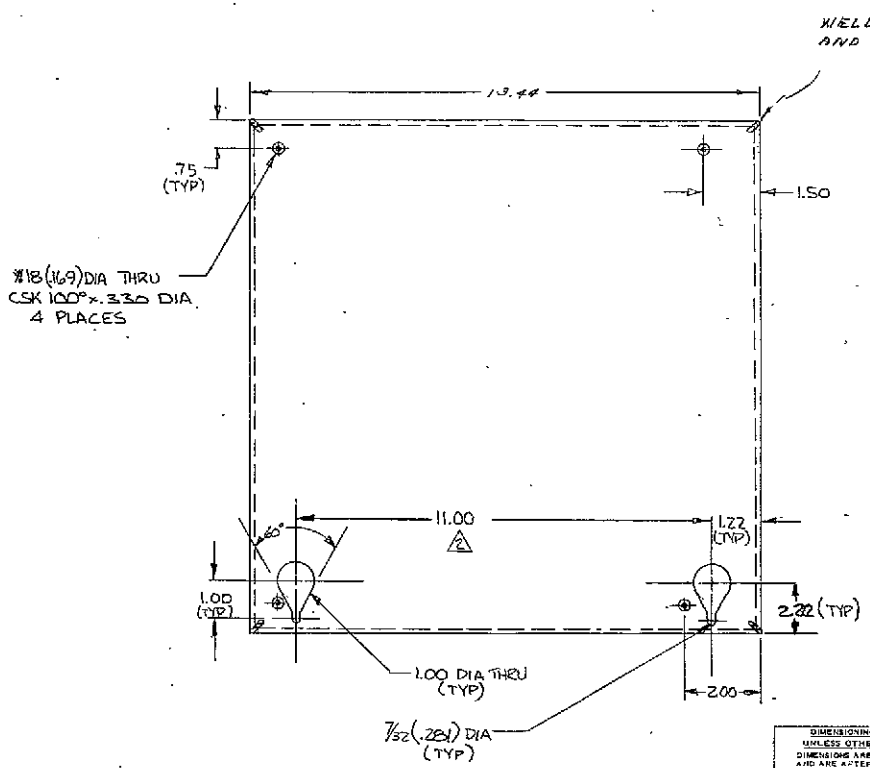
FOLDOUT FRAME 1

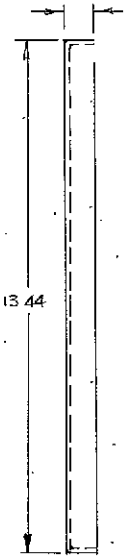
FOLDOUT FRAME 2

GENERAL NOTES:

1 - ALL DIMENSIONS +.00 -.03

2 TO MATCH RES 31658





MATERIAL: 5052 AL. ALLOY .060 THICK

DIMENSIONING REF. MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING
TOLERANCES O/S DECIMALS

FRACTIONS	.X	.XX	.XXX	ANGLES
±1/32	±.1	±.03	±.010	±1/2°

MACHINED SURFACES REF. MIL-STD-10 ✓

MIL-I-8500 STATUS

INTERCHANGEABLE	
REPLACEABLE	
UNCONTROLLED	

DRAWN PCORVELEYN 10/13/69
CHECKER
STRESS ENGR
WT ENGR
MATL ENGR
RELIABILITY
QA ENGR
PROJECT
CUST APPRVTY

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER, COLORADO

END PANEL - LEFT

SIZE A | CODE IDENT NO 04236 | RES 31662

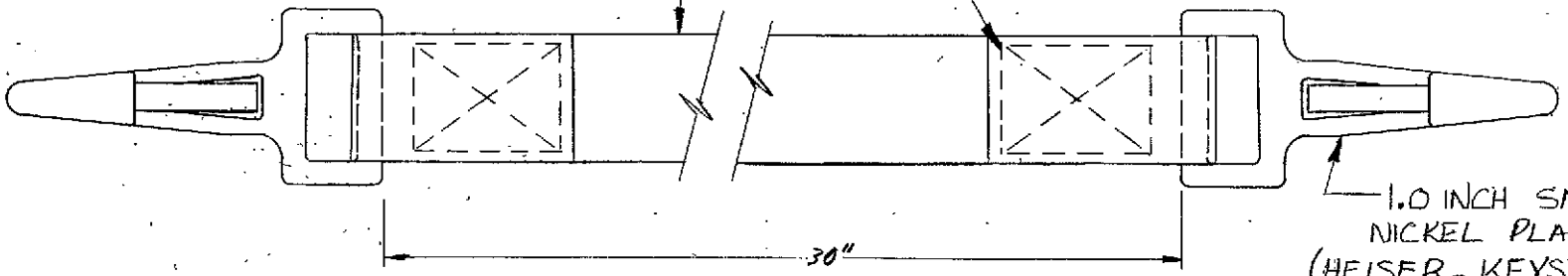
SCALE 1/4 | SHEET

FOLDOUT FRAME 1

FOLDOUT FRAME 2

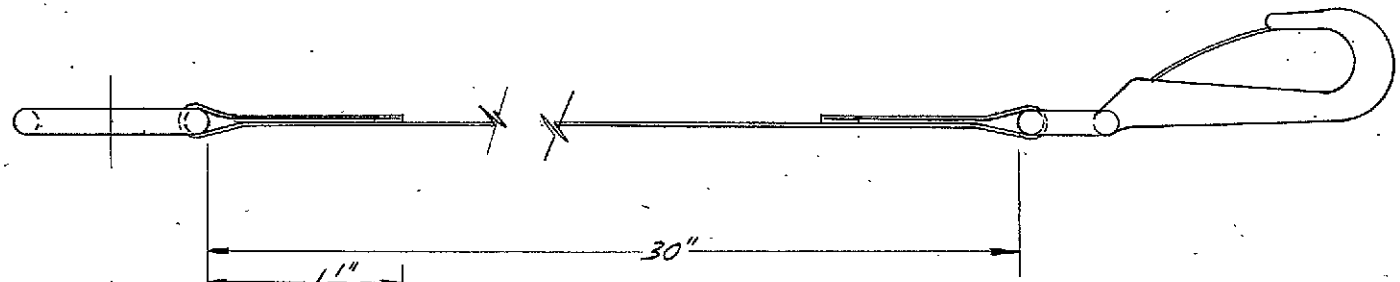
NYLON TAPE PER MIL-T-5038
TYPE III 1" WIDE COLOR NATURAL
(SEAR ENDS PRIOR TO STITCHING)

BOX STITCH WITH E SIZE THREAD 6-10 STITCHES PER INCH, TYPE 301 STITCHING PER FED STD 751 THREAD TYPE I CLASS I PER V.T 295. COLOR TO MATCH FABRIC

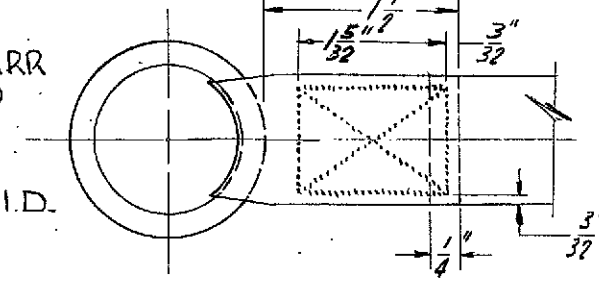


001

1.0 INCH SNAP Nº 200
NICKEL PLATED
(HEISER-KEYSTON 1024
CHEROKEE ST DENVER)



McMASTER CARR
SUPPLY CO. 640
WEST LAKE ST.
CHICAGO
Nº S 3564 1.0 I.D.



002

R. BELLESS 11/6/69

CHECKED
STRESS ENGR
WT ENGR
MATL ENGR
RELIABILITY
QR ENGR
STRUCT

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER, COLORADO

TETHER
ASTRONAUT TOOL KIT

B 04236 RES 31663

SCALE FULL SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

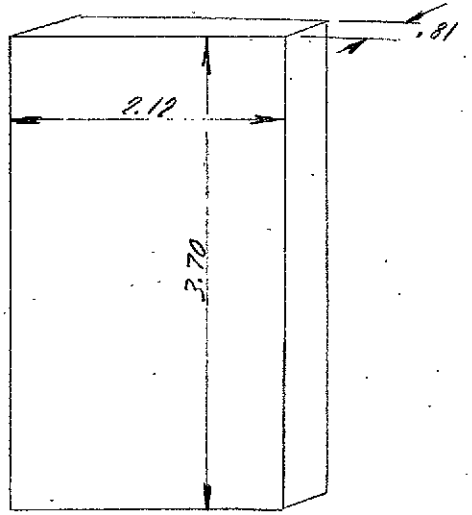
BATTERY POWER SUPPLY INFO

I. ASSUMPTIONS

A. MULTIMETER - 5 WATTS
B. MS & DU - 30 WATTS
C. TWO LIGHTS - 12 WATTS
D. POWER - 28 v.D.C
E. BATTERY TYPE - NICKEL CADMIUM, HERMETICALLY SEALED, RECHARGEABLE, 1.25 v CELLS.

F. START WITH SIX CELLS OF GULTON INDUSTRIES, INC., P/N 804322, TYPE VOG-HS, NOMINAL CAP. AMP-HR = 6, INTERN. RESISTANCE OF 0.006 OHMS (CATA. DTD. AUG. '66, AS USED BY SPACE POWER LAB, REF. CHAS. BROOK)

G. CELL CONFIGURATION:

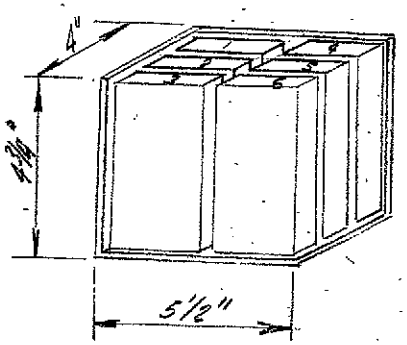


GENERAL NOTES

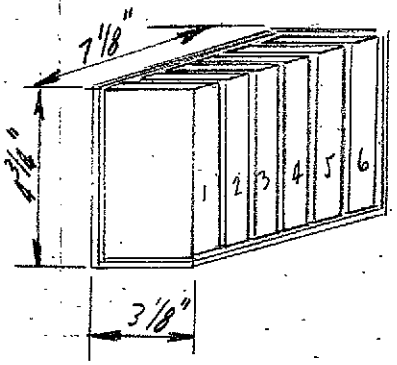
1. DIMENSIONS ARE OVERALL

H. POSSIBLE 6-CELL BATTERY ASSEMBLIES

CONFIGURATION -1



CONFIGURATION-2



WEIGHT: APPROX. 4#

FOLDOUT FRAME 2

R BELLESS 10/31/69

MARTIN MARIETTA CORPORATION

TEST KIT BATTERY

ASTRONAUT TOOL KIT

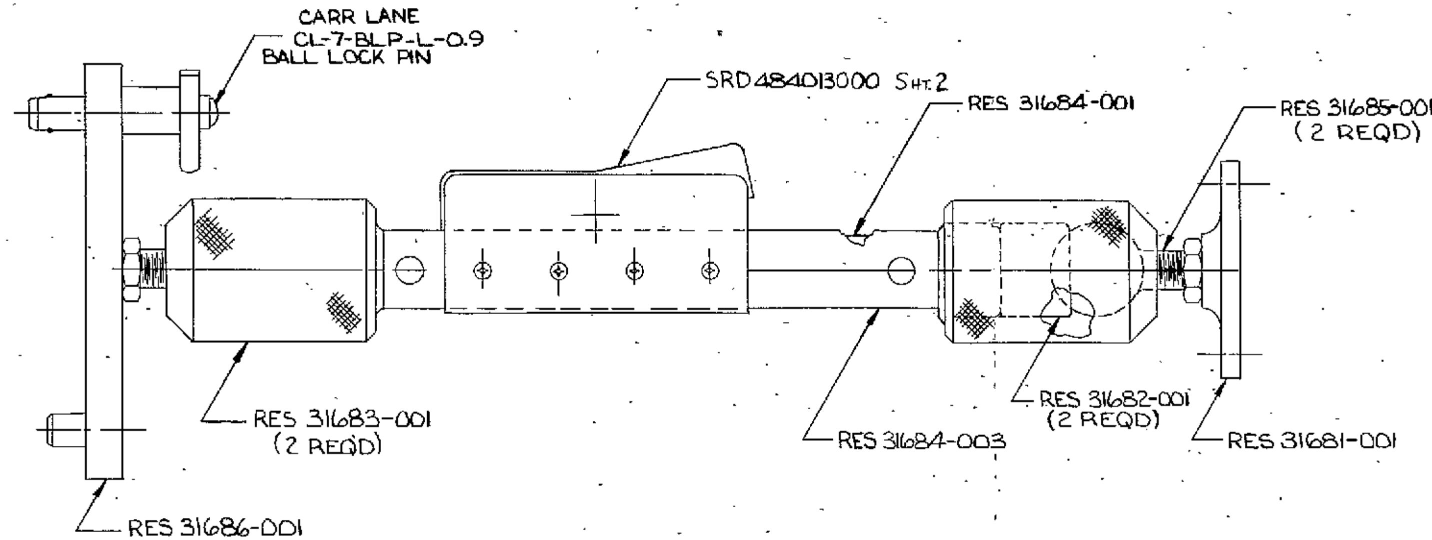
B 04231

RES 31669

SCALE NONE

SHEET 1 OF 1

FOLDOUT FRAME 1



QUANTITY/DASH NO	PART NO	ZONE	SEQ ITEM	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	MATERIAL SPECIFICATION	FINISH OR MFR CODE
	-001			BOOM ASSY				

LIST OF MATERIAL

DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING
TOLERANCES ON: FRACTIONS ± 1/32; DECIMALS .X ± .1, .XX ± .03, .XXX ± .010; ANGLES ± 1/2°

MACHINED SURFACES REF - MIL-STD-10 ✓

DRAWN BY: J. Jowells DEPT: 1646 DATE: 1-12-69

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

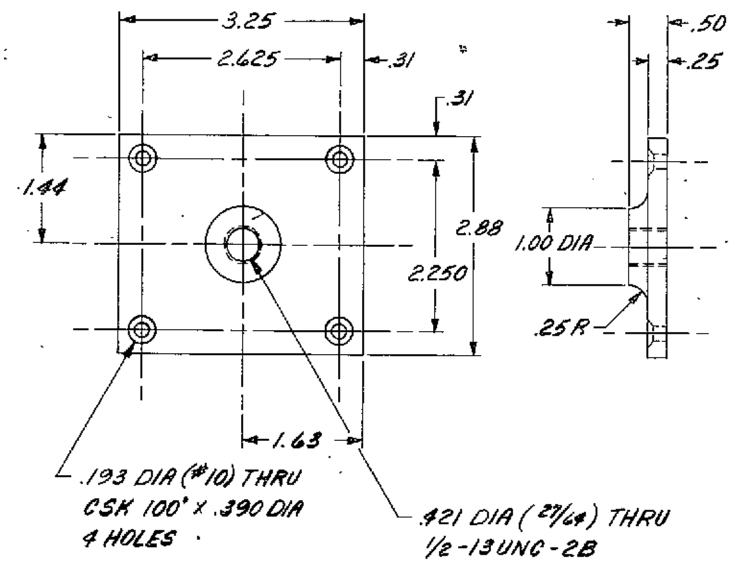
BOOM ASSY,
TELESCOPIC BOOM
ASTRONAUT TOOL KIT

SIZE: C | CODE IDENT NO: 04236 | RES 31680

SCALE: 1/1 | SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2



-001 (SHOWN)
-003 (OMIT 1.00 DIA BOSS)

QUANTITY/DASH NO.	PART NO.	ZONE	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	MATERIAL SPECIFICATION	CHG
	-003		PLATE	.25 THK PLATE	2024-T4 OR EQUIV.		
	-001		PLATE	.50 THK PLATE	2024-T4 OR EQUIV.		

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING
MACHINED SURFACES 125

DRAWN: [signature] DEPT 1600 DATE 1-6-70

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

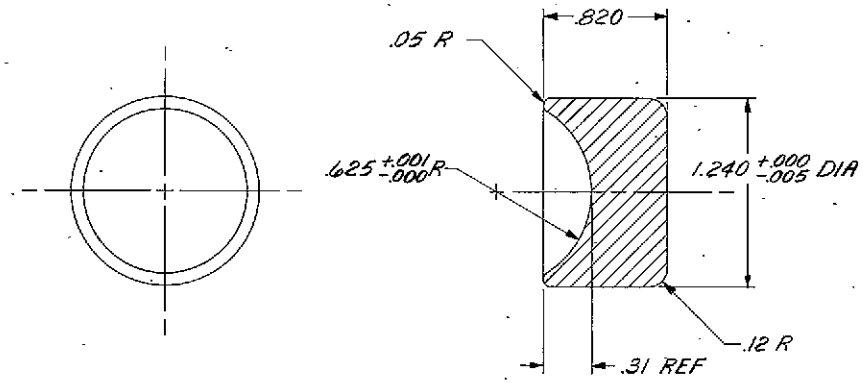
PLATE, MTG - TELESCOPIC BOOM, ASTRONAUT TOOL KIT

SIZE C | CODE IDENT NO. 04236 | RES 31681
SCALE 1/1 | SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED



QUANTITY/DASH NO.	PART NO.	ZONE	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	TRADE CHNG	MATERIAL SPECIFICATION	FINISH OR MFR CODE	CHG
	-001		SEAT	1.25 DIA ROD	BRASS		FREE CUTTING		

ODD DASH NO SHOWN — EVEN DASH NO OPP — LIST OF MATERIAL

EFFECTIVE ON	CALC WT	DASH NUMBER	NEXT ASSY	USED ON	FINAL ASSY	TEST
			APPLICATION		QTY REQD	

DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
AND ARE AFTER PLATING
TOLERANCES ON:

FRACTIONS	DECIMALS X	DECIMALS XX	DECIMALS XXX	ANGLES
± 1/32	± .1	± .03	± .010	± 1/2°

MACHINED SURFACES 63
REF: MIL-STD-10

MIL-1-8500 STATUS

DRAWN	DEPT	DATE
S. Engel	1640	1-7-70

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

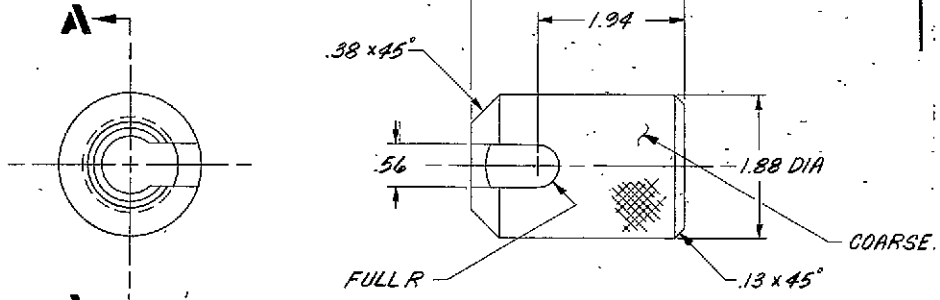
SEAT, LOCKING - TELESCOPIC BOOM ASTRONAUT TOOL KIT

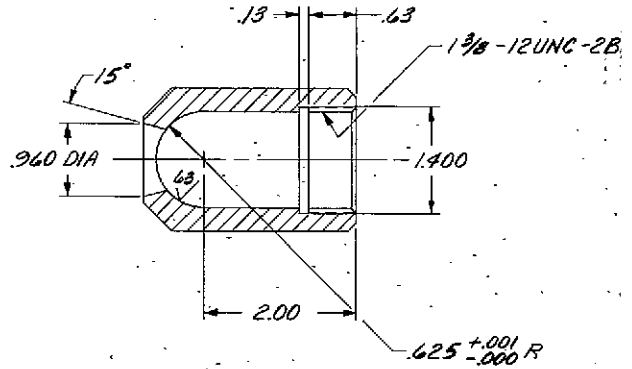
SIZE	CODE IDENT NO	
C	04236	RES 31682
SCALE 2/1		SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED





SECTION A-A

QUANTITY/DASH NO.	PART NO	ZONE	REV SYM	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	ISSUE CODE	MATERIAL SPECIFICATION	FINISH OR MFR CODE	CHG
	-001			SEAT	2.00 DIA ROD	2024-T4 OR EQUIV				

ODD DASH NO SHOWN — EVEN DASH NO. OFF — LIST OF MATERIAL

EFFECTIVE SER	CALC WT	WORK INVOICE	NEXT ASSY	USED ON	FINAL ASSY	TEST
			APPLICATION		QTY REQD	

DIMENSIONING PER MIL-STD-9
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
AND ARE AFTER PLATING
TOLERANCES ON:
FRACTIONS ± 1/32 | DECIMALS .X ± 1 | .XX ± .03 | .XXX ± .010 | ANGLES ± 1/2°
MACHINED SURFACES 125
REF: - MIL - STD - 9
MIL - 1 - DASH STATUS
INTERCHANGEABLE
REPLACEABLE
SUBSTITUTABLE

T. Boyle 1640 1-7-70

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER COLORADO

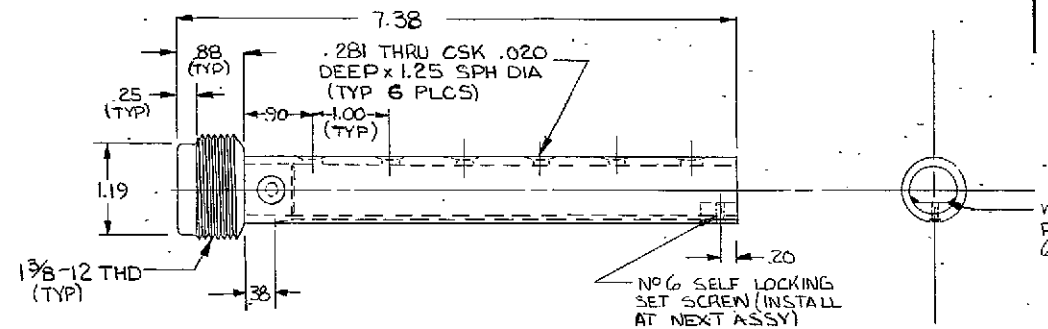
SEAT, BALL -
TELESCOPIC BOOM
ASTRONAUT TOOL KIT

SIZE	CODE IDENT NO.	DWG NO.
C	04236	RES 31683
SCALE 1/1		SHEET 1 OF 1

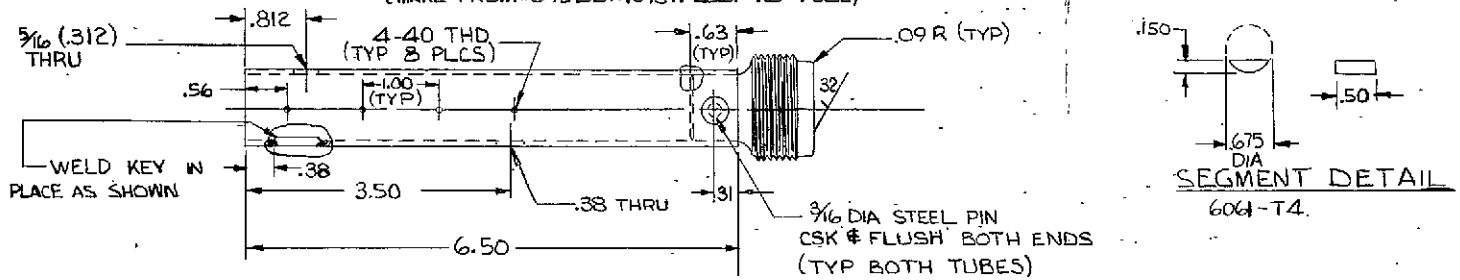
FOLDOUT FRAME

FOLDOUT FRAME 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED

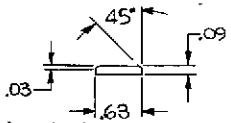


-001 TUBE
(MAKE FROM .875 OD x .093 W 6061 T6 TUBE)



SEGMENT DETAIL
6061-T4.

-003 TUBE
(MAKE FROM 1.00 OD x .063 W CRES TUBE)



KEY DETAIL
.125 WIDE CRES

QUANTITY/DASH NO.	PART NO	ZONE	SER SYM	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	ITEM CONG	MATERIAL SPECIFICATION	FINISH OR MFR CODE	CHG
	-003			TUBE ASSY				304 CRES		
	-001			TUBE ASSY				6061-T6		

ODD DASH NO SHOWN — EVEN DASH NO. OFF — LIST OF MATERIAL

EFFECTIVE SN	CALC WT	DASH NUMBER	NEXT ASSY	USED ON	FINAL ASSY	TEST
			APPLICATION		QTY REQD	

DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
AND ARE AFTER PLATING
TOLERANCES ON
FRACTIONS ± 1/64 — DECIMALS .X ± .1 — .XX ± .03 — .XXX ± .010 — ANGLES ± 1/2°
MACHINED SURFACES 125
REF: MIL-STD-10
MIL-1-8060 STATUS
INTERCHANGEABLE
REPLACEABLE
UNCONTROLLED

DRAFTSMAN J Dowells — CHECK 1640 — DATE 1-9-70
DESIGN
STRESS ENGR
WT ENGR
RAEL ENGR
RELIABILITY
MFG ENGR
PROJECT
QUALITY

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER COLORADO

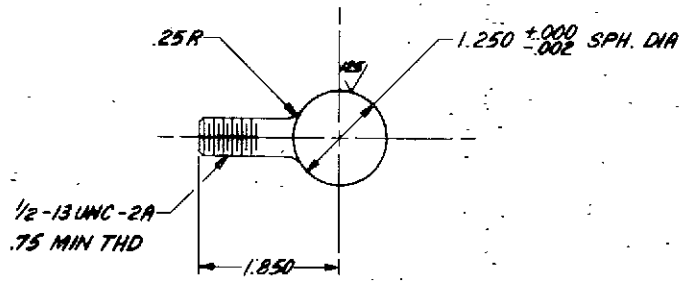
TUBE
TELESCOPIC BOOM
ASTRONAUT TOOL KIT

SIZE	CODE IDENT NO.	
C	04236	RES 31684
SCALE 1/1		SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS				
ZONE	REVISION		DATE	APPROVED



QUANTITY/DASH NO	PART NO.	ZONE	REVISION	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	LABOR CODE	MATERIAL SPECIFICATION	FINISH OR REF. CODE	CHG
	-001			BALL	1¼ DIA ROD	4130 STL				

ODD DASH NO. SHOWN — EVEN DASH NO OPP — LIST OF MATERIAL

EFFECTIVE ON	CALC WT	DASH NUMBER	NEXT ASSY	USED ON	FINAL ASSY	TEST
			APPLICATION -		QTY REQD	

DIMENSIONING REF MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING
TOLERANCES ON:

FRACTIONS	DECIMALS .X	DECIMALS .XX	DECIMALS .XXX	ANGLES
± 1/32	± .1	± .03	± .010	± 1/2°

MACHINED SURFACES
REF: MIL-STD-10 ✓

MIL-1-8500 STATUS
INTERCHANGEABLE
REPLACEABLE
UNCONTROLLED

DRAWN K. Boyle DEPT 1640 DATE 1-6-70
DIVISION
STRESS ENGR
WT ENGR
MATL ENGR
RELIABILITY
HR ENGR
PROJECT
QUAL SPECIALTY

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER COLORADO

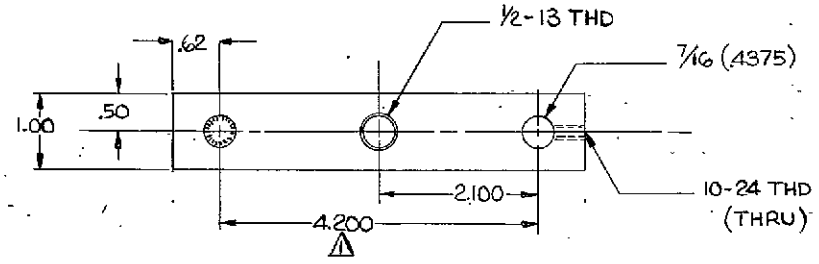
BALL - TELESCOPIC BOOM, ASTRONAUT TOOL KIT

SIZE	CODE IDENT NO	
C	04236	RES 31685
SCALE 1/1		SHEET 1 OF 1

FOLDOUT FRAME

FOLDOUT FRAME

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED



PRESS .420 DIA PIN &
WELD IN PLACE AS SHOWN
(6061-T6)

QUANTITY/ASSY NO.	PART NO.	ZONE	SUB SYS	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	SPEC CODE	MATERIAL SPECIFICATION	FINISH OR APP CODE	CMR
1	-001			PLATE ASSY	.50 THK PLATE	6061-T6				

ODD ASSY NO. SHOWN — EVEN ASSY NO. OFF — LIST OF MATERIAL

DRAWN BY J Daniels 1640 1-7-70

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179, DENVER, COLORADO

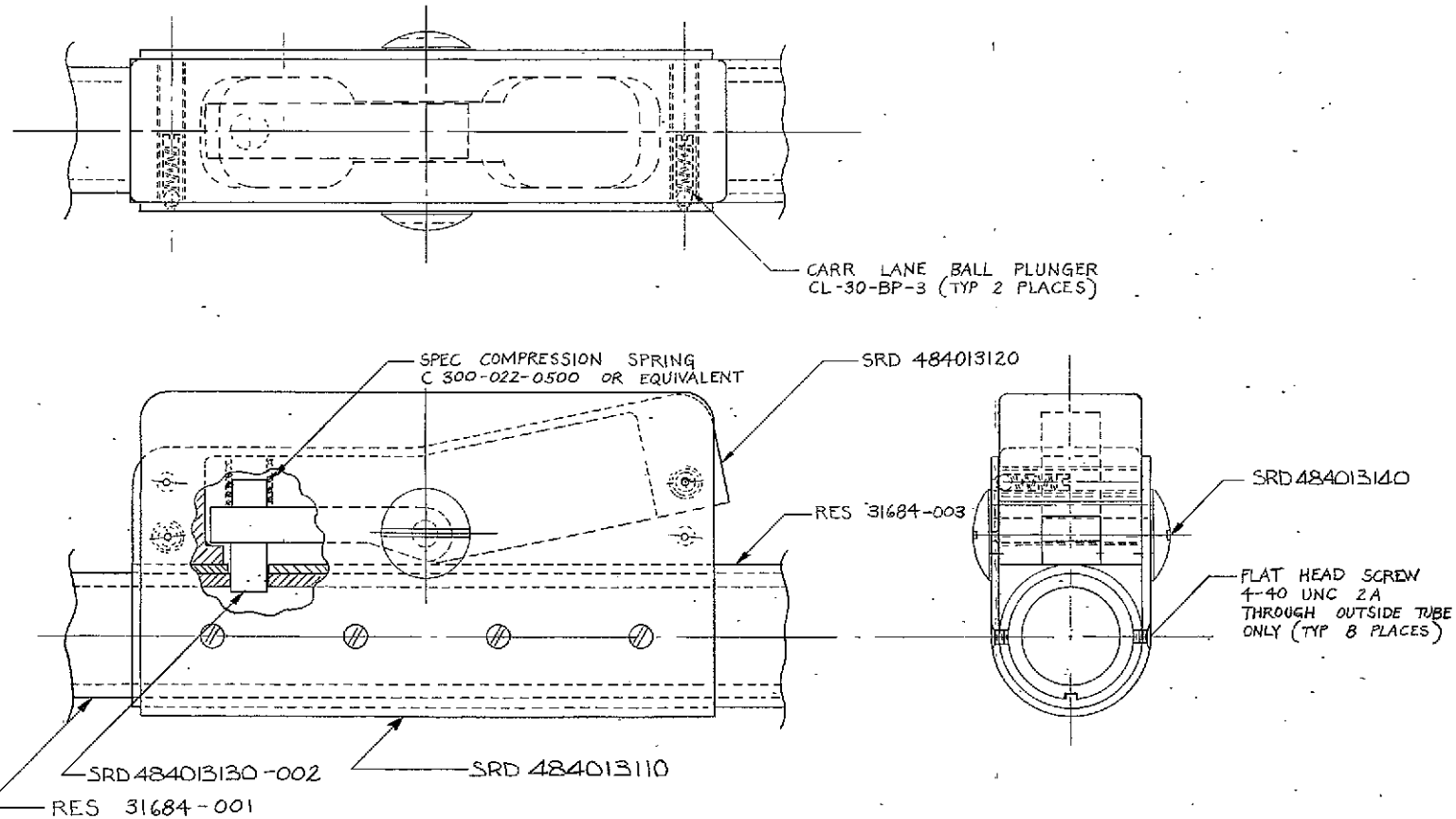
ANCHOR PLATE ASSY
TELESCOPIC BOOM
ASTRONAUT TOOL KIT

SIZE	CAGE SHEET NO.	
C	04236	RES 31686

SCALE 1/1 — SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

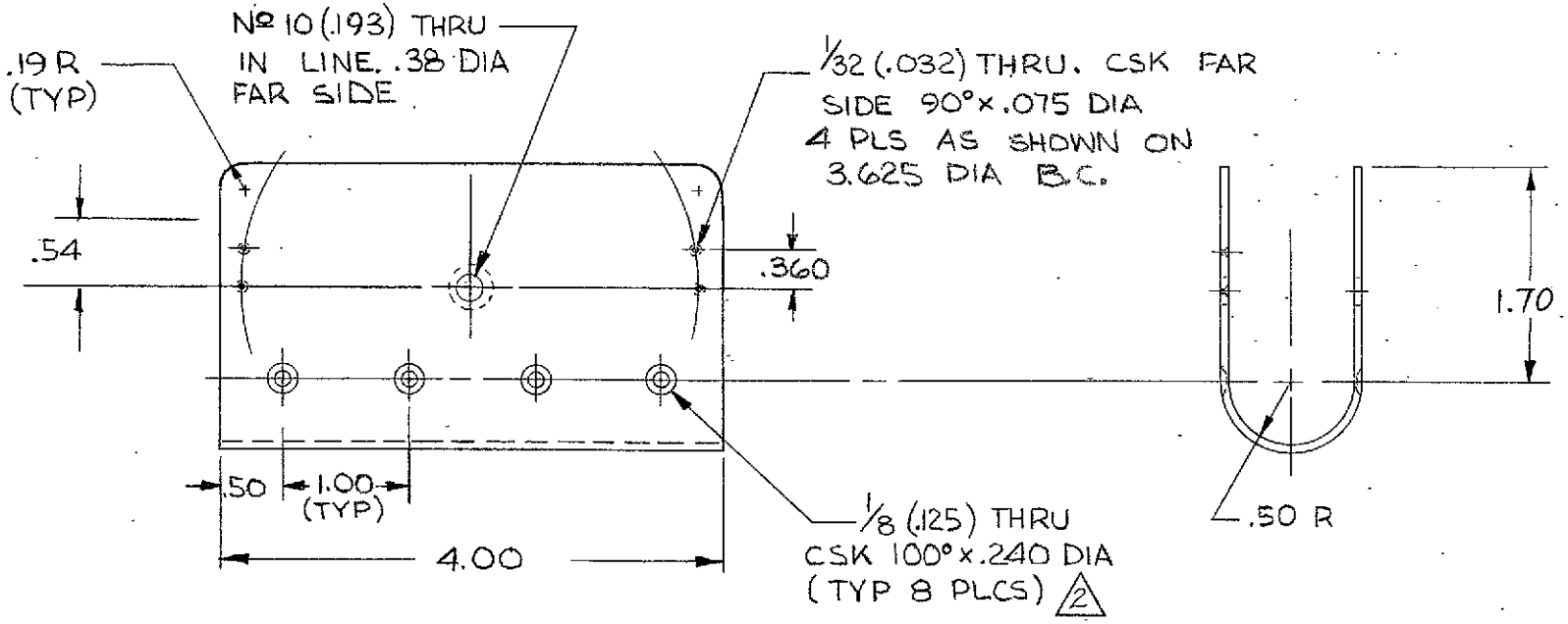


TELESCOPIC ADJUSTMENT

DIMENSIONING REF MIL-STD-8 UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING. TOLERANCES ON DECIMALS: FRACTIONS ±1/32, .X ±.1, .XX ±.03, .XXX ±.010, ANGLES ±1/2°. MACHINED SURFACES REF MIL-STD-10 ~√. MIL-I-4800 STATUS: INTERCHANGEABLE / REPLACEABLE / UNCONTROLLED. DEN 05836 (10-68)	DRAWN B.J. BUELL DEPT 1640 DATE 1-22-70	CHECKED		MARTIN MARIETTA CORPORATION, POST OFFICE BOX 179 DENVER, COLORADO	
	STRESS ENGR	WT ENGR	MATL ENGR	RELIABILITY	QR ENGR
	PROJECT	CUST APPRVTY		BOOM ASSEMBLY	
				SIZE:	CODE IDENT NO: 04236
				SCALE 2/1	SHEET 2 OF 2
					SRD 484013000

FOLDOUT FRAME 1

FOLDOUT FRAME 2



FOLDOUT FRAME 2

J Howells 1640 1-29-70

FOLDOUT FRAME 1

3. QUANTITY REQD 1 EACH

2 TO MATCH SRD 484013090 TUBE

1. MAT'L ~301 CRES FULL HARD

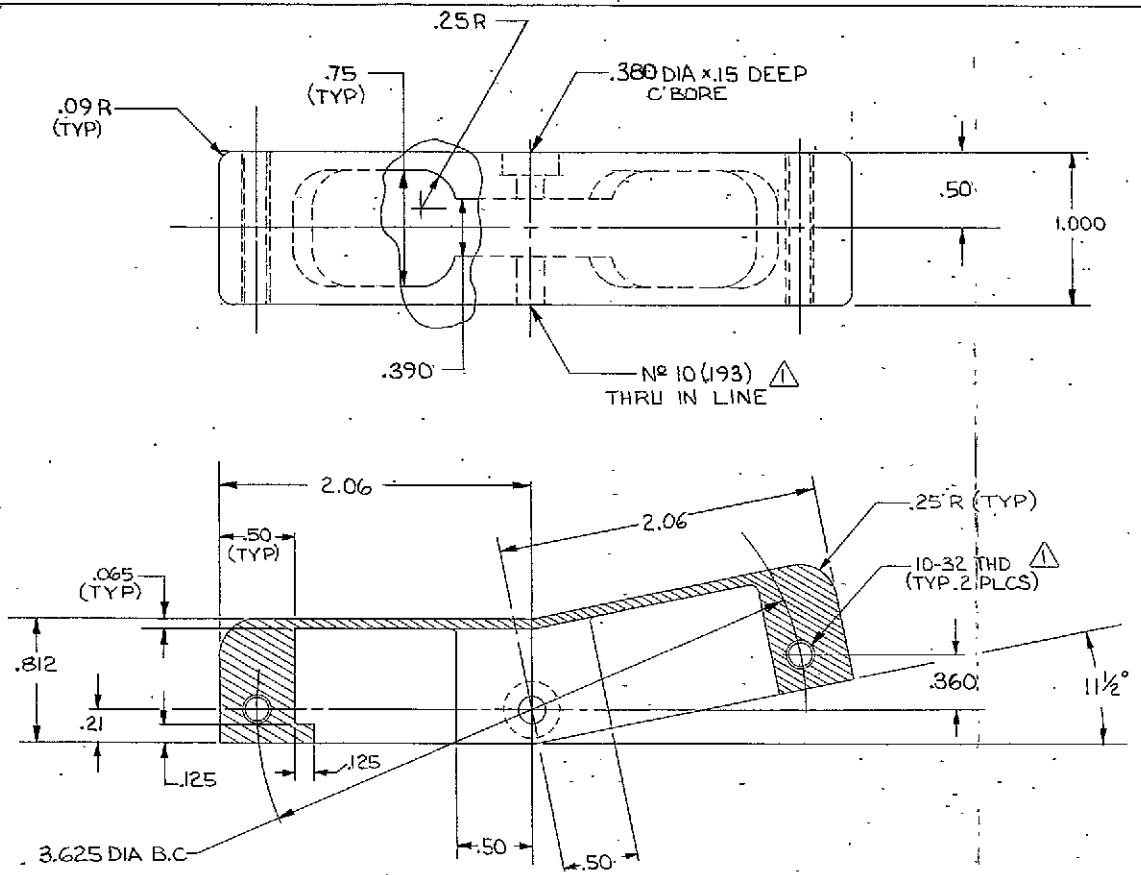
125/

HANDLE, TELESCOPIC ADJ.
BOOM ASSEMBLY

B 04236 SRD 484013110

1/1

1 OF 1



NOTES ⚠ TO MATCH SRD 484013110 HANDLE

2. MAT'L 2024-T4 OR EQUAL

3. QUANTITY REQ'D ~ 1 EACH

J. Uewells 1040 2-2-69

125

MARTIN MARIETTA CORPORATION

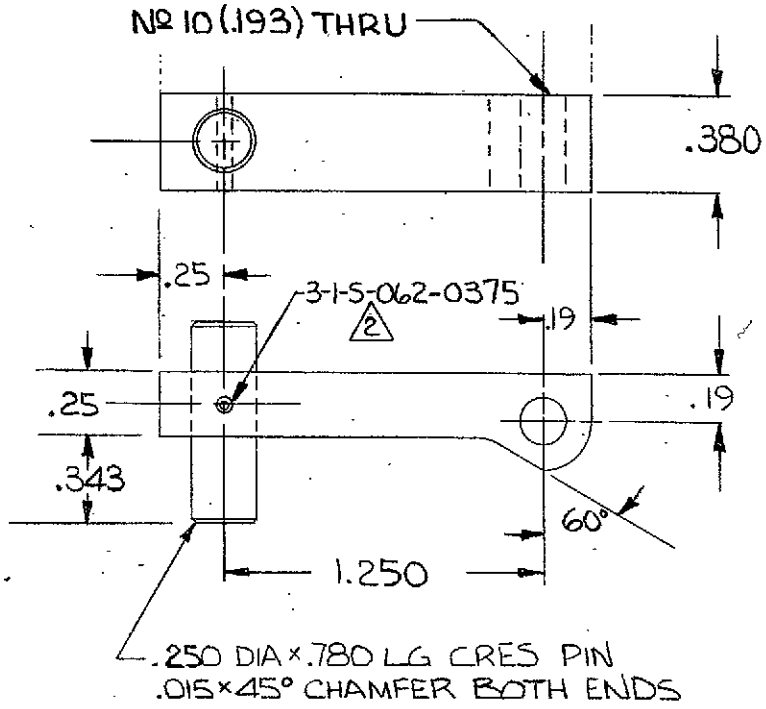
LEVER, TELESCOPIC ADJ. BOOM ASSEMBLY

C. 04236 SRD 484013120

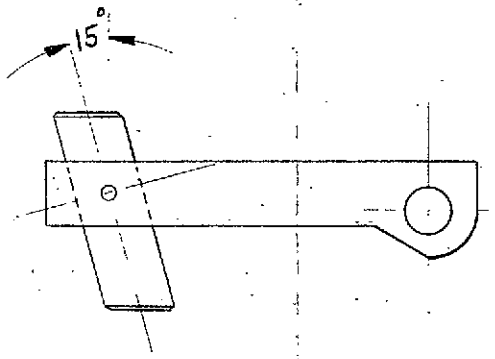
SCALE 2/1 SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2



– 001



– 002

(SAME AS -001 EXCEPT AS NOTED)

FOLDOUT FRAME 2

J Vowells 1640 1-28-70

3. QUANTITY REQD 1 EACH

2 SEL LOK SPRING PIN, PRECISION FASTENER DIV. PRESSED STEEL CO.

1. MAT'L 304 CRES STEEL.

NOTES : FOLDOUT FRAME 1

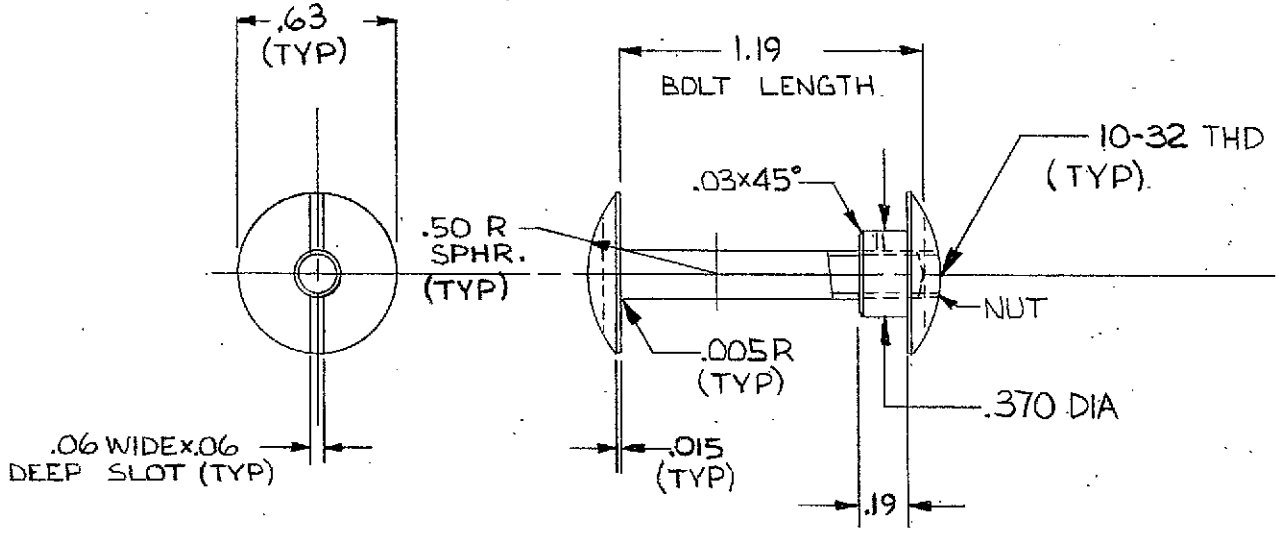
125

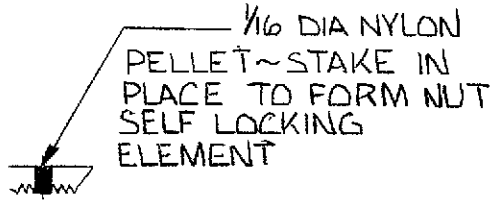
LOCKING PIN, TELESCOPIC ADJ. BOOM, ASSEMBLY

B 04236 SRD 48401330

1/1

1 OF 1





J. Jowells 1640 2-2-70

MARTIN MARIETTA CORPORATION

BOLT ASSY. SPECIAL
BOOM ASSEMBLY

B 04235 SRD 484013140

2/1 1 OF 1

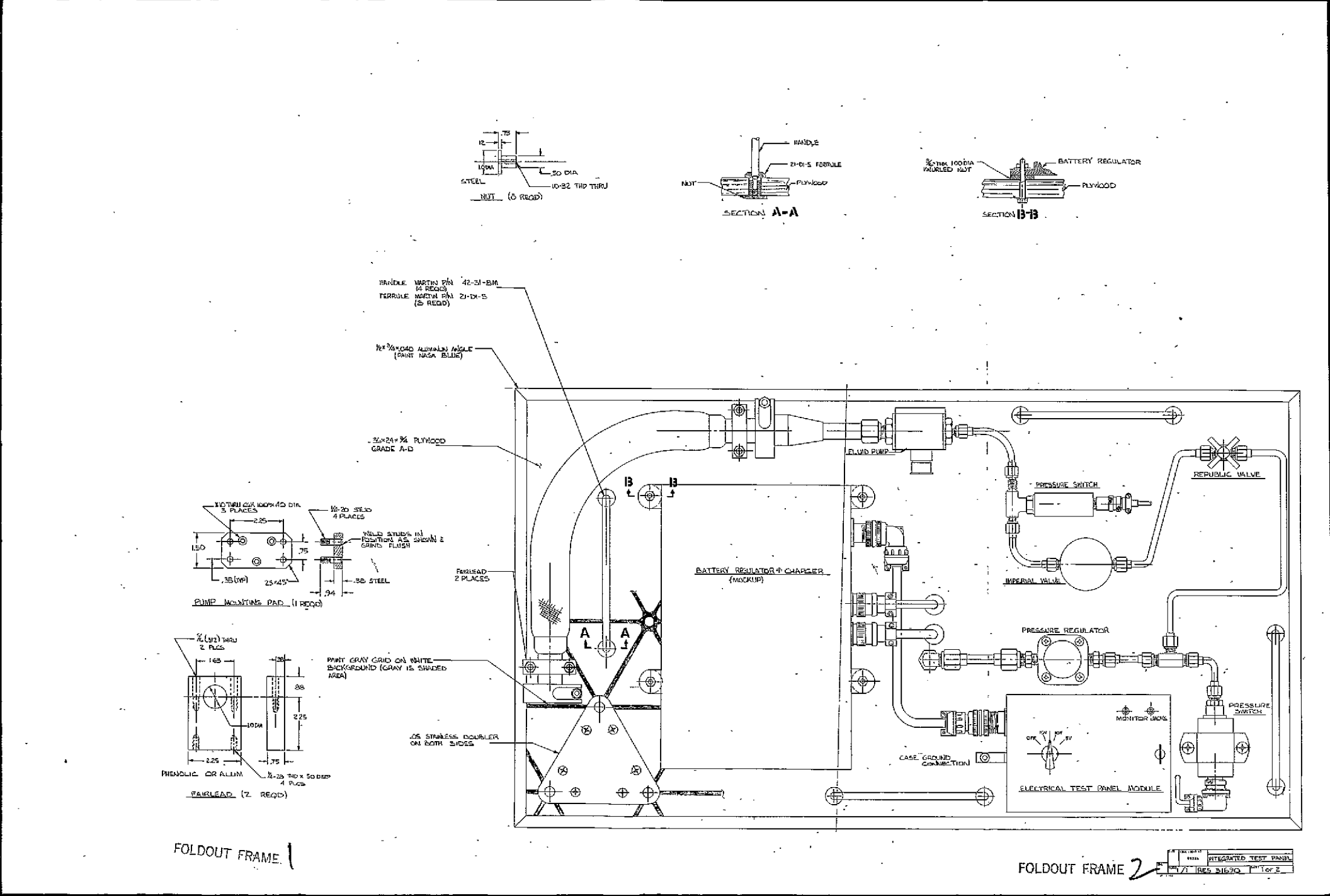
2. QUANTITY REQD 1 EACH

1. MAT'L ~ 304 CRES.

NOTE FOLDOUT FRAME 1

125

FOLDOUT FRAME 2



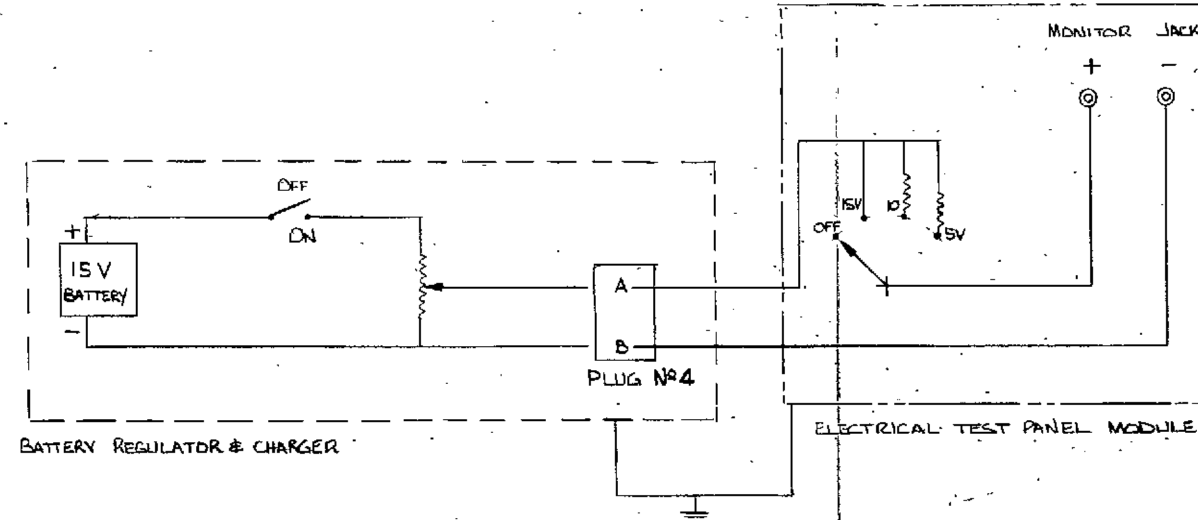
FOLDOUT FRAME 1

FOLDOUT FRAME 2

		INTEGRATED TEST PANEL	
	1/1	RES 31690	1 of 2

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVED



LIST OF MATERIAL

DIMENSIONING PER MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND ARE AFTER PLATING
TOLERANCES ON:

FRACTIONS	.X	.XX	.XXX	ANGLES
±1/32	±.1	±.03	±.010	±1/2°

DRAWN BY: J. Vowells 1640 1-14-69

MARTIN MARIETTA CORPORATION
POST OFFICE BOX 179 DENVER COLORADO

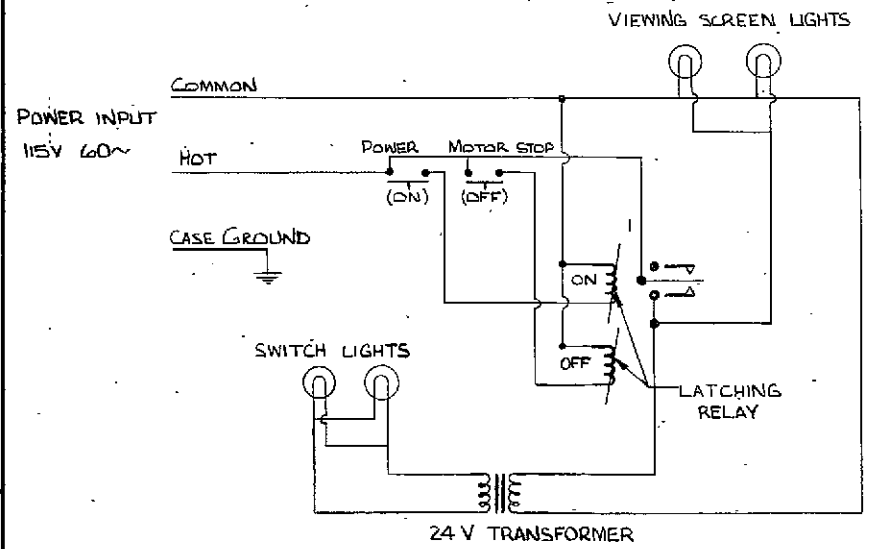
SCHEMATIC, ELECTRICAL
INTEGRATED TEST PANEL

SIZE: C | CODE IDENT NO. 04236 | RES 31690

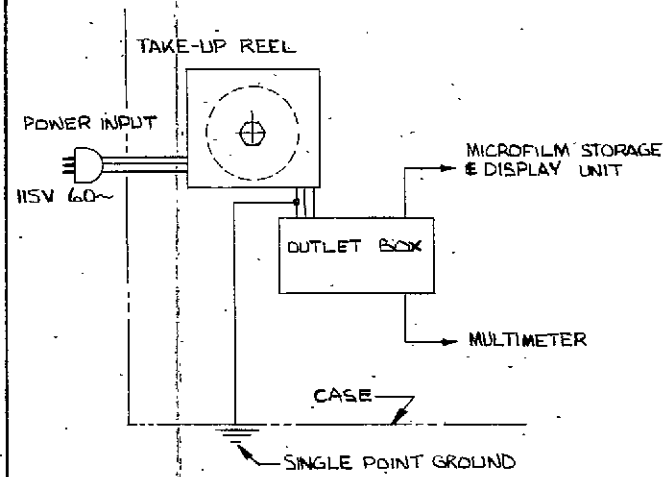
SCALE: ~ | SHEET 2 OF 2

FOLDOUT FRAME 1

FOLDOUT FRAME 2



MICROFILM STORAGE & DISPLAY UNIT
(MOCK-UP)



TEST KIT
(MOCK - UP)

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVED

LIST OF MATERIAL

QUANTITY/EACH REQ.	PART NO.	ZONE	DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	MATERIAL SPECIFICATION	CAGE CODE	DWG
EACH ASSY NO. ASSIGNED	EACH ASSY NO. USED							

J. Uscilla 1-12-69

POST OFFICE BOX 179, DENVER, COLORADO

SCHEMATIC, ELECTRICAL
ASTRONAUT TOOL KIT

SIZE	CAGE IDENT NO.	RES 31665
C	04236	
FINISH NONE		SHEET 1 OF 1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

APPENDIX B

DEVELOPMENT PHASE DOCUMENTATION

1. B-I. Inflight Maintenance Requirements.(10 pages)
2. B-II. Tool Selection List. (4 pages)
3. B-III. Summary of Maintenance Support Requirements and Priorities. (3 pages)

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 7-31-69

Subsystem/Equipment	Fail. Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
A. ENVIRONMENTAL CONTROL (ECS) A.1 Life Support									
a. Quick Disconnect - MDA Find No. E2001 - Fails to Disconnect.	.5	II	Fair	Unsch	One crewman must attempt physical disconnection of coupling. MDA docking tunnel must be pressurized. Vented, full pressure IVA suit used. Tunnel entry made from CM side. Assumed failure mode: fails to disconnect. If physical disconnection cannot be effected, disassembly or replacement actions may be necessary.	.8 Hr or 1.5 Hr	1 or 2	Visual isolation; monitoring not required. System activation provides retest. Tools that may be required incl. open-end wrenches, large crescent wrench, screwdrivers, pliers, drift punch, soft face hammer, portable light, parts holder and spare parts stowage provision. One spare E2001 QDIS assy. should be spared. Simple instructions needed; no supplies required.	1. 10M30899-B 2. ED2002-850-1
b. O_2 & N_2 Filter - CM Find No. E5111 - Clogged.	.1	III	Fair	Sch	One crewman performs time scheduled replacement of filter element. Shutoff valves provide system isolation. Performed in press. portion of CM. Access panel removal required.	.8 Hr	1	Tools incl. screwdriver, open-end wrenches, portable light, parts holder, and spare parts stowage. One spare element required. No instructions or supplies are needed. Post-maint. test not required.	1. 10M30899-1 2. SS-3414 3. ED2002-756
c. Cabin Press. Transducer - MDA Find No. E2065 - Mech. Failure, Erroneous Output.	1.0	III	Good	Unsch	One crewman replaces transducer. Isolation needed to distinguish between faulty and backup XDCR. Performed in pressurized atmosphere.	1.0 Hr	2	Elect disconnect or short each of two XDCR's to isolate faulty one. Replace using wire cutters, pliers, ratchet & socket set, parts holder, portable light and spare parts stowage provision. One spare needed, no supplies, and simple instructions.	1. 10M30899-1 2. SS-3414 3. ED2002-756
d. Cabin Ventilation Fan - AM & MDA Find No's. E2016 & E1255 - Fails to Operate.	8.3	III	Good	Unsch	One crewman replaces obviously failed fan. Reactivate elect. circuit to retest. Performed in press. atmosphere.	.8 Hr	1	Tools incl. screwdriver, wire cutters, pliers, box-end wrenches, ratchet and socket set, parts holder, portable light & spare parts stowage. One spare needed, no supplies, and simple instructions.	1. 10M30899-1 2. SS-3414 3. ED2002-756 4. ED2002-850-1 5. Apollo 8 and 9 Failure
e. Flexible Ventilation Duct - MDA Find No's. E2019, E2067 - Accidental Tear or Puncture.	1.0	III	Fair	Unsch	One crewman effects inplace repair. Equip. shutdown may be unnecessary. Leak isolation effected visually. Performed in press atmosphere.	.8 Hr	1	Tools incl. glass mending tape, portable light, supplies stowage provision. No instructions or post maint. test needed.	1. 10M30899-1 2. SS-3414 3. ED2002-756 4. ED2002-850-1
f. O_2 Press. Reg. Assy. - CM Find No's. E5125 & E5149 - Fails Closed (No Output).	6.0	II	Fair	Unsch	One crewman effects replacement. E5126 O_2 flow XDCR assists fault isolation plus shutoff valves. SOV's also enable physical isolation of reg. assy's. for replacement actions. Performed in press atmosphere.	1.5 Hr	3	Tools incl. open and box-end wrenches, socket, & ratchet set, leak detector, portable light, parts holder, spare assy. stowage provision. One spare and detailed instructions needed.	1. 10M30899-1 2. SS-3414 3. ED2002-756 4. ED2002-850-1
g. MOL Sieve Inlet Solids Trap - STS Find No. E1121 - Prohibits Flow.	0.1	III	Good	Unsch	One crewman replaces trap in response to E1228 delta P XDCR indication. No physical isolation problem. Performed in press. atmosphere.	.5 Hr	1	Tools incl. screwdriver, socket & ratchet set, portable light, parts holder and spare parts stowage provision. One spare, no supplies and no instructions.	1. 10M30899-1 2. SS-3414 3. ED2002-756 4. ED2002-850-1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 7-31-69

Subsystem/Equipment	Failure Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
A.1 Life Support h. Cabin Press. Relief & Dump Valve - IM Find No. E3300 - Fails closed.	4.0	Ib	Fair	Unsch	One crewman attempt inplace repair. If remedies do not "fix", replacement may be necessary. E3716 cabin press. XDCR signifies high pressure. Physical isolation of valve is good and facilitates maint. actions. Reactivate system for test. Pressurized cabin atmosphere.	1.5 Hr	3	Open & Box-end wrenches socket & ratchet, temporary cabin press. Plus seal, leak detector, portable light, parts holder, spare assy. stowage provision. One spare, new seals, and detailed instructions needed.	1. 10M30899-B 2. ED2002-850-1 3. SS-3414 4. ED2002-756
i. Waste Water Tank - CM Find No. E5400 - Small ext. leak.	0.5	III	Good	Unsch	One crewman attempt inplace repair. Water in cabin atmosphere signifies leak. Performed in cabin atmosphere.	1.0 Hr	2	Glass mending tape, portable light, supplies stowage provision, foam spray sealer, leak detector, instructions needed.	Same
j. Waste Management System Blower - CM Find No. 14.1 - fails to operate.	3.0	III	Good	Unsch	Same as A.1.d, above.	1.0 Hr	2	Same as A.1.d, above.	Same
A.2 Thermal Control a. Glycol Diverter Valve - CM Find No. E5219 - fails closed.	5.0	II	Fair	Unsch	One crewman effects replacement, E5250 temp. control valve and temp. sensors in SM and temp. transducer in CM enable isolation of fault. SOV's enable physical isolation for circuit disassembly. Reactivate system for test. Pressurized cabin atmosphere.	1.8 Hr	3	Same as A.1.f, above, plus fluid containment device.	Same
b. Glycol Pump (primary) - Part of CM find No. E5217 pump assy. - fails to start or run.	20.0	III	Fair	Unsch	One crewman effects repairs of assy. by replacing faulty pump, E2576 press. XDCR useful to detection and isolation. Secondary glycol system activated during repair cycle. Reactivate system for test. pressurized cabin atmosphere.	2.0 Hr	3	Same as A.1.f, above, plus wire cutters, pliers and fluid containment device.	Same
c. Cabin Air Recirculation Blower - CM Find No. E5401 - fails to operate.	8.3	III	Good	Unsch	Same as A.1.d	1.3 Hr	2	Same as A.1.d, above	Same
d. Cabin Temp. Control Valve - CM Find No. E5255 - fails closed.	6.0	II	Fair	Unsch	Same as A.2.a	1.8 Hr	3	Same as A.1.f, above, plus wire cutters, pliers and fluid containment device.	Same

FOLDOUT FRAME 2

FOLDOUT FRAME 1

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 8-7-69

Subsystem/Equipment	Fail. Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
A. ENVIRONMENTAL CONTROL A.1 Life Support									
k. Compressor - AM Part No. 52-83700-419. Compressor Inoperative.	14.8	II	Fair	Unsch	Perform remove/replace of inoperative compressor. Partial system shutdown required; alt. operation capability exists. Perform in cabin atmosphere. Use system sensing & readout devices to verify system restoration.	1.8 Hr	2	Socket & ratchet set, open & box-end wrenches, wire cutters, pliers, screw-driver, tool and spare part holder, parts holder, detailed instructions and a 5.15 lb. spare part (MDAC recommends one flight spare).	1. SS-3414 2. AM Design Data Book 3. 10M30899-B
1. Hydrogen Gas Removal Equip. - CM - Fails to Work. Lack of Backup Equip. to Detect Level of, and Remove, Fuel-Cell-Generated Hydrogen Gas from Crew's Potable Water Can Lead to Serious Crew Discomfort.	10.0	Ib	Good	Sch	Perform periodic task to obtain and chemically analyze samples of potable water supply. Replace, on as-necessary basis, device used to remove hydrogen gas from potable water.	Sch. - 0.5 Hr Unsch 0.3 Hr	1	Water sampling container and analysis tester, built-in valve device to obtain sample, or built-in water filter, e.g., silver palladium, to remove gas as it leaves fuel cell. Spare gas-removal device, e.g., hand-held spinning device, if applicable.	1. Apollo 10 Failure Report. 2. 10M30899-B

FOLDOUT FRAME 1

FOLDOUT FRAME 2

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 7-31-69

Subsystem/Equipment	Failure Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
A.2 THERMAL CONTROL									
e. Suit Cooling Heat Exchr - AM Find No's. E1018 & E1019	2.0	III	Good	Sch	Periodically check wet status of wicks and apply H_2O as necessary or replace wicks. Pressurized cabin atmosphere.	0.5 Hr	1	Screwdriver, socket and ratchet set, portable light, H_2O spray-type applicator, parts and supplies holder, wetness sensor. Simple instructions, no monitor, and no retest requirements.	1. 10M30899-B 2. Apollo 10 Failure Reports 3. ED2002-756
f. Cold Plate Connectors (fittings) - ATM Find No. E4018 (typical) - External Leakage.	0.5	II	Poor	Unsch	One crewman perform pressurized EVA, external task to repair leak source. Diff press XDCR E4061 senses leak. Visual check required to isolate leak. SOV's E4042/E4045 and CV's E4006 enable circuit disassembly. Reactivate system and perform visual check for post-maint. test.	1.3 Hr	3	Screwdriver, pliers, socket and ratchet set, open and box-end wrenches, leak sealant, or tape, fluid containment device and parts, supplies holder, portable light and leak detector. Detailed instructions, remote monitoring and circuit activation retest are required.	Same
g. Thermal Fluid Fitter - ATM Find No. E4004 - Clogged.	0.5	II	Poor	Unsch	One crewman perform pressurized EVA ext. task to remove and replace fitter element. Pressure XDCR's in circuit sense problem. Backup pressure onto CV's E4006/7 should show on Diff. Press. XDCR's E4073 and E4074 so that fitter fault is determined. Reactivate and readout system for post-maint. test.	1.0 Hr	2	Same as A.1.g., plus fluid containment device and leak detector.	Same
B. INSTRUMENTATION & COMMUNICATION									
B.1 Pressure Transducers - CSM ME449-0052 Monitors (in various applications). Excessive Leakage Due to Weld Failure.	1.0	Ib	Poor	Unsch	Quantity gages on C&D panels signify loss of supplies. Failure also detected by ground via telemetry. Crew tasks involve both IVA & EVA and leak repair.	1.3 Hr	3	Glass mending tape, leak sealant, microscope, portable light, supplies holder, leak detector, detailed instructions.	1. 10M30899-B 2. SS-3414 3. SD68-926-19

FOLDOUT FRAME 1

FOLDOUT FRAME 2

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 8-4-69

Subsystem/Equipment	Failure Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
B. INSTRUMENTATION AND COMMUNICATION B.2 Radiation Survey Meter - CSM RFB-OP-4-2-001 (Used as Radiation Indicator for Space Crew) - Short, Open or Out of Tolerance.	1.0	Ib	Good	Sch	Periodic check performed, wing master comparative meter. Performed in cabin atmosphere.	0.5 Hr	1	Master comparative meter, continuity tester, screwdriver, socket & ratchet set, pliers, tool holder, and brief instructions.	1. SD68-926-19 2. SS-3414
B.3 VHF/FM Transmitter Switch - CSM - No Output.	1.0	II	Fair	Unsch	One crewman confirm and locate failed item. Detected by crew as loss of IM/ATM control. Alternate operation capability not available. Performed in cabin atmosphere. Task involves removal/replacement of failed switch.	0.8 Hr	2	Screwdriver, continuity tester, socket & ratchet set, tool holder and brief instructions, wire cutters, wire stripper, crimping tool and terminal kit. Spare switch with lug fasteners.	1. SD68-926-6 2. MT17,540
B.4 S-Band Omni Antennas CSM ME481-0048-0001-Physical Destruction of Quartz Rod Due to Vibration Causing Hole in Heat Shield and Loss of Thermal Control.		Ia	Poor	Unsch	One crewman perform EVA to confirm and assess heat shield damage. Perform emergency repair, if possible, to restore thermal balance and ensure safe re-entry. Assume	2.5 Hr	3	Heat shield* repair kit, tether, kit and supplies holder, task instructions for other crew members to read from and monitor task, visual monitoring device, and portable light (*Heat shield ablative material).	1. SD68-926-6

FOLDOUT FRAME

FOLDOUT FRAME 2

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 8-7-69

Subsystem/Equipment	Fail. Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
E. ELECTRICAL POWER & DISTRIBUTION									
E.1 Nickle-Cadmium Battery - AM (comprises 30 series - connected nickel-cadmium sealed cells). Failure mode: cell shortout.		II	Good	Unsch	Remove/replace inoperative cell modules. Solar array provides daytime backup capability. EVA required by task. System provides detection and checkout provisions.	1.8 Hr	2	Socket & ratchet set, wire cutters, pliers, parts holder, portable light, spare parts stowage, spare cell module, and brief instructions used by other crewmen. TV or visual monitoring required. Use system for post-maint. test. Tethering & crewman restraint equip. required.	1. AM Design Data Book 2. M-68-21
E.2 Fuel Cell - CSM - No voltage output - possible contamination of S/C water.		II	Poor	Unsch	Remove/replace inoperative cell. EVA required on Apollo. System provides detection, isolation and post-maint. checkout provisions.	2.3 Hr	3	SM panel-fastener removal tool, screwdriver, wire cutters, pliers, crewman restraint equip., open-end wrenches, socket & ratchet set, parts holder, portable light, spare parts stowage, spare fuel cell, visual monitoring, fluid-containment device. Use system for post-maintenance test.	1. SD68-926-15 2. M-68-21
E.3 Circuit Breaker - CSM - Fuel Cell Pump & Fan-fail open causing loss of one fuel cell & inability to select AC bus.	0.5	III	Fair	Unsch	Remove/replace defective breaker. Failure detectable by crew. System provides post-maint. test capability. EVA required on Apollo.	1.8 Hr	2	SM panel-fastener removal tool, screwdriver, wire cutters, pliers, crewman restraint equip., combination wrench set, parts holder, portable light, spare part stowage, spare C.B., visual monitoring.	1. SD68-926-15 2. MIL-HDBK-217 3. SM2A-03-Block II (AAP 1932)
E.4 Buck-type Battery Charger Regulator, AM. Failure Mode: charging current output too high.		III	Fair	Unsch	Perform inplace tests of input and output voltage/current valves, using both amp-hour meter and astronaut switch induced commands. If connections are faulty perform inplace repair; if regulator is faulty, perform remove/replace action. EVA required. System provides post-maint. checkout capability.	2.0 Hr	3	Combination wrench set, wire cutters, pliers, detailed instructions, crew restraint equip., portable light, multimeter, test leads with heavy-duty probes, pin-alignment tool, visual monitoring, parts holder, spare part stowage, spare reg.	1. AM Design Data Book
E.5 Charger, Battery, & Regulator Module, ATM. Failure Mode: Erratic and out-of-tolerance Output.		III	Fair	Unsch	Same as E.4, above, incl. EVA.	2.5 Hr	3	Same as E.4, above.	1. MSFC-Man-001-AP
E.6 Rotary Switch (Selector for Battery Charging: CM Item C22-24203528). Failure Mode: Fail Open.	1.0	II	Fair	Unsch	Crewmen able to visually detect & isolate fault using system C&D equipment. Alternate operational capability not available. Recommend remove/replace task in cabin atmosphere or across-terminal jumpering for more exigent response.	0.8 Hr	2	Screwdriver, allen wrench, socket & ratchet set, continuity tester, tool holder, brief instructions, wire cutters, wire stripper, crimper tool and thermal kit, spare switch with lug fasteners, clip type test (jumper) leads.	1. MIL-HDBK-217A 2. SM2A-03-Block II (AAP #1932) 3. SD68-926-15

FOLDOUT FRAME

FOLDOUT FRAME 2

Table B-I Inflight Maintenance Requirements

Contract: NAS8-24296

Date: 8-15-69

Subsystem/Equipment	Failure Rate (Per 10^6 Hr)	Maint. Critic. Category 1	Equip. Repair-ability 2	Maintenance Task Requirements					Comments and References
				Type	Description	Maint. Time 3	Complex Index 4	Support Provisions	
E. ELECTRICAL POWER & DISTRIBUTION									
E.7 Motor Switch, LM/ATM - CM Power Transfer, P/N ME-452 (2 Required); Open (Fail to Actuate).		III	Fair	Unsch	Failure detectable by crew. Task involves inplace visual check of switch and connections (having first disconnected the control panel), continuity test of switch, and switch replacement or restoration of function by jumping the switch terminals.	0.8 Hr	2	Screwdriver, allen wrench, socket & ratchet set, continuity tester, wire cutters, wire stripper, crimping tool & terminal kit, spare switch with lug fasteners, clip type test (jumper) leads, tool holder, spare part stowage provision and brief instructions.	1. SD 68-926-15 p. 16 of 23
E.8 Temperature Controller, AM P/N 61B8300010-19-Panel Meter Indicates No or Inaccurate Temperature. Assume This Mode Caused By Connector Pins Being Shorted by Excessive Moisture in S/C Cabin.		III	Fair	Unsch	Perform incremental continuity tests to isolate fault. Disengage connector halves, physically inspect pins and receptacles for surface condition and straightness. Dry connector halves thoroughly using portable N_2 supply and hand-held gas spray applicator.	1.5 Hr	2	Multimeter, clip and probe test leads, portable N_2 storage bottle with gas-jet applicator, tool holder, work shelf, flashlight. Instructions not required.	1. MDAC Report F673, p. 4.2.1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

Table B-I Footnote Explanations

1. Footnote No. 1, "Maintenance Criticality Category" - This entry is an arbitrary indication of the importance of maintaining equipment in support of safe and effective spacecraft operation. Coded entry definitions are as follows (Reference: S & E-QUAL-69-9, NASA-MSFC):

Ia - Applies to equipment that must receive maintenance attention within a specified time in order to effect safe abort of the crew.

Ib - Applies to equipment that must receive maintenance attention within a specified time in order to prevent abort of crew or loss of life.

II - Applies to equipment that must receive maintenance attention in order to preclude major degradation of the mission.

III - Applies to all other items.

2. Footnote No. 2, "Equipment Repairability" - An entry of either Good, Fair, or Poor, indicates the extent to which an item is capable of being serviced, repaired, replaced, etc., in its normal installed location. This entry is a measure of item and system-level maintainability, accounting for such factors as item maintenance conveniences (e.g., test points, lubrication fittings, and removable fasteners) and item accessibility in the installed location.

3. Footnote No. 3, "Maintenance Time" - Time entries are in hours, and include the time required to fault detect, isolate, obtain spares and

working equipment and perform the specific maintenance task including system-level checkout, where applicable. The time entries do not include astronaut translation time, IVA or EVA suiting, prebreathing, or post EVA airlock times. The human factors time portions of overall spacecraft time periods allocated to, or consumed by, maintenance requirements are established by subsequent analysis, as necessary.

4. Footnote No. 4, "Complexity Index" - This entry is an arbitrary indication of the complexity of maintenance tasks earlier described in the Table I form. Coded entry definitions are as follows:

1. This signifies low-complexity-level maintenance requirements, e.g., visual inspections, minor adjustments to out-of-tolerance equipment, and replacement of filter elements. Some maintenance instructions and hand tools may be needed, but no special crew skills or task difficulties would be expected.
2. This signifies medium-complexity-level maintenance requirements, e.g., removal and replacement of failed end-item equipment. Such maintenance will commonly require use of fault isolation equipment, maintenance instructions and tools/test equipment. The crew must also have greater system knowledge and technical skills than for the "1" level, above.
3. This signifies high-complexity-level maintenance requirements, e.g., (a) removal and replacement of failed end-item, and sub-

assembly portions of assemblies, equipment; and (b) in-place repair of failed or damaged equipment. Sophisticated fault isolation equipment, detailed maintenance procedures, and tools/test equipment may be required. The crew must possess highly specialized maintenance skills in addition to their capabilities for performing mission operations.

5. Footnote No. 5, "Find No." - Signifies AAP-assigned location/identification numbers (see M-D prepared NASA-MSFC Document 10M30899, Rev. B, 4-15-69, for typical list of AAP "find numbers"). AAP "find numbers" are used whenever applicable and available.

Table B-II Tool Selection List

1. Temperature meters
2. Portable Electric hack saw
3. Moto tool (grinding, sanding, buffing, polishing, carving, counter sinking, sawing, cleaning, slotting) in storage case with accessories
4. Flexible shaft tools
5. Soft face hammer/mallet
6. Offset screwdriver
7. C-clamps
8. Vise grips
9. Crescent wrench
10. Pipe wrench/strap wrench
11. Hand vise
12. Spring clamp
13. Combination pattern tin snips
14. Cold chisel
15. Specially treated, repair kit glass tape
16. Aluminum/steel patch-type sealing putty (does not depend upon evaporation)
17. Portable lights (plug-in and battery-powered)
18. Continuity tester
19. Wire stripper
20. Flaring tool

21. Metal saw (see 3, above)
22. Tubing cutter
23. General purpose scissors
24. Ratchet/socket set
25. Pin-type spanner wrench
26. File/file handle set
27. Inspection mirror
28. Pin vises
29. Open-end wrench set
30. Combination wrench set
31. Screwdriver (standard 5/16" x 8", and 8" Phillips)
32. Pliers (standard 6" size)
33. Wire-cutting pliers
34. Drift punch
35. Leak detector (e.g., mass spectrometer, leak-check tool)
36. Torque wrench
37. Dewpoint sensor/indicator (Dewcel sensing device, moisture monitor)
38. Multimeter
39. Crimping Tool and Terminal Kit
40. Portable signal generator
41. PCM Test Set
42. Test leads with heavy duty probes
43. Alligator clip test leads
44. Strain gage calibrator (shunt calibrate strain gage transducer)

45. DC millivolt source (for testing millivolt signal conditioning assemblies)
46. Watt-meter (measures spacecraft transmitter power output)
47. Input switch box - Multiplexer and single side-band unit (monitors signals or applies input signals)
48. Digital voltmeter
49. Portable power supply
50. Portable oscilloscope (with probes)
51. Electrical-connector, pin-alignment tool
52. Fluid-lines blank-offs or closures kit
53. Assorted fittings and pressure caps
54. Electrical extension cables
55. Jumper cables
56. Portable TV monitor camera/and central cabin-area TV receiver
57. Elapsed time indicator
58. Solid state circuit checker
59. Flowmeter kit
60. Conoseal wrenches (backup wrenches for conoseal flanges)
61. Gaseous/liquid system sampling tools (to sample media for possible particulate contamination)
62. Long-nose pliers
63. L-shaped "Allen" or hex wrenches
64. Heavy-duty service tweezers
65. Knife set
66. Tape rule

67. Screw extractor set

68. Voltage insulation and leakage tester

69. Beau-tech vacuum system (small, portable vacuum handler of miniature parts)

70. Lab-vac vacuum

Table B-III Summary of Maintenance Support Requirements and Priorities

Contract: NAS8-24296 Date: 7-31-69

	Subsystems					Priority Category		
	Environ. Control	Instrum. & Comm.	Guidance & Control	Controls & Displs.	Power & Distrib.			
Percent of Total System Failures	46%	26%	15%	6%	2%			
Priority Based Upon Above Per Cent	1	2	3	4	5	I	II	III
Maintenance Support Requirements:								
A. Standard Tools & Test Equipment								
1. Screwdrivers	X	X	X	X	X	X		
2. Wirecutters	X	X	X	X	X	X		
3. Pliers	X	X	X	X	X	X		
4. Open-End Wrenches	X		X		X	X		
5. Box-End Wrenches	X							X
6. Socket & Ratchet Set	X	X	X	X	X	X		
7. Large Crescent Wrench	X						X	
8. Drift Punch	X							X
9. Soft-Face Hammer	X							X
10. Continuity Tester		X	X	X	X	X		
11. Combination Wrenches					X			X
12. Vise Grips	X		X				X	
13. Torque Wrench	X		X				X	
14. Power Tool Kit, e.g., "Moto Tool"	X		X		X			X
15. Wire Stripper & Crimping Tool, e.g., "Super Champ"		X	X	X	X		X	
16. Electrical Connector Pin-Alignment Tool		X	X	X	X		X	
17. Elapsed Time Indicator		X		X				X

	Subsystems					Priority Category		
	Environ. Control	Instrum. & Comm.	Guidance & Control	Controls & Displs.	Power & Distrib.			
Percent of Total System Failures	46%	26%	15%	6%	2%			
Priority Based Upon Above Per Cent	1	2	3	4	5	I	II	III
Maintenance Support Requirements								
B. Special Tools & Test Equipment								
1. Leak Detector	X	X					X	
2. Fluid-Containment Device	X					X		
3. Wick-wetting Water Applicator	X							X
4. Wetness-Level Sensor	X							X
5. Heat Shield (Ablative) Repair Kit		X						X
6. Master Radiation Survey Meter		X						X
7. Ext. Panel Fastener Removal Tool	X	X	X		X		X	
8. Apollo-Type Panel Fastener Removal Tool		X	X	X	X	X		
9. Multimeter		X	X	X	X	X		
10. Test Leads with Heavy-Duty Probes		X	X	X	X	X		
11. Connector-Pin Alignment Tool		X	X	X	X		X	
12. Potable Water Sampler & Tester	X							X
13. Space Suit Repair Kit (Sewing, Patching, Seal Replacement)	X							X
14. Portable Life Support System (PLSS) Maintenance & Repair Kit (Lube, Spare "O"-Rings and Patching Tape)	X							X
15. Electron Beam Welder	X		X					X
16. Blended-Gas Analyzer	X			X				X
17. Vacuum Sensing/Measuring Device	X			X				X
18. Battery/Battery Cell Tester		X		X	X			X
19. Air Flow Sensor/Display Meter	X							X
20. Fabric Repair Kit (e.g., for OWS Ceiling, Shower Stalls, Beds, etc.)	X						X	
21. Cabin Pressure Measuring Device	X			X				X
22. Cabin Temperature Measuring Device	X			X				X
23. Portable Electric Hack Saw	X	X						X
24. Portable N_2 Storage Bottle with Gas-Jet Applicator (for "Drying" Use)		X	X	X	X		X	

APPENDIX C

SPACE SIMULATION, DEMONSTRATION TEST INFORMATION

INTRODUCTION

The Portable Astronaut's Test Kit (PATK), developed by Martin Marietta Corporation under Contract NAS8-24296, was delivered as a mockup suitable for demonstration testing in space-simulation test facilities. The purpose of demonstration testing was to evaluate the various design features and working characteristics and to obtain useful experience with the performance of inflight maintenance that could be applied to future kit and inflight maintenance task developments.

The NASA-Marshall Space Flight Center (MSFC) technical monitor for Contract NAS8-24296, Mrs. A. Folsom, arranged for reduced-gravity space simulation tests to be performed in the Manufacturing Engineering Mechanical Simulation Laboratory at MSFC on 2-3 March 1970. The test program was developed and conducted by the MSFC Reliability & Quality Assurance Laboratory (R-QUAL). The MSFC Manufacturing Engineering Laboratory (R-ME) provided technical support that included test facility setup work and active participation in test operations. The Martin Marietta Corporation also provided direct support that included test materials, and technical personnel.

TEST SETUP

Setup work for tests was based upon use of mechanical space-simulation test facilities and equipment located in the MSFC-Manufacturing Engineering Laboratory Building 4711. The specific test-facility location was the smooth-floor test laboratory that is specifically prepared for air-bearing-pad test equipment. A description of test and support equipment used follows:

FIVE-DEGREES-OF-FREEDOM SIMULATOR - This device consists of three major assemblies: a cradle for supporting the test subject in an erect position, a roll yoke, and a base structure that distributes the total load of the

simulator and test subject to three air-bearing pads equally spaced around the nominal yaw axis (Figure C-1). Detailed information relative to this simulator is available in Reference (1), pp. 2-3.

FREE-FLYING AIR BEARING PLATFORM - This is a lightweight adjustable platform used as a support mount for the PATK during simulated space translation and attachment activities. The basic platform is a welded aluminum tubular structure with mounting platform on top for the PATK, and a floor base containing bladder-type air-bearings, air pump and electric control attachments (Figure C-1). Detailed information relative to this platform is available in Reference (1), pp. 16-17.

MECHANICAL SIMULATION TASK BOARD - The task board is mounted on an adjustable and transportable "A" frame, and is equipped with tether points, mobility handrails and mounting fixtures for test hardware (Figure C-1). For this test, the task board served as a handrail facility in support of translation activities. Detailed information relative to the task board is available in Reference (1), pp. 12-13.

LUNAR GRAVITY & EARTH ORBITAL SIMULATOR - This device is a frictionless air-bearing parallelogram that provides a single (vertical) degree of freedom to a work panel counter-balanced to give an upward force equal to 1/6 of the test subject's weight (Figure C-2). For this test, the simulator was used to provide vertical freedom only, and was modified as follows:

1. A horizontal strut with platform was added to support the PATK during test activities when the Free-Flying Air Bearing Platform was not used (Figure C-3).

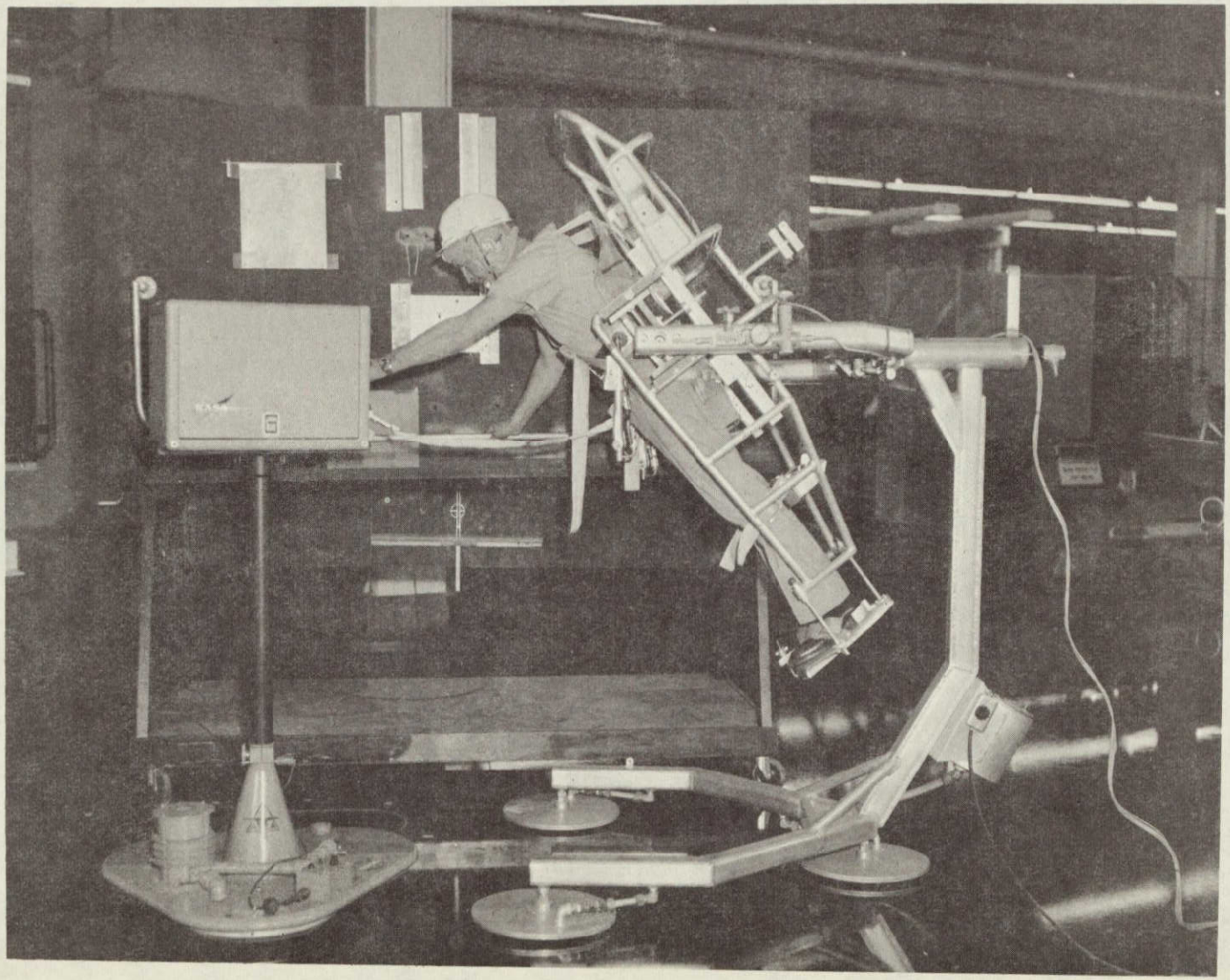


Figure C-1 Five-Degrees-of-Freedom Simulator

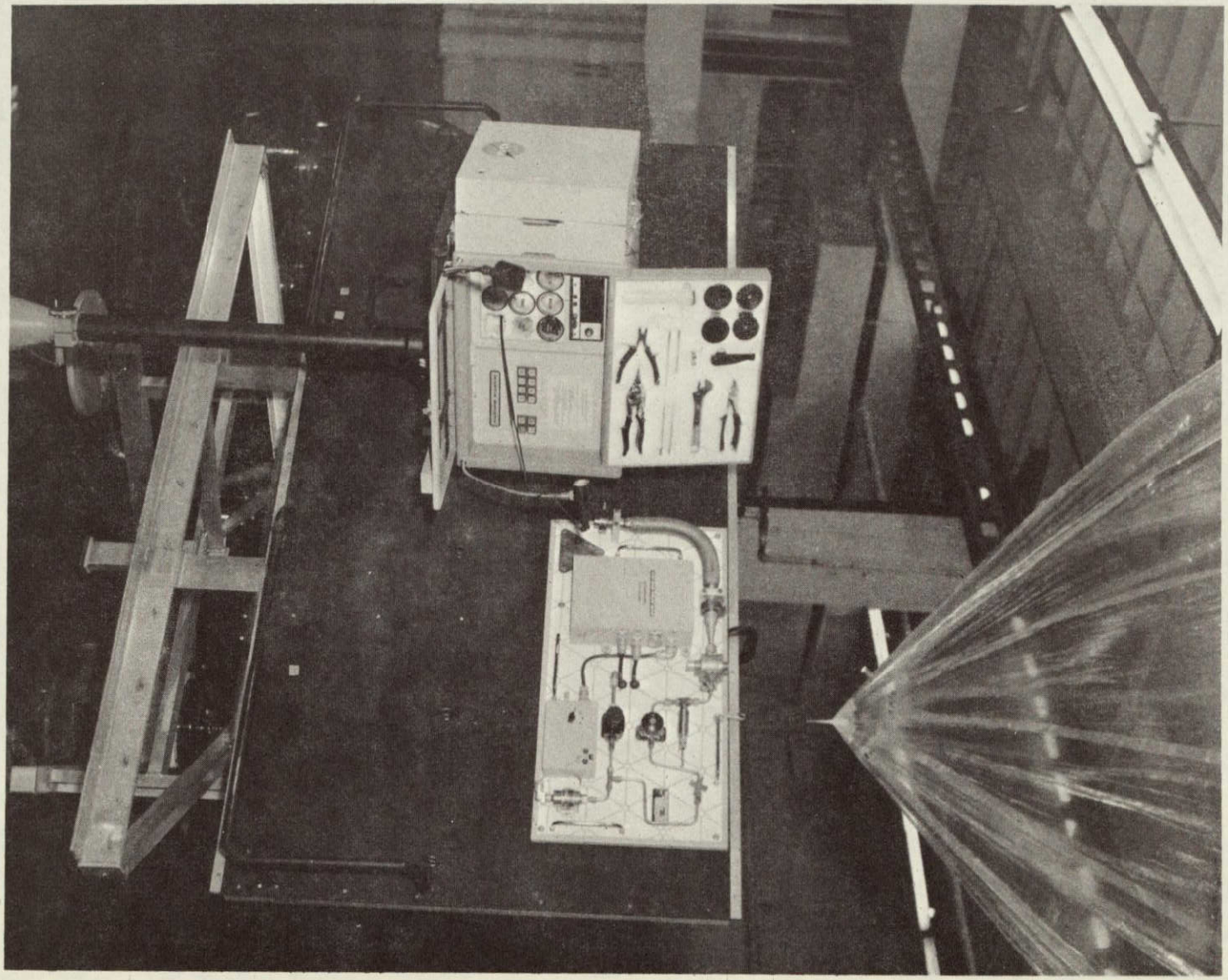


Figure C-2 Lunar Gravity and Earth Orbital Simulator

2. The PATK Task Demonstration Panel described below was rigidly attached to the upper right section of the work panel (Figure C-2).
3. A translation rail and tether connection points were located to be useful, yet non-interfering, during tests (Figure C-4).

Detailed information for this simulator work panel is available in Reference (1), pp. 10-11.

DEMONSTRATION TEST PANEL - This panel was developed and supplied by Martin Marietta to facilitate demonstration of representative space maintenance tasks, and capabilities of the PATK. The panel is approximately 24" X 36", on which are mounted a number of integrated spacecraft hardware items, carrying handles, and a mounting plate for physical attachment of the PATK (Figures C-4 and C-5). A detailed description of the panel is provided in Reference (2), pp. 33-35.

HOIST & SUPPORT HARNESS - A flexible, strap-type support harness was developed and supplied by Martin Marietta to enable hoisting and suspending of the PATK in preparation for PATK mounting to the task board and work panel (Figure C-6). An adjustment feature is incorporated into each of the four suspension straps to enable establishment of center of gravity (CG) of the PATK under different operational conditions, and balanced positioning of the PATK.

COUNTERBALANCING BALLOON - One large test balloon filled with gaseous helium had been prepared by the ME laboratory to provide 1-1 ratio counterbalancing of the 1-g weight of the PATK, thereby providing a weightless state for the PATK. It was learned during test setup that the balloon was inadequate for PATK weight, and intended balloon use was discarded; however, the balloon was used for unintended services of offsetting weight of test

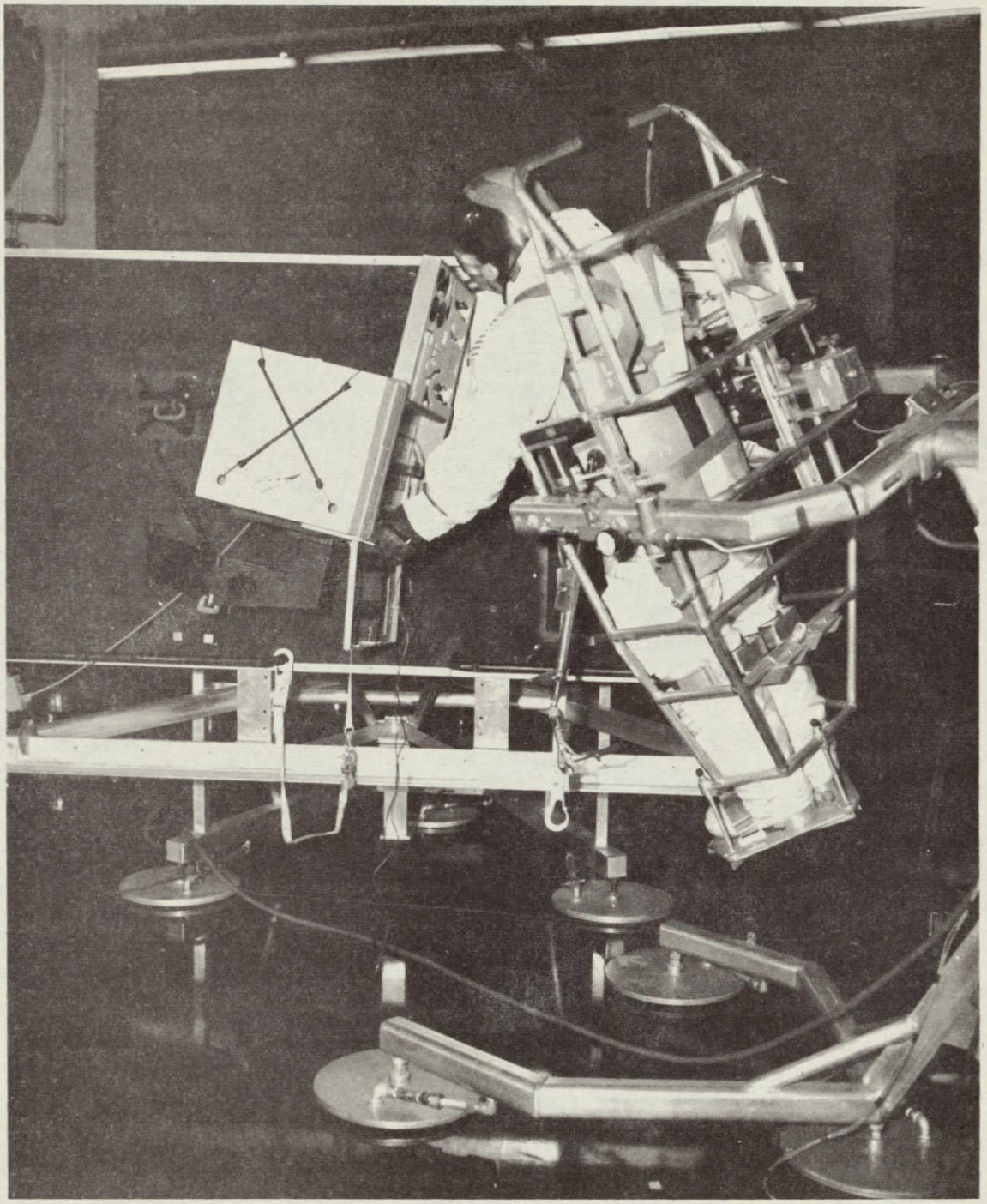


Figure C-3 PATK Horizontal Support Strut and Platform

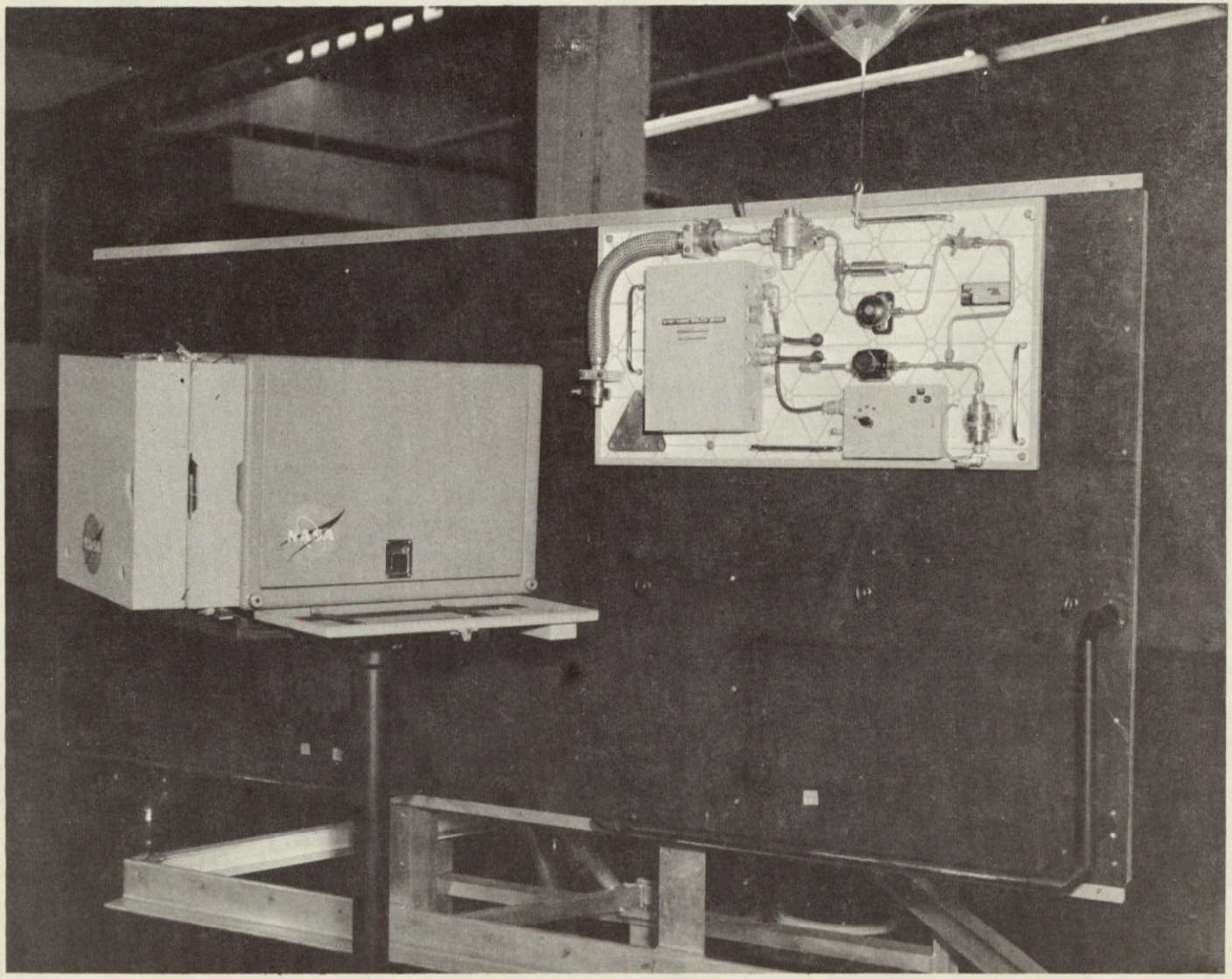


Figure C-4 Demonstration Test Panel

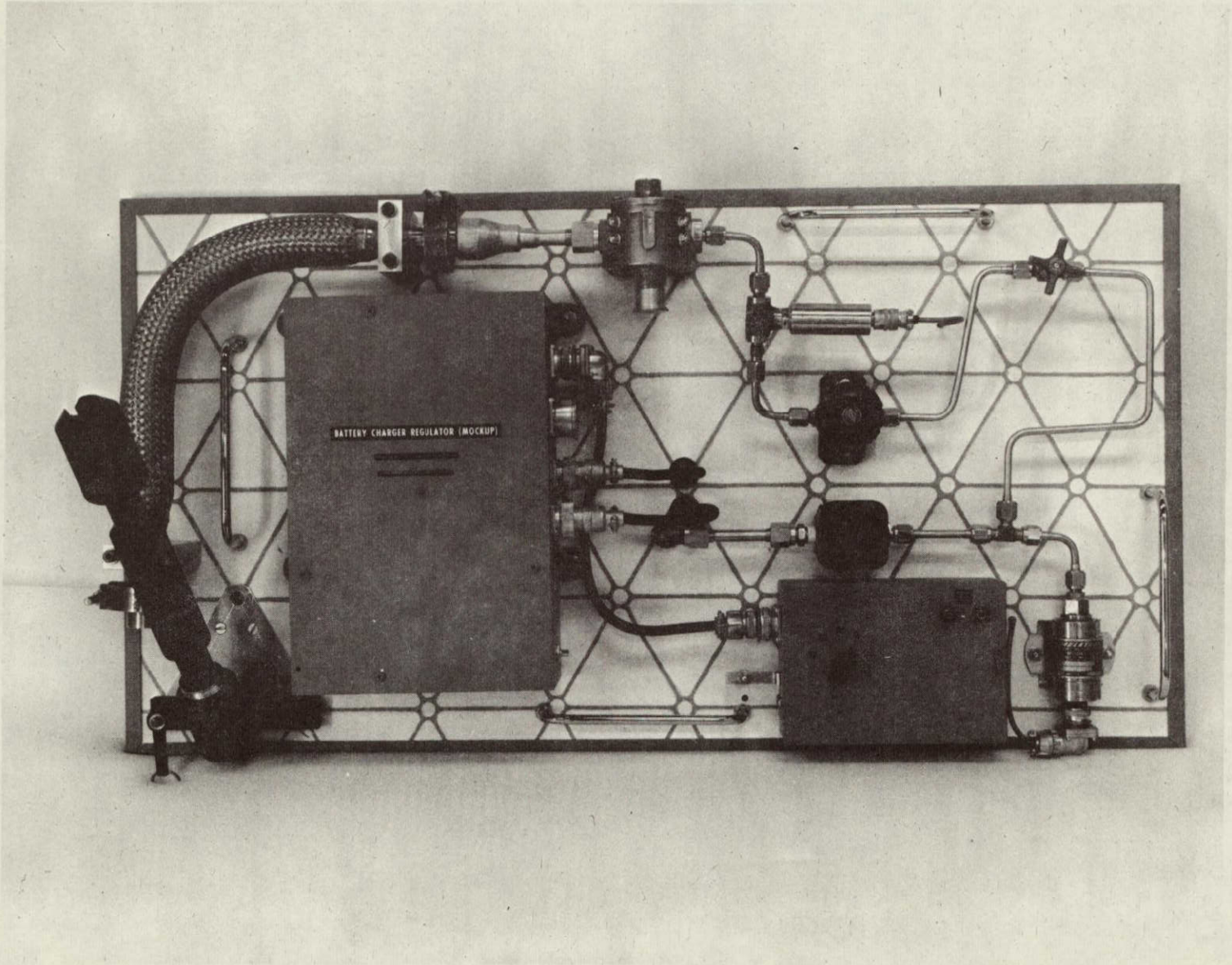


Figure C-5 Demonstration Test Panel

Figure C-6 Hoist and Support Harness

cantilevered devices.

ASTRONAUT RESTRAINT - An adjustable and rigidizable astronaut waist restraint device was supplied by Martin Marietta for test-subject use, during selected test activities (Figure C-7). This device was a prototype of the article being developed by Martin Marietta under NASA-MSFC Contract NAS8-24840.

MISCELLANEOUS EQUIPMENT & SERVICES - A number of ancillary equipment and facility items and personnel services were provided in support of test activities. These included:

1. Headset communication capability was provided by NASA between test conductor, test subject, and test observer (the test subject's "well being" was constantly monitored during suited operations).
2. Television monitoring and recording were provided during the entire test activities by NASA.
3. Still and movie film equipment was made available by NASA for selected coverage of test activities.
4. Test subject suit equipment (Apollo flight coveralls and space suit) was provided by NASA.

TEST PROCEDURES

An initial set of suggested demonstration task procedures was developed by Martin Marietta and submitted to NASA-MSFC, R-QUAL-F, for considerations (Reference 2, pp. 35-38). The R-QUAL-F office subsequently developed formal test procedure documentation (Reference 3) that served as test outline, test-indoctrination material, training material for the selected test subject, and a record sheet for task time observations. Table I presents a condensed version of the formal NASA procedures that signifies

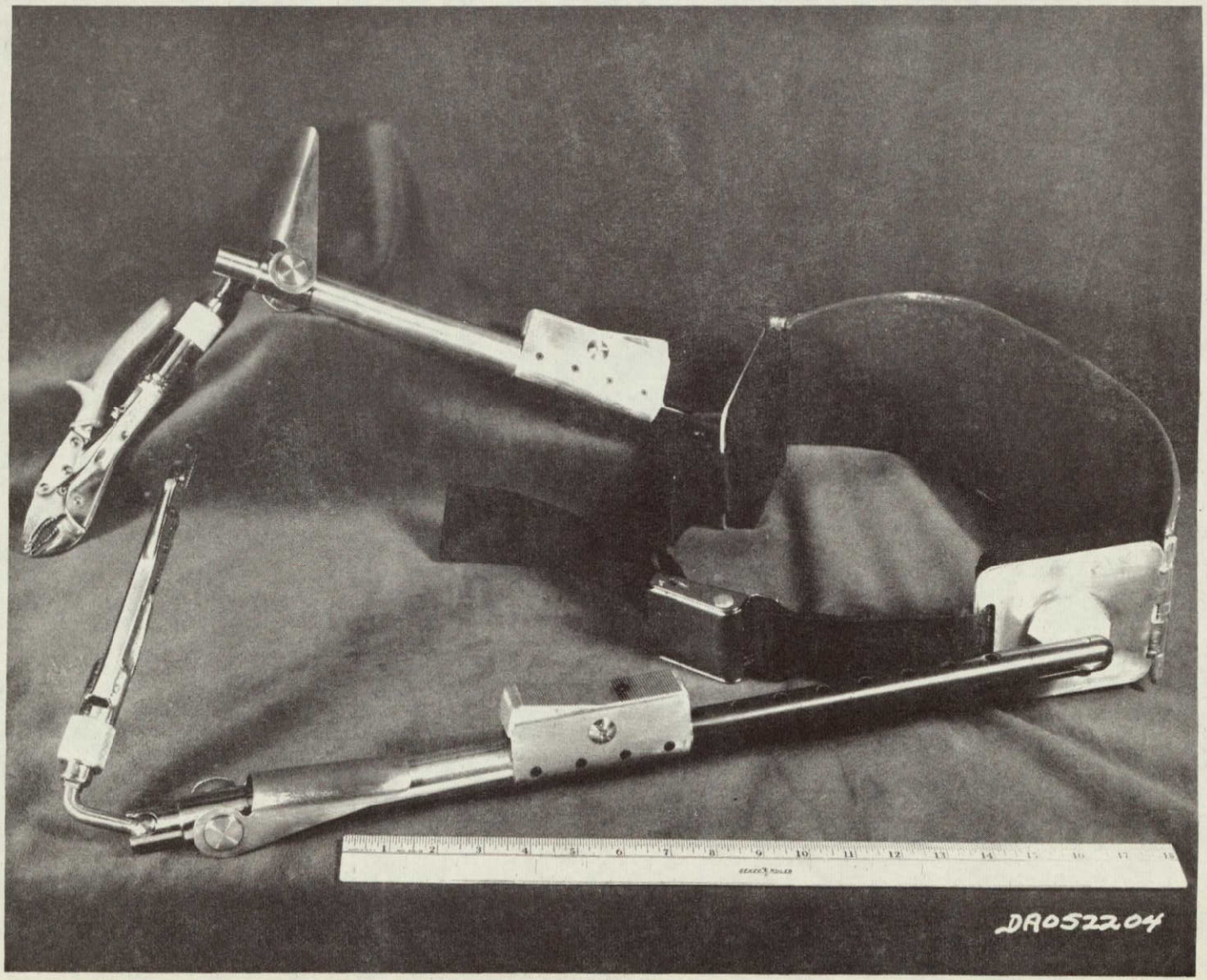


Figure C-7 Astronaut Waist Restraint

the gross test operations that were performed, and the respective test-subject suit mode in which they were performed. Test procedures, activities and tool configurations were previously based upon potential space needs of a spacecraft system typified by the AAP Skylab I.

Table I Test Operations Synopsis

	Test Operation	Coveralls Walk-Thru	Coveralls Timed	Space Suit Timed
A.	Test subject translates to test panel with PATK (Fig. 1).*	X	X	X
B.	Test subject tethers PATK to test panel worksite (Fig. 8).*	X	X	X
C.	Test subject tethers self to test panel worksite (Fig. 8).*	X	X	X
D.	Test subject attaches PATK to worksite with mounting boom assembly.*	X	X	X
E.	Test subject exercises PATK panels and latches (Fig. 9).	X	X	X
F.	Test subject exercises sub-kit tool holder (Fig. 10)	X	X	X
G.	Test subject removes & replaces spares, exercising storage pouches (Fig. 11).		X	X
H.	Test subject removes & replaces large spares stored in end of PATK		X	X
I.	Test subject removes & replaces tools stored in core and sub-kit locations of PATK	X	X	X
J.	Test subject removes tool items contained in front panel of PATK, and installs and stores PATK illumination devices (Figure 13).	X	X	X
K.	Test subject exercises microfilm storage & display unit, and multimeter including use of test probes	X	X	X
L.	Test subject performs selected maintenance tasks on test panel (Fig. 13).		X	X
M.	Test subject removes PATK from worksite.*	X	X	
N.	Test subject untethers and translates with PATK.*	X	X	

*PATK was supported by separate air-bearing stand during the A,B, C,D,M and N operations.

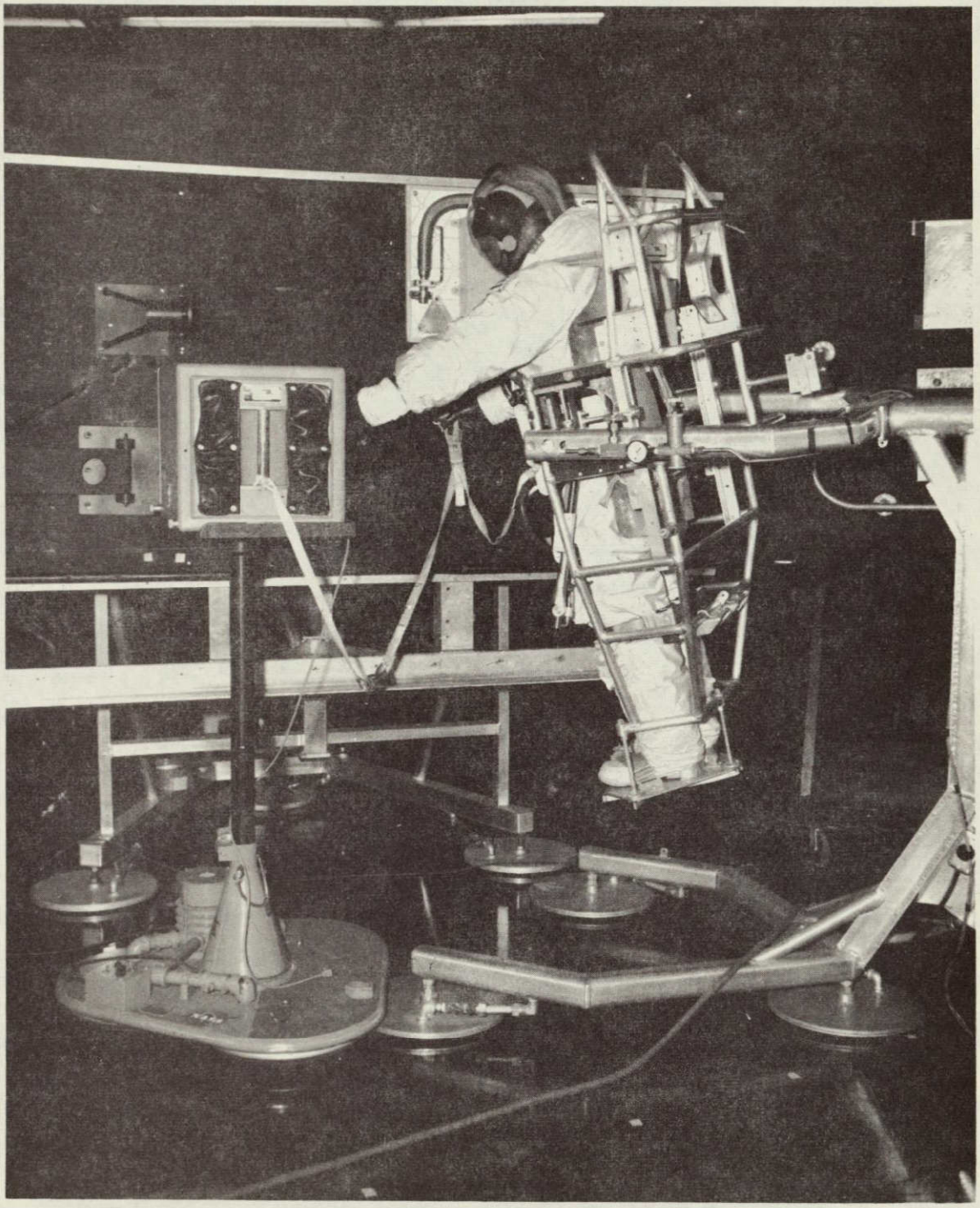


Figure C-8 Tethering to Demonstration Worksite

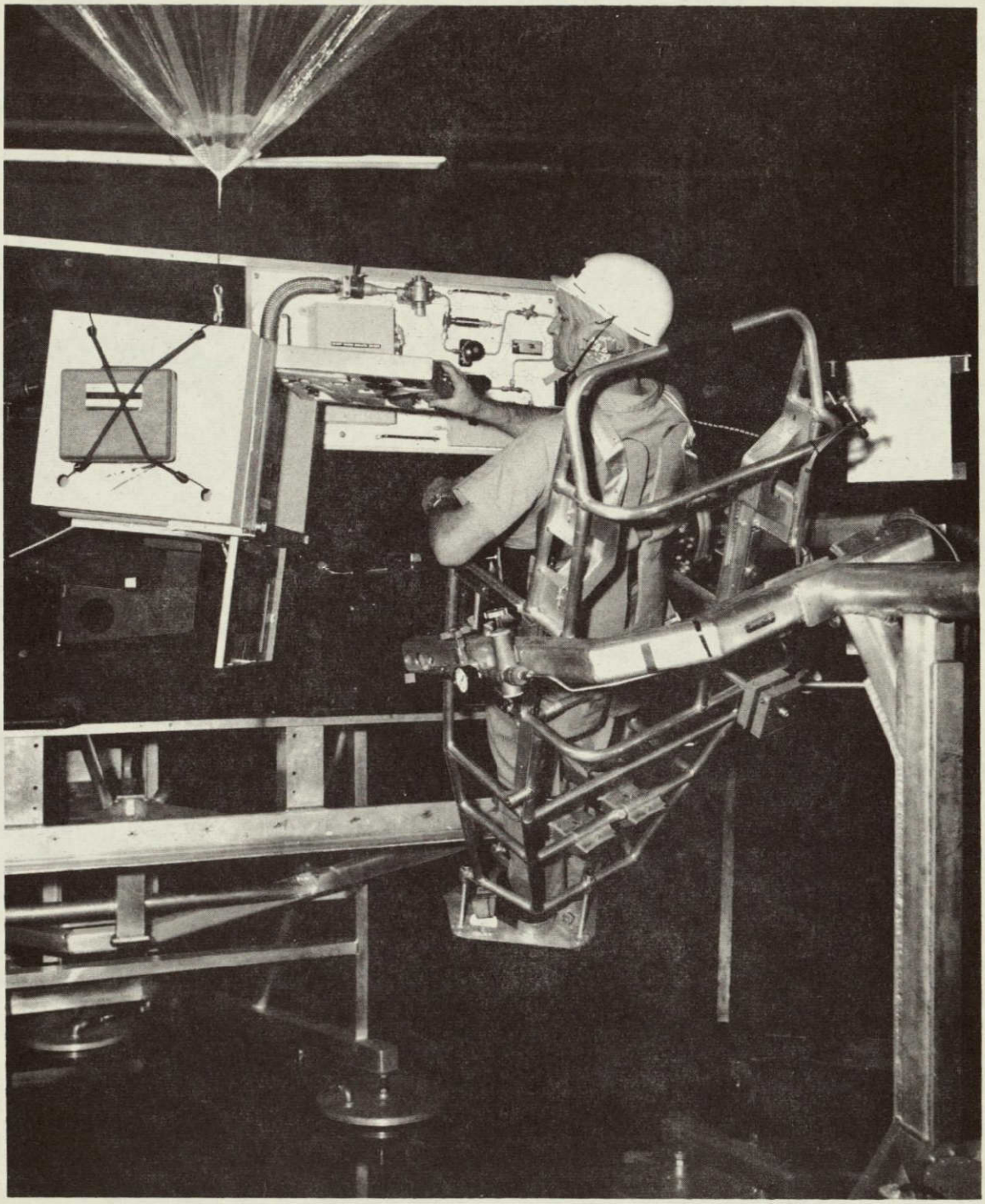


Figure C-9 Exercising of PATK Panels & Latches

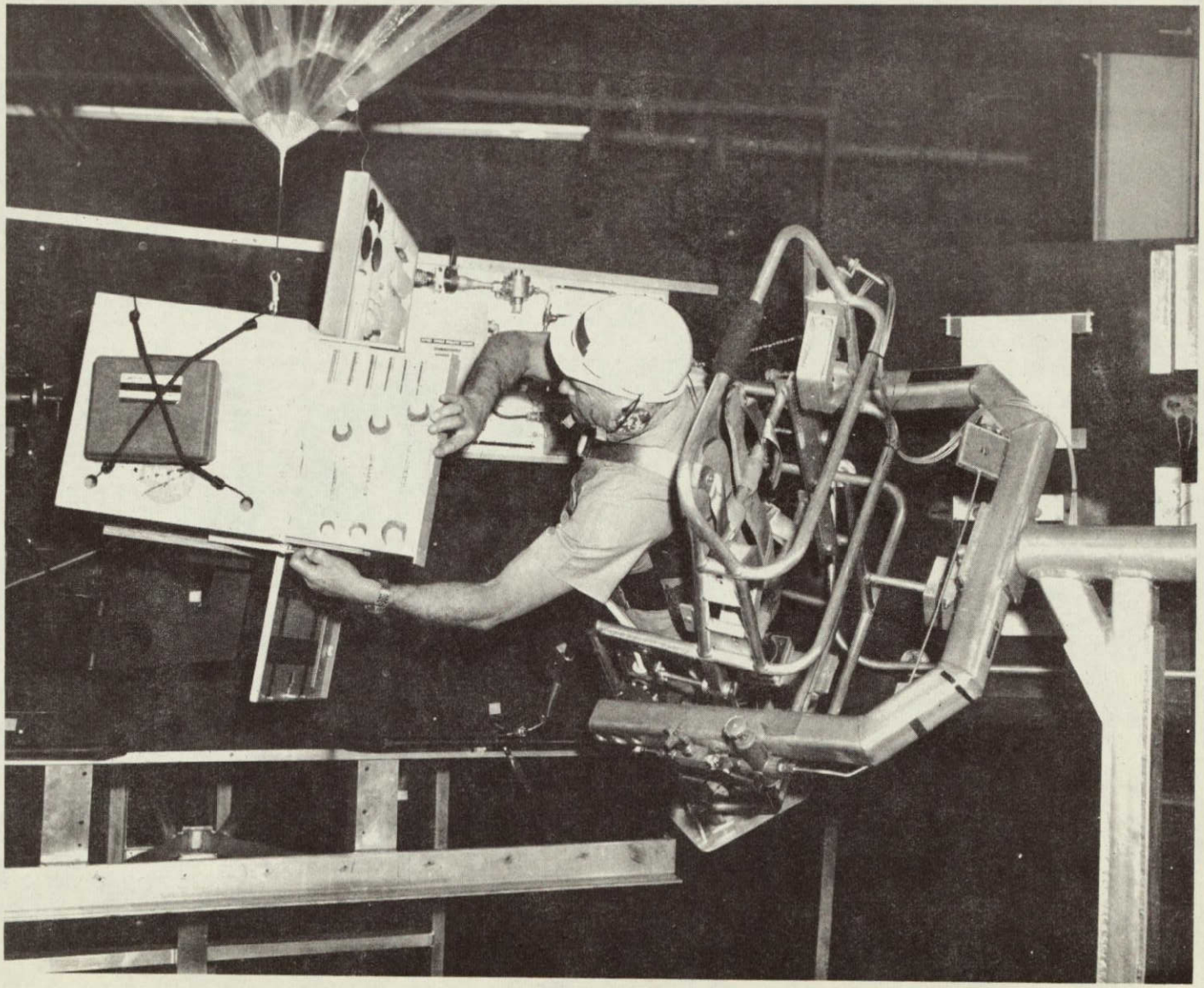


Figure C-10 Exercising of PATK Sub-Kit Tool Holders

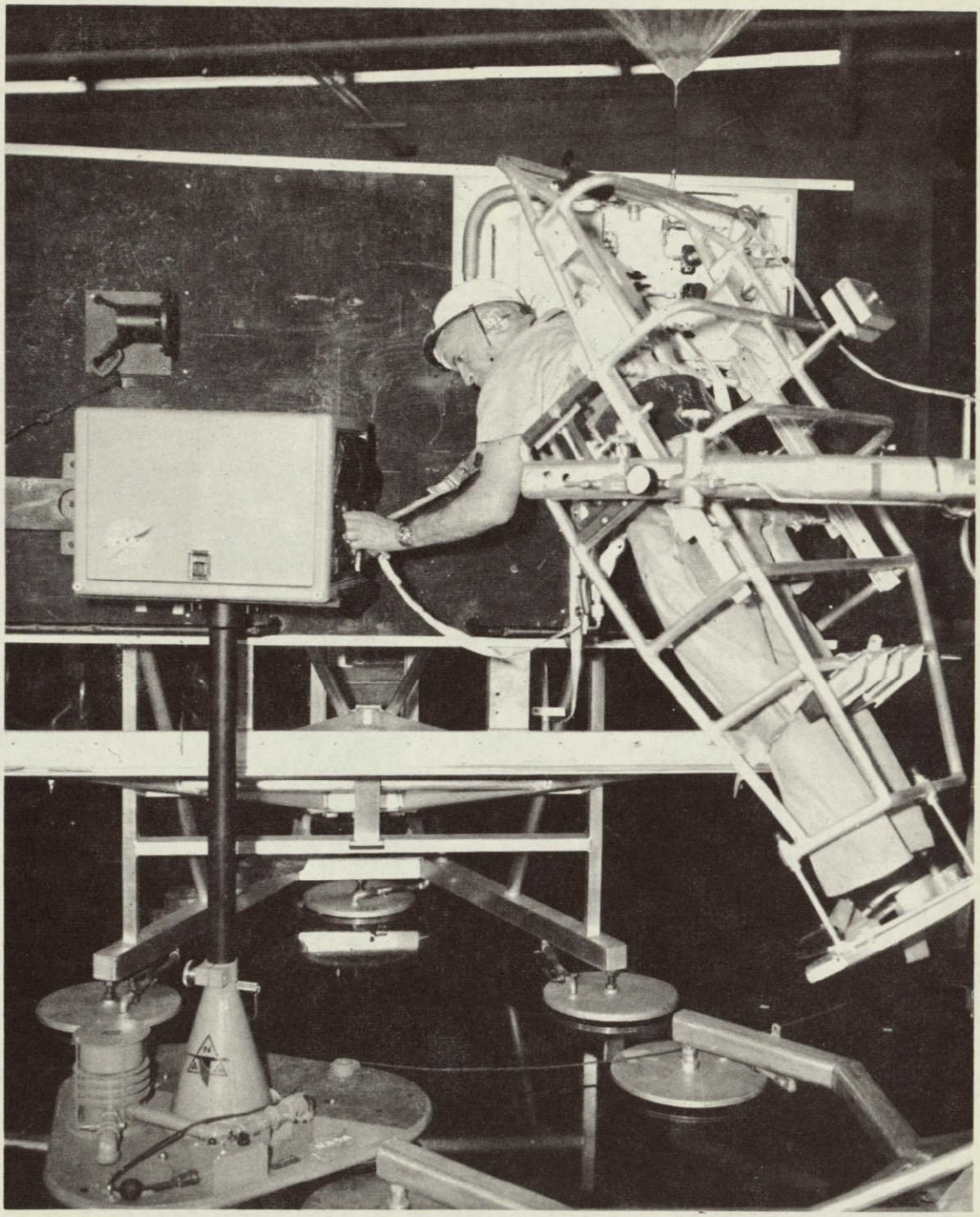


Figure C-11 PATK Spares Storage Pouches

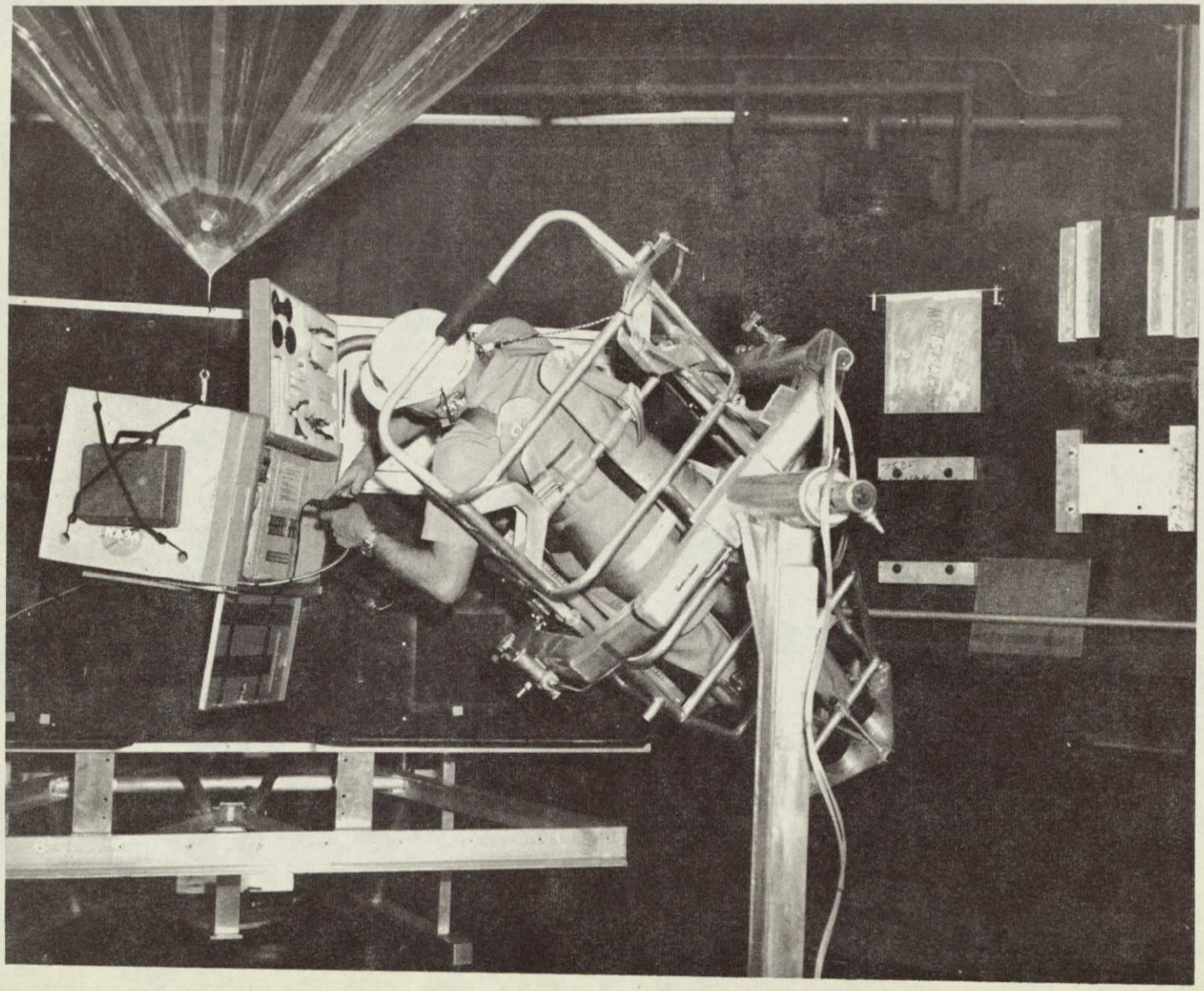


Figure 12 Exercising of PATK Tools and Lights

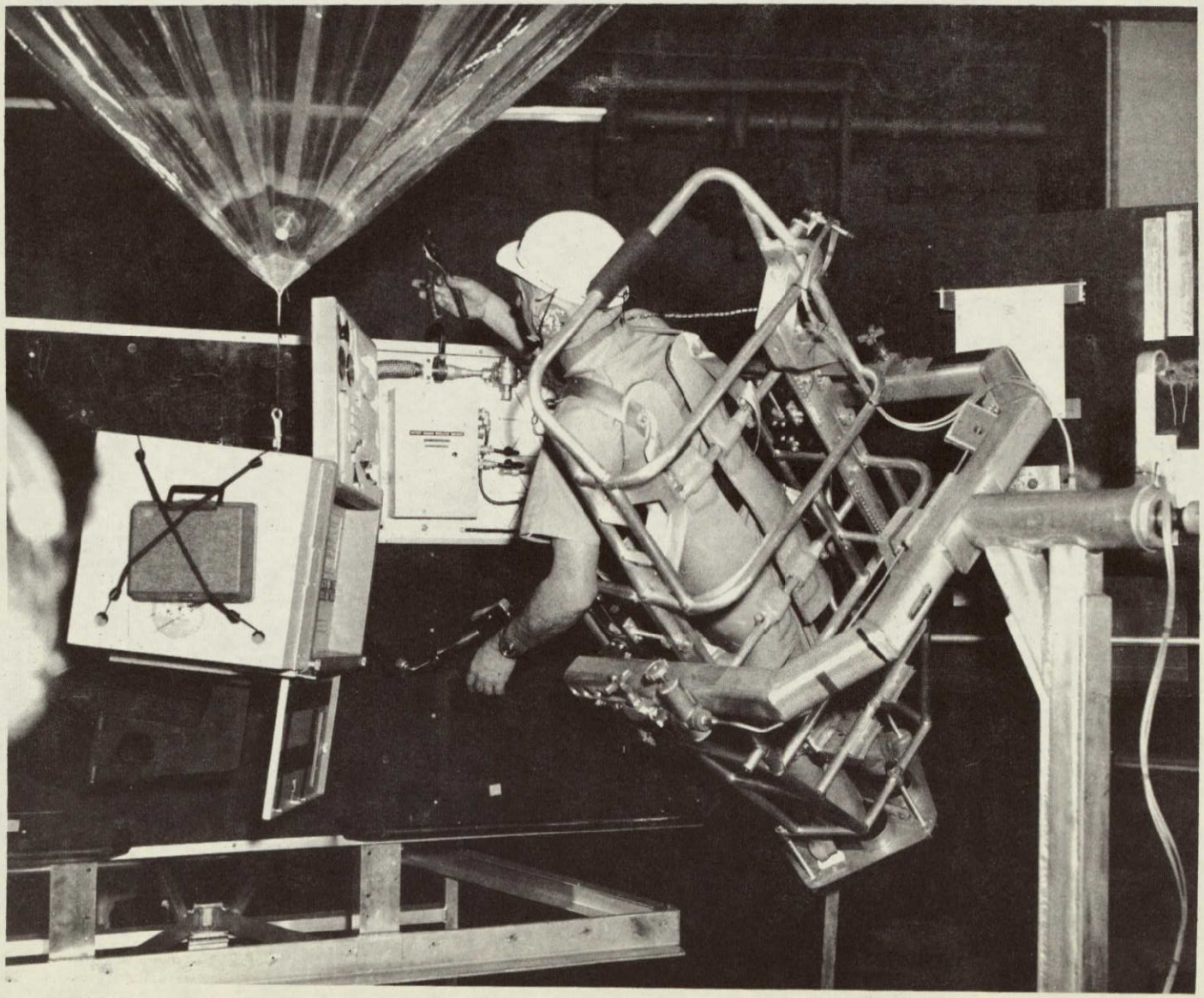


Figure C-13 Performing Maintenance Tasks with PATK

TEST OPERATIONS SUMMARY

Test operations are visually presented by 16 mm moving-film coverage that is the property of the R-QUAL-F office, NASA-MSFC. Figures C-1 through C-13, herein, also present selected portions of test activities. In addition to these sources, the following information and information provided in the Conclusions and Recommendations section are provided.

During the translation, tethering and attachment tasks, the PATK was supported on the small Air Bearing Platform (Figure C-1). The remainder of the tasks were performed with the PATK mounted on the Lunar Gravity and Earth Orbital Simulator (Figure C-2). The objective was to make the PATK and the Demonstration Test Panel static with respect to each other as they would be in space orbit once the PATK was attached to the spacecraft structure. In orbit, the PATK would be free to rotate about the mounting boom assembly. To simulate this, it was necessary for the PATK to be rotated on the stand by observer assistance.

Test activities commenced on the morning of 2 March. The test subject was placed in the Five-Degrees-of-Freedom Simulator and balanced. The balancing was repeated for each run. The Lunar Gravity and Earth Orbital Simulator was also balanced. The test subject was then conducted through a coveralls-mode familiarization or walk-thru run. During this time; the test subject used flexible, strap-type tethers. All other test runs were made with the telescoping waist restraint device. Following the familiarization run, the first coveralls-mode runs were made. The coveralls-mode portion of the demonstration tests was completed on 2 March. The following day, the same test subject donned the space suit, was pressurized, and then placed in the Five-Degrees-of-Freedom Simulator. The test subject then made the suited runs of the test. Both movie and still photographic

coverages were obtained during the test runs on both days. Television monitoring and recording were also provided. The test subject was normally directed through the tests by headset communication with the test conductor and observer. Loud speakers were used to transmit the communications to other test observers and audience personnel.

TEST PARTICIPANTS AND OBSERVERS

PARTICIPANTS -

S. Peck	NASA-MSFC (R-QUAL-F)	Test Conductor
C. Graham	NASA-MSFC (ME)	Test Subject
H. Blaise	NASA-MSFC (ME)	
C. Troup	NASA-MSFC (ME)	
R. Belless	Martin Marietta	
J. Spencer	Martin Marietta	

OBSERVERS -

W. Cowart	NASA-MSFC (S&E-ASTN-SO)
R. Sperr	NASA-MSFC (S&E-ASTN-SO)
D. Shipman	NASA-MSFC (PM-AA-EI)
E. Harris	NASA-MSFC (PM-AA-SW)
W. Funston	NASA-MSFC (PD-UP-T)
V. Yost	NASA-MSFC (ME)
D. Spangler	McDonnell-Douglas, West Division
J. Compton	McDonnell-Douglas, West Division

TEST CONCLUSIONS AND RECOMMENDATIONS

GENERAL COMMENTS -

1. The PATK design approach and maintenance capabilities demonstrated appear to be good. A number of representative tasks were successfully performed on the Demonstration Test Panel. It is suggested that learning-curve experience can profit from further task performance with the PATK.
2. Observer comments stressed the need for neutral buoyancy testing to better evaluate translation, attachment, and general PATK operation. Certain limitations of mechanical simulation were recognized, e.g., the high inertias involved

in the airbearing machines, the interference of the bases of the different machines, the 1-g weight of some parts of the test such as the man, the kit, and the tool, and the limited movement created by the test setup. A suggestion was made to mount the PATK on a rigid shelf on the task board rather than on a movable arm.

3. The test subject would have preferred the kit to have been mounted on his right side where he felt he could have done a better job. (Note: The subject was right handed).
4. The test subject could have benefited from more familiarization with the PATK, Demonstration Test Panel, and the test sequence had time permitted.
5. During the initial coverall-mode runs with the rigid tether, the test subject was not properly balanced on the Five-Degrees-of-Freedom Simulator. He could not fit back into the body cradle due to interference with the tether belt. This was later rectified by mounting the belt on the outside of the cradle. The cradle was later modified for pressure-suited activities.
6. The kit was designed for pressure-suited, unpressurized-mode operation, however, the suited test was performed in the pressurized mode which provided good results. This allowed observations of worst-case conditions. It was felt that this would provide the greatest benefit and, had time permitted, the unpressurized mode also could have been performed.

7. It is recommended that 1-g tests be performed to study reach problems, look-angle limitations, one-handed operations, and task timing.
8. Gloved-hand operations did not present many problems (pressurized).

In general, the PATK design displayed many good features. The test results signified areas for investigation and improvement. A smaller and more specific kit for AAP Skylab application should be considered using the present PATK as a baseline reference.

DETAILED COMMENTS -

1. The test subject translation tasks demonstrating the maneuverability and handle design of the PATK were easily accomplished in both the suited and coverall modes.
2. The attachment of the PATK to the Demonstration Test Panel was easily accomplished in the coverall mode but difficulty was experienced and considerable time consumed before attachment could be made by the suited test subject. The mockup attachment boom did not adequately demonstrate the ultimate design principle. The pin attachment device could be improved by a different pin handle and incorporation of a lead-in on the device. Such features could have been built into the mockup but only at greater expense than was allowed for mockup fabrication.
3. The PATK translation and attachment tasks illustrated the need for several tether points on the kit exterior. These are needed for kit-to-man and kit-to-worksite flexible tether attachment points.

4. It appears that a more rigid kit-to-worksite attachment device may be needed. Neutral buoyancy tests should be run to confirm this point. A possible solution is to provide lockable joints at each end of the telescoping boom rather than using a fixed friction joint. Another possibility would be to provide hand holds on the kit such that the reaction force could be applied by a crewman with his free hand. Still another possibility is to provide separate tethers to act as guy lines augmenting the rigid boom.
5. All corners on all kit edges and components should be well and smoothly rounded. This was apparent in the handle area.
6. For worksite operation, a rigid tether for the man is a must. The flexible tether proved to be of little help. A combination of restrained feet ("Dutch"shoes) and a rigid waist tether is highly recommended.
7. The location of both the larger and small spares stowage devices requires more study to ensure expedient spares handling by crewmen. A neutral buoyancy study of the tasks involved is recommended. The type of man-to-worksite restraint and kit-to-worksite restraint will greatly effect the locations. The present locations may be more acceptable in a 0-g environment. The need for larger, more flexible spares stowage pouches was also evident.
8. The front door design concept is good; however, the mockup door required two hands for closing operations. The concept of fixed positions at 10-degree increments appears good;

however, an easy lock-unlock mechanism should be utilized. All other panels were easily operable; however, the latching mechanisms deserve further study.

9. The cords for the mockup portable lights were in the way of certain operations. This can be corrected by relocation of the light receptacles and the flexible attachment arms. More light attachment arms may also help.

10. More study is required of tool locations with respect to frequency of use; also, tool holders should not require orientation of the tool prior to replacement in the PATK. Tool sizes should also be made readily apparent.

11. More study is required in the area of tool tethering. Whether all independent tools need tethering is not at this time clear.

12. The electrical test probes could be easily removed and replaced from storage with the test subject in the coverall mode. The container for the probes should allow easy repeatability of the remove-replace task. Gloved-hand replacement was difficult. A set of probes with jack pins on both ends is required. The set used for demonstration used jack pins on the multimeter end, and probe pins on the other. The result was that the probe pins were inclined to fall out of the test jacks on the Demonstration Test Panel.

13. The multimeter, microfilm display, and test panel switches could be operated easily in both suited and coverall modes.

14. Sub-kit extending and retracting operations were effected; however, two hands were required. The latching mechanism of the sub-kit drawer did not exhibit good repeatability.

This latch will require a redesign. The rotating member of the drawer requires addition of a device to prevent rotation when removing or replacing a tool. The concept calls for detents at various intervals; however, a hand hold to provide the reactive force may be required. This would require two-handed operation but would be positive.

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