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FINAL REPORT

THE DESIGN, FABRICATION AND DELIVERY OF A SPACELAB NEUTRAL BUOYANCY INSTRUMENT POINTING SYSTEM (IPS) MOCKUP

CONTRACT NAS8-3[illegible]430

Prepared For:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Prepared By:

Charles N. VanValkenburgh
ESSEX CORPORATION
3322 South Memorial Parkway
Huntsville, Alabama 35801

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FOREWORD

This final report describes work performed under contract NAS8-35480. The report describes contract activity involving development and support of the Instrument Pointing System (IPS) underwater trainer.

Essex Corporation appreciates the opportunity to develop the IPS trainer under this competitively acquired contract and looks forward to serving NASA on contracts in the future. We would like to extend our thanks to Richard Heckman for support and guidance throughout the contract.

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ACRONYMS AND ABBREVIATIONS

CCP	Charge and Current Probe
COR	Contracting Officer's Representative
DCIU	Digital Control and Interface Unit
EPF	Equipment Platform
EVA	Extravehicular Activity
FPEG	Fast Pulse Electron Generator
GSS	Gimbal Support Structure
IPS	Instrument Pointing System
JSC	Johnson Space Center
MLI	Multilayer Insulation
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NBS	Neutral Buoyancy Simulator
OSP	Optical Sensor Package
PAR	Payload Attachment Ring
PCA	Payload Clamp Assembly
PCU	Payload Clamp Unit
PGSM	Payload Gimbal Separation Mechanism
PRD	Payload Rentention Device or Passive Radiation Detector
PVC	Polyvinyl Chloride
SL-2	Spacelab Two Mission
SRPA	Spherical Retarding Potential Analizer
STS	Space Transportation System
VCAP	Vehicle Charging and Potential
VFI	Verification Flight Instrumentation
WETF	Weightless Environment Test Facility

1.0 INTRODUCTION

1.1 BACKGROUND

The NASA Space Transportation System (STS) requires all payloads to be two failure tolerant with no hazard to the Orbiter or crew. During IPS design review, it was found that certain conditions could cause Category 1 critical hazards without meeting the two failure tolerance criteria. For this reason, verification based on underwater simulations of EVA contingency operations (manual jettison, payload disconnect, payload clamp actuation and others) was specified. Two series of simulations (tests) were conducted in the MSFC Neutral Buoyancy Simulator (NBS) using the IPS trainer (see Figure 1, 2) provided under this contract.

The first test series was used to define crew aid needs such as handrail and foot restraint locations. This series was also used to define mockup peculiarities and characteristics to verify the validity of simulations using the trainer.

For the second test series flight configuration crew aids, fabricated during the interim period, were installed on the trainer. These were determined by the SL-2 EVA crew (S. Musgrave, T. England) to be suitable aids in the fulfillment of IPS EVA procedures (See Appendix A).

Additionally, during the second series of tests, a set of mockup IPS Contingency Struts were tested. Based on test findings minor modifications and refinements were made to the struts until finally, flight configuration struts were tested and verified to be operable by the flight crew.

It is expected that the IPS trainer, developed in fulfillment of this contract effort, will be used by the flight crew for dress rehearsals of the IPS EVA contingency tasks in the JSC Weightless Environment Test Facility (WETF). IPS trainer simulations will also be used in the development and refinement of crew procedures.

1.2 SCOPE

In fulfilling the underwater trainer needs for the IPS EVA contingency tasks it was determined that the items listed below were to be provided under contract. Most of the items listed are described in the original contract scope of work although some items deemed necessary after the onset of the contract were added through contract modifications.

- o IPS Gimbal System
- o IPS Payload
- o IPS Payload Clamp Aassembly (PCA)
- o Spacelab Pallet (pallet one of SL-2 three pallet arrangement)

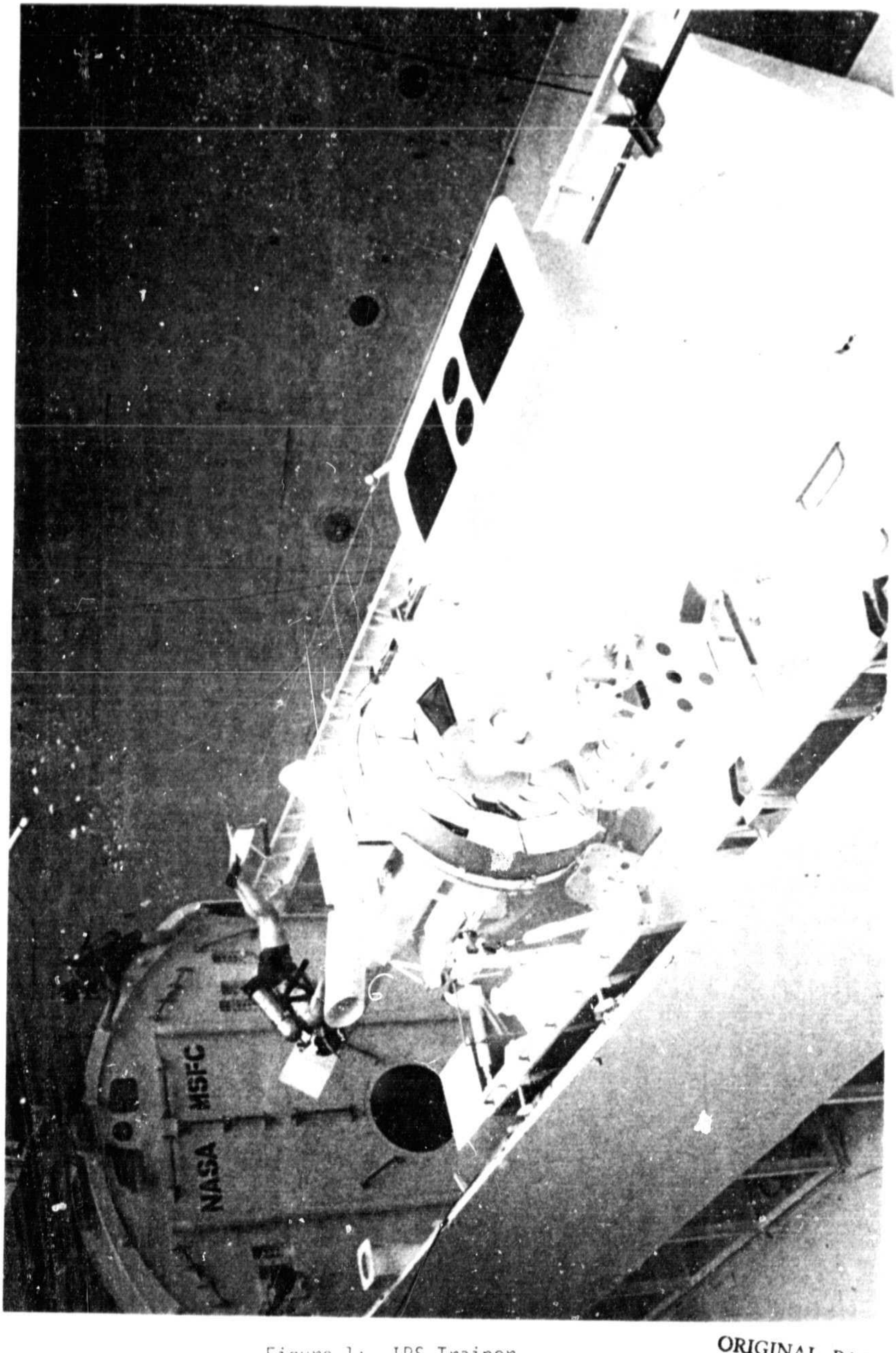

Figure 1: IPS Trainer

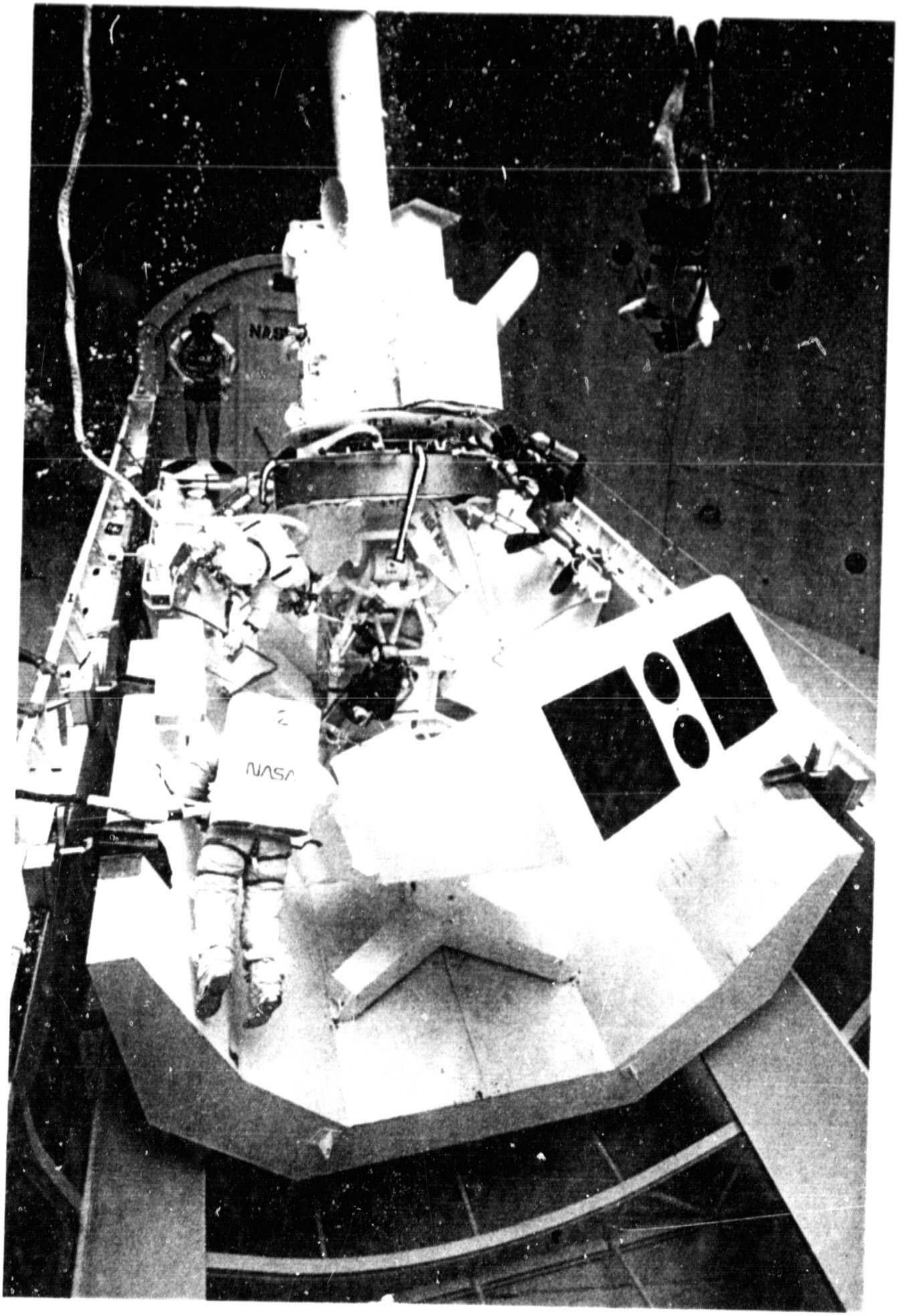

Figure 2: IPS Deployed Configuration

- Igloo (Volumetric)
- Other Pallet One Experiments and Hardware (Volumetric)
- Experiment 7
- Pallet Two Experiments and Hardware (Volumetric)
- EVA Hand Tools
- EVA Support Hardware (Handrails, Foot Restraints)
- Test Plan Preparation
- Test Support

The following sections describe the end items listed above in more detail, describe the tasks involved in the development of the end items, and conclude by presenting information gained through this contract effort and recommendations for future use of the trainer.

2.0 TECHNICAL APPROACH

In fulfilling contract responsibilities, Essex performed the five tasks described below.

2.1 TASK 1 - MOCKUP DESIGN

At the onset of the contract, Essex received IPS and related hardware drawings, photos and other documentation from the COR. This documentation was reviewed to define missing information and discrepancies which may have occurred due to design changes, etc. A request of drawings and information which had yet to be received or for which clarification was required was made to Dornier through the COR.

As drawings were received from NASA, Essex designers began discussing possible trainer configurations with the COR. Concept sketches of mockup systems and components were then prepared and presented to the COR for approval. Once concept sketches were approved, engineering drawings of the individual mockup parts were prepared.

2.2 TASK 2 - FABRICATION AND ASSEMBLY

The engineering drawings of the IPS trainer parts developed in Task 1 were submitted to the Essex Shop. The parts were fabricated of materials and fabrication techniques best suited for simulations in the underwater environments of the MSFC NBS and the JSC WETF.

The primary fabrication material for the mockup was 6061-T6 aluminum with 5052-H32 aluminum used where a bent sheet or plate was required. ABS plastic was used in areas which were required to be lightweight yet somewhat rigid (ex. star tracker cones). All fasteners were either stainless steel rivets or stainless steel bolts with brass nuts used to prevent galling. Bronze was used on bearing surfaces because of its resistance to corrosion and low coefficient of friction. In addition, the materials listed below were used for special applications.

Material	Application
Herculite 80	Simulates Beta-Cloth Insulation
Scotchmate Dual Lock Fastener SJ-3441	Water Compatible Velcro
17-4ph Stainless Steel	Jettison Bolts, Jettison Tool

Fabrication techniques reflected fidelity needs of the trainer. For instance, areas which required immediate crew interface were machined to accurately represent the flight hardware. Similarly, areas which needed to only represent a hardware item volumetrically were fabricated of bent or welded aluminum sheet or of an aluminum angle frame covered with Herculite 80. Corners and edges of al' parts were radiused to meet standards in MSFC-STD-512A.

When the major trainer parts were completed they were bolted or welded together for a fit check. Since it was known that the IPS gimbal system and IPS payload were to be neutralized, many of the large structural tubes were sealed by welding, then leak checked. Additionally, the hardware was fitted with mounting tabs for installation of sealed PVC tubing flotation.

The parts were then given surface finish treatment. Surface finish of the parts included combinations of anodizing: clear, red or hardcoat and/or painting with white, clear or yellow Plasite paint according to JSC WETF specifications.

The IPS trainer was then assembled and once approved by the COR, was ready for delivery.

2.3 DELIVERY AND INSTALLATION (MSFC)

The trainer was delivered to MSFC Building 4705, the Neutral Buoyancy Simulator and installed in the water. The IPS gimbal system and payload and Experiment 7 were then neutralized. Since these items were already fitted with flotation based on weight calculations, neutralization was just a matter of attaching small amounts of flotation and weights in strategic locations to achieve the desired effect. Neutralization of the IPS gimbal system was particularly difficult because of the three-axis rotation capability.

With the neutralization complete, all mechanisms and crew operated systems were tested by the COR to verify proper operational characteristics. As the hardware was tested, fine adjustments were made and handrails and foot restraints were mounted based on preliminary determinations of location.

2.4 TASK 4 - TEST SUPPORT

Test support by Essex included preparation of a test plan (See Appendix A) as well as support from divers in the water and personnel in the control room at the NBS. During IPS testing, Essex divers insured that hardware was set-up for each test operation and stood by to fetch tools or take measurements for placement of crew aids as needed. Between tests, Essex made hardware modifications for which the needs arose during testing. Essex personnel in the NBS control room read procedures, documented test subject comments and recommendations, and answered questions as required. Essex supported IPS testing during the December 1 - 14, 1983 and the April 26 - May 3, 1984 test series.

2.5 TASK 5 - DELIVERY AND SETUP (JSC)

Following NBS testing, Essex disassembled the hardware for shipping. The trainer hardware was packed and shipped to JSC by NASA. Once the hardware arrived at JSC, Essex personnel went to reassemble it. All pallet one hardware was installed on the pallet. Pallet two hardware, for which a pallet does not currently exist, was match-drilled on a JSC-supplied pallet for later installation by JSC personnel.

A demonstration was then given to JSC WETF personnel of the operation and maintenance of the trainer.

3.0 END ITEM DESCRIPTION

The IPS trainer supplied by Essex represents all of the pallet one Spacelab 2 hardware including the pallet, Experiment 7 and the hardware located on the forward end of pallet 2, EVA tooling and spare parts. A detailed description of the hardware is given below.

3.1 IPS GIMBAL SYSTEM (see Figure 3)

The IPS gimbal system trainer represents the flight version gimbal system volumetrically with many structural and detail similarities. High fidelity is found in the following areas of expected crew interface: Jettison Bolts and tool guides, Harness Separator, Payload Gimbal Separation Mechanisms (PGSM); electrical connectors and removable Multi-layer Insulation (MLI) and handrails. All three of the gimbal joints are movable and may be locked in place by support divers using a one inch open end wrench. The mockup is neutrally buoyant in all orientations regardless of gimbal joint positions.

3.2 IPS PAYLOAD (see Figure 4)

The IPS payload is a volumetric mockup. Its base is a rigid aluminum frame covered with fabric. The telescopes and avionics are represented in low fidelity of aluminum sheet or an aluminum frame covered with fabric (depending on their size and complexity). The mockup is equipped with high fidelity trunnion fittings, PRD attach loops and Manual Span Band (payload release) EVA interface. The actual payload release is effected by a diver-operated mechanism on the aft end of the payload. The payload is neutrally buoyant in all orientations.

3.3 SPACELAB PALLET

A Spacelab pallet was supplied under a contract modification to which all the pallet one trainer hardware was mounted. The pallet, like the previous pallets supplied to NASA by Essex, is sturdy and dimensionally correct, constructed of .125 in thick aluminum. To it are attached flight configuration trunnion fittings (4) and handrails (6). It is painted with white Plasite paint to MSFC NBS and JSC WETF specifications.

3.4 PAYLOAD CLAMP ASSEMBLY (PCA)

The PCA is similar in construction to the flight-version PCA. Strut assemblies and mounting details are configured as the flight hardware but welded construction was used to reduce fabrication costs. The payload clamp units are simple, volumetric representations of the flight hardware with accurate trunnion interface characteristics. The EVA aspect of the PCA actuator is accurately represented on the trainer with removable MLI and wrench interfaces which provide correct torque values.

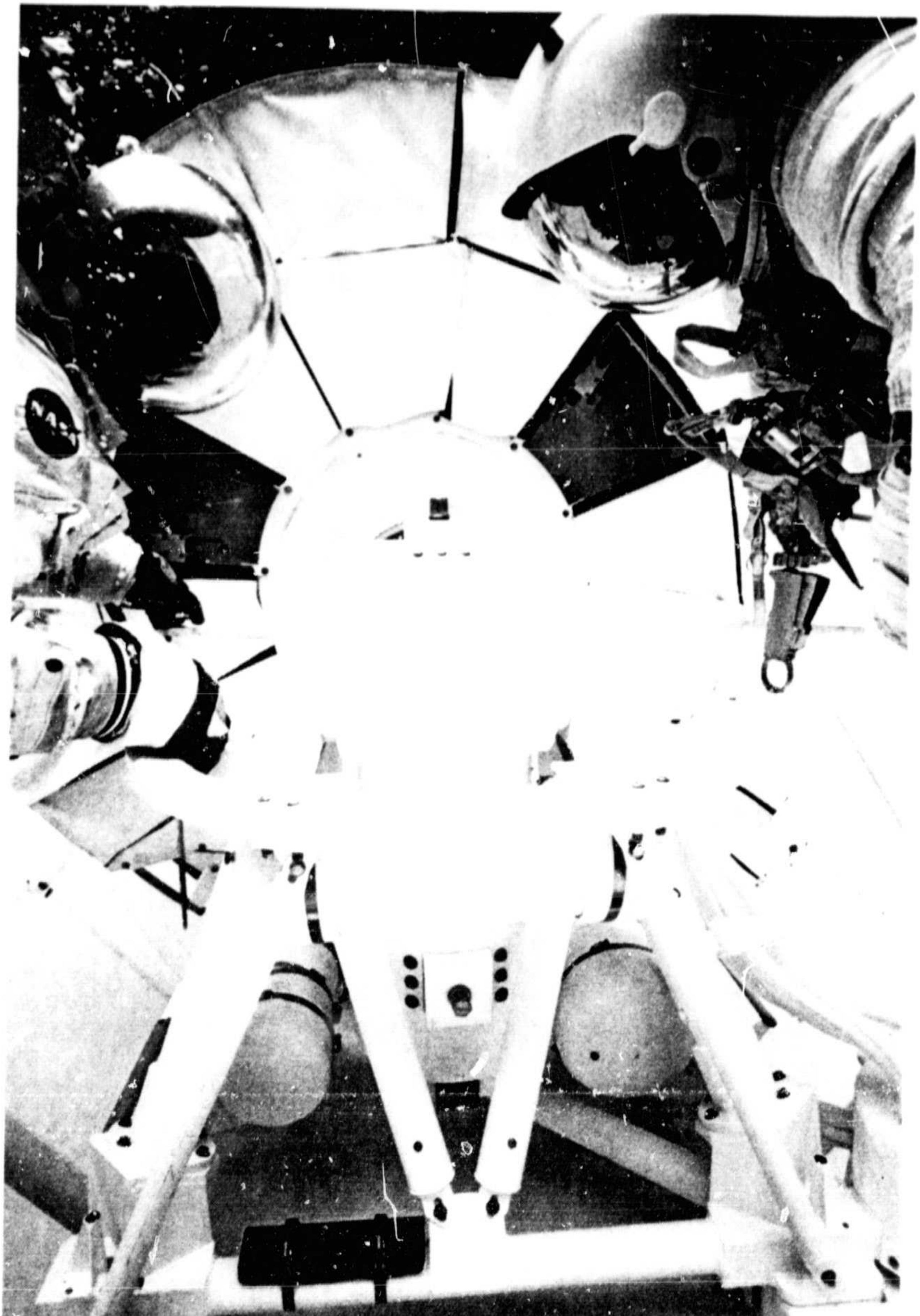

Figure 3: IPS Gimbal System

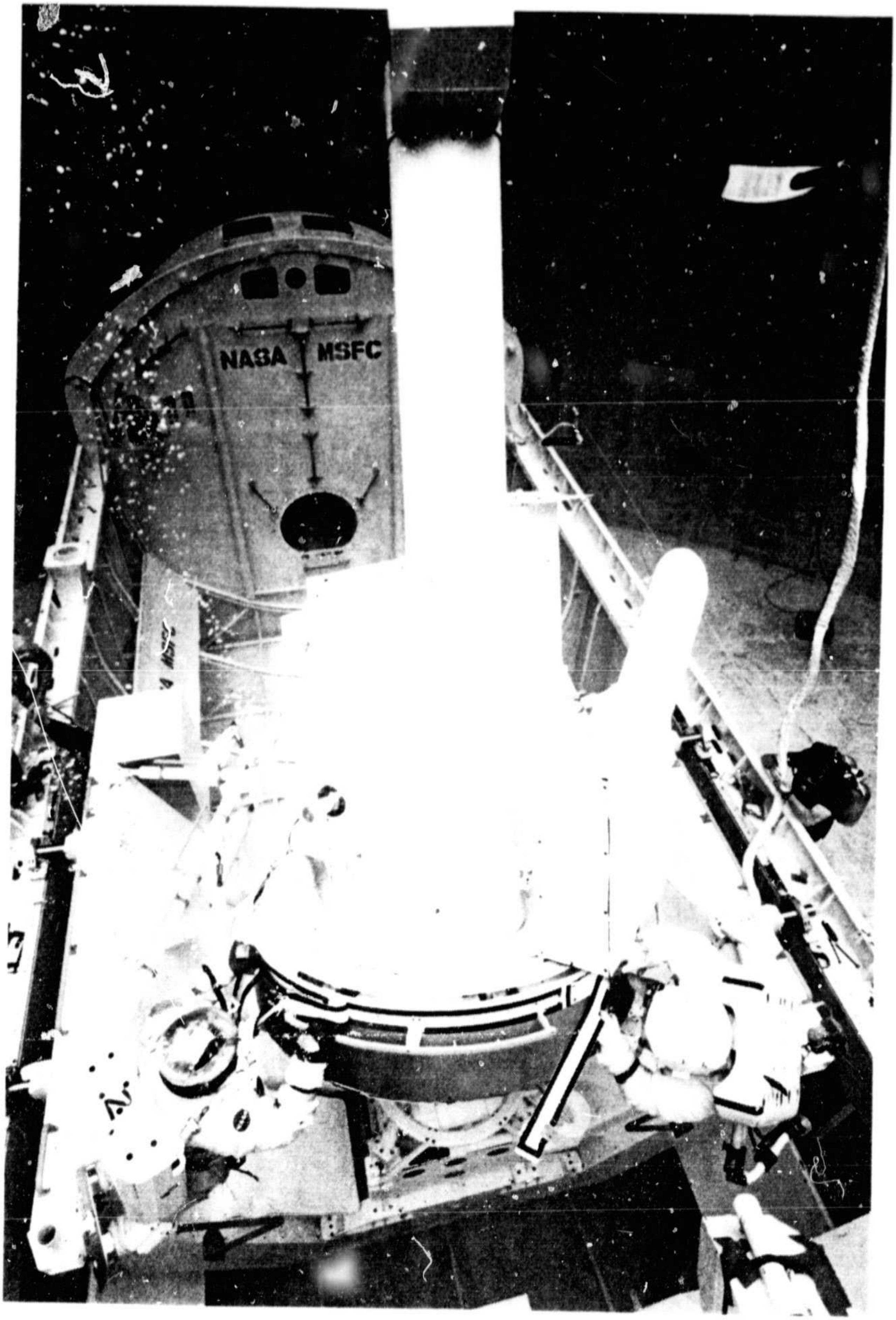

Figure 4: IPS Payload

3.5 IPS CONTINGENCY STRUTS

The contingency strut design was ongoing during IPS trainer development and testing in the NBS. Initially, Essex built a set of struts under a contract modification per MSFC drawings and installed them on the trainer. During NBS testing the need for refinements and improvements was made evident. These design modifications which were reflected on the trainer struts involved: stowage receptacle, swivel base, turnbuckle thread series and jam nut configuration modifications.

Later, after flight configuration drawings were completed, Essex prepared a starboard side set of contingency struts for installation on the SL-2 mockup in Building 4612. The struts, which were fabricated under another contract modification, were used to verify clearance between the struts and other pallet one hardware items.

3.6 EXPERIMENT 7 (see Figure 5)

The Experiment 7 mockup has the same yaw and roll capability of the flight version experiment. It is a low fidelity, volumetric mockup with the exception of the launch lock EVA override. The lock has the same operational characteristics of grip, squeeze and rotate to lock/unlock as the flight unit. It has a high-fidelity handrail with tether loop for attachment of the PRD for simulation of tieing the experiment down for return-to-earth. The entire mockup is covered with Herculite 80 fabric to simulate Beta cloth insulation.

3.7 IGLOO AND ADJACENT HARDWARE ITEMS (see Figure 6)

The trainer items which were not expected to receive direct crew interface such as spacelab subsystem equipment were represented volumetrically. These items were fabricated using either bent or welded aluminum sheet or aluminum frames covered with fabric. Most of these items are illustrated in Figure 6.

3.8 SUPPORT HARDWARE, TOOLS AND SPARE PARTS

Support hardware which was provided under contract includes: foot restraints (2), space telescope type foot restraint receptacles (8), adjustable foot restraint mount brackets (6), permanent foot restraint mount brackets (2), handrails (15 total), and Passive Radiation Detector (PRD) attach brackets (2).

The following tools were provided: IPS jettison tool, EVA connector tool (loop pin puller), PCA actuator tool, contingency strut wrench and two worm gear tools (diver operated).

Spare parts were also provided with the trainer. These include: jettison bolts; jettison tool end effector, electrical connectors with cables, PGSM actuator cables, PGSM springs; spring detents (used on harness separator, electrical connectors and manual span band) and scotchmate dual lock fastener (bulkrolls).

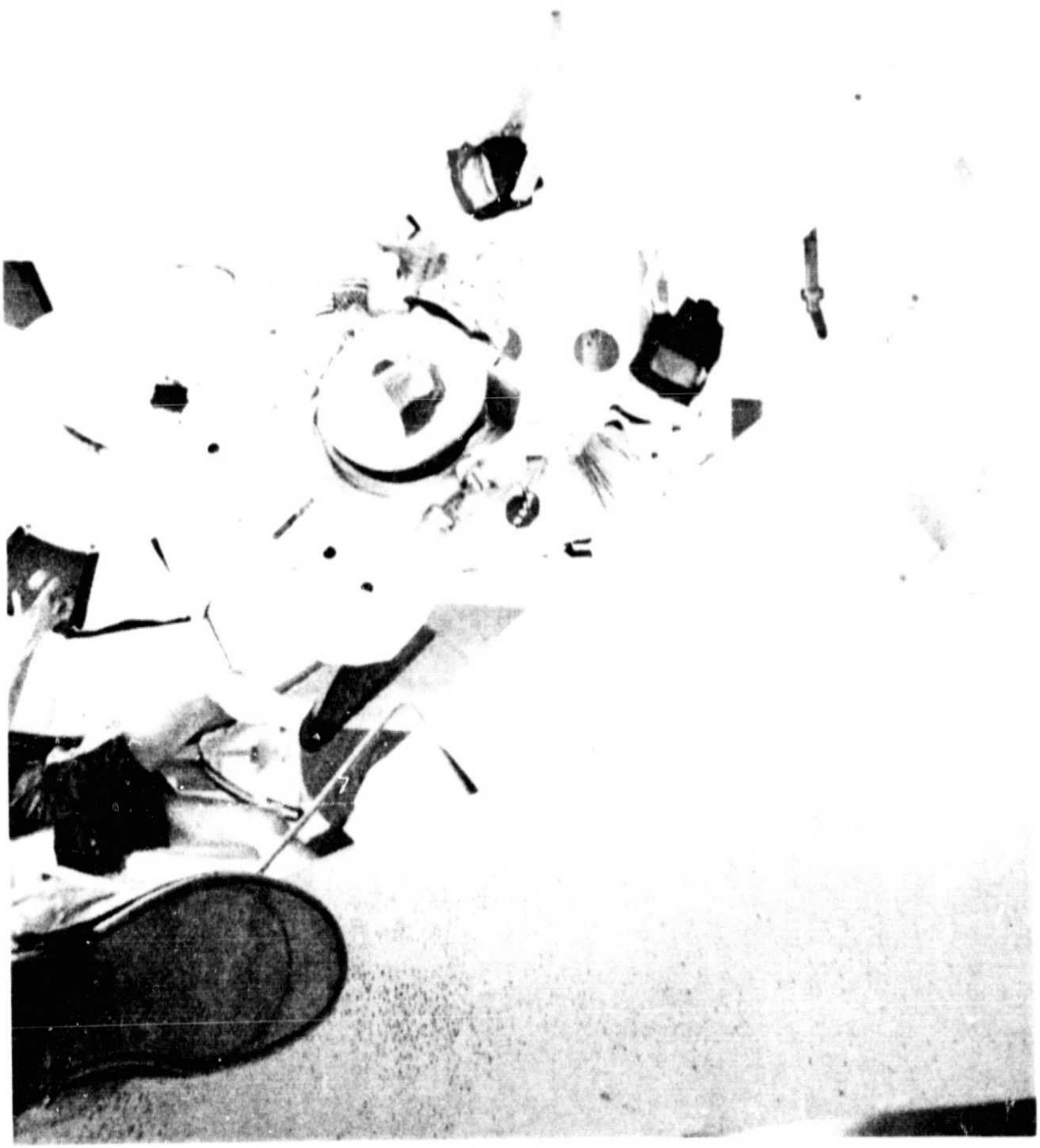

Figure 5: Experiment 7

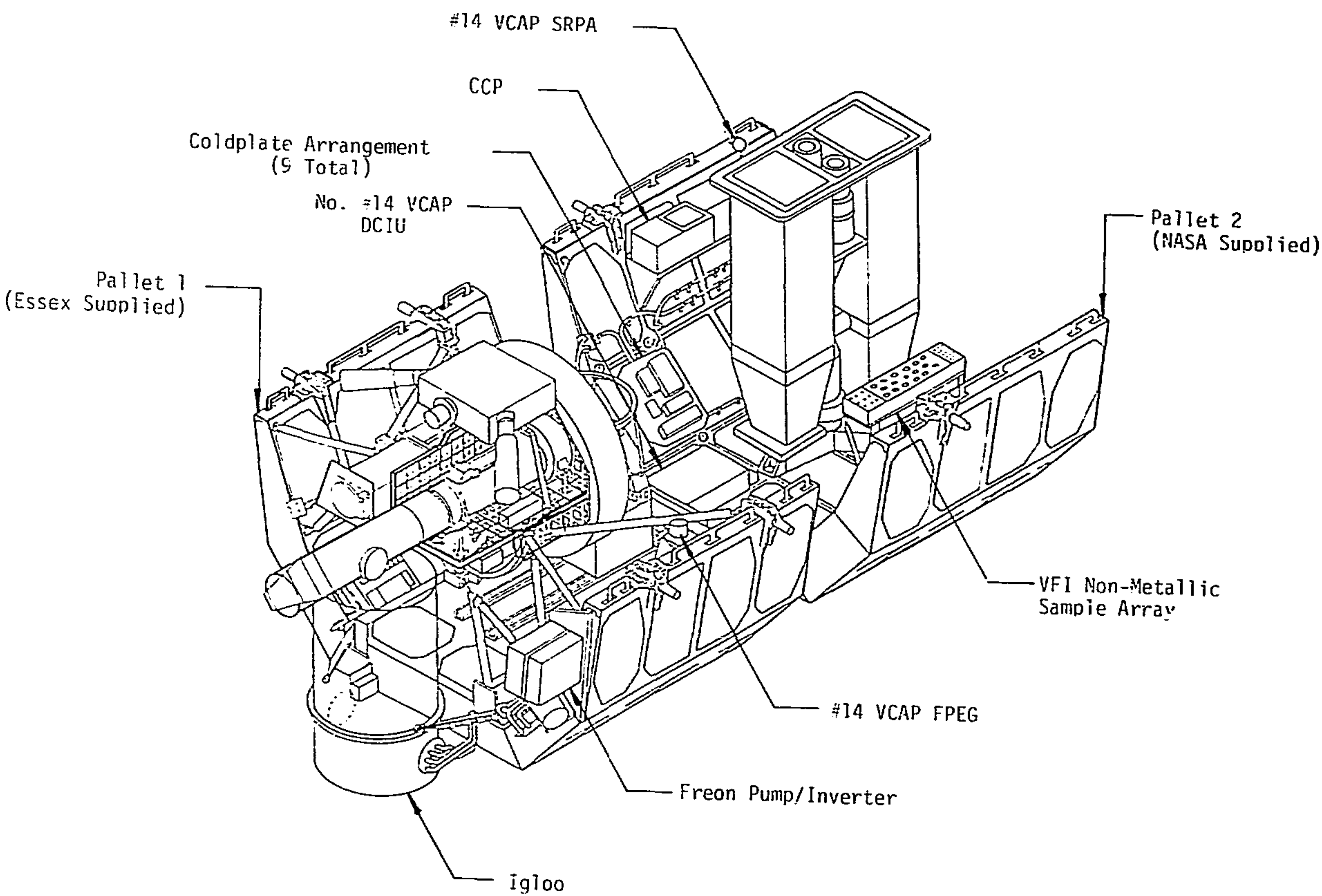

Figure 5. IPS Trainer Illustration Showing Igloo and Adjacent Hardware Items

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following sub-section, 4.1 Conclusions, is an evaluation of the operational feasibility of EVA tasks based on results of Neutral Buoyancy testing. Also included in this section are recommendations for future use of the trainer.

4.1 CONCLUSIONS - IPS EVA VERIFICATION AND SL-2 EXPERIMENT 7 EVA VERIFICATION

Assisted Jettison - Foot restraint positions and handrail locations were satisfactory. No changes to the flight design which reflected recommendations from developmental testing were required.

Harness separator actuation was simple and presented no problems. It was noted that this actuator serves as a backup to the pyro circuitry but does not provide a redundant method of physically separating the harness.

The separation bolt removal was accomplished without any difficulty. The tools provided by Dornier were satisfactory. No changes were recommended.

The possible failure of the PGSM with the IPS partially in the clamps was simulated and the entire IPS and payload was retracted from the clamps and jettisoned. It was felt that the jettison task should be performed by two crewmen but under emergency conditions could be performed by one crewman without risk to the crewman and with only slight risk of inadvertant minor contract with Orbiter or Spacelab payload bay structure during jettison.

Payload Disconnect - The circumferential handrail around the IPS equipment platform was very useful and in conjunction with the foot restraints, provided sufficient stability to perform this task. No changes were required.

The EVA electrical connectors were accessible using the Orbiter loop pin puller although a slightly longer tool would facilitate the task. The handles provided to pull back the MLI for access were satisfactory and the velcro on the EPF frame kept the MLI strip from interfering with operations. No changes were required. The operation to mechanically disconnect the payload was satisfactory. The tool interface for the Essex 3/8 drive wrench was well marked and tool operation was straight forward. No changes were recommended.

Payload Retraction - The handrails on the payload clamp struts were adequate for access to the work area for this task and for stability during PRD attachment and operation. PRD installation and operation was no problem. It is not possible to retract the payload very far before cocking of the payload causes the PGSM cable mounts to contact the EPF and impede further retraction. This is not a problem because it is only necessary to retract the payload such that the PGSM springs are no longer forcing the payload against structure, thus allowing jettison without danger of any stored energy in the PGSM springs. No changes were recommended.

Payload Clamp Actuation - The handrails on the payload clamp struts were satisfactory for operating the EVA payload clamp actuator. The sun shades on the OSP do not extend into the work area required for payload clamp actuation although they are close. The handle on the MLI cover was satisfactory for removal and the velcro on the cover held the cover out of the way for operations. The Dornier provided tool was satisfactory. Nomenclature was satisfactory. No changes were recommended.

Contingency Struts - The handrails on the payload clamp struts are sufficient for installation of the contingency struts. No additional handrails are required. The mini workstation tether was useful for maintaining a stable position during operations. Some contact was made with the sun shades during the installation of the forward struts but according to Story Musgrave and Tony England, the SL-2 EVA crew, this could be controlled and would not affect the installation or be a hazard to operations.

Wrench operations to loosen and tighten the locking nuts were performed without difficulty and the adjustment of the length of the struts was accomplished satisfactorily. During the course of the verification testing, several changes were recommended and were implemented into flight documentation and the trainer prior to final test runs with the flight crew as a result of NBS testing. These changes included a scheme to prevent rotation of the aft strut while rotating the turnbuckle, an alignment aid for the strut end fittings (see Figure 7)to compensate for limited visual access while installing the "Pip" pins, and other minor changes. No further changes were recommended.

Experiment 7 - The EVA operations to release the launch lock and to tie Experiment 7 in a safe position for return or for continued IPS operations were performed satisfactorily.

The handhold on Experiment 7 was useful for positioning the telescope. The cables and cable support brackets located just to port of the telescope served as mobility and stability aids for unlocking and relocking the telescope. Installation of the PRD to the tether loop on the telescope and to the pallet under the VFI Materials Sample Array was no problem and it was verified that tightening the Payload Retention Device (PRD) placed the telescope in the desired position. No changes to either task were recommended.

4.2 RECOMMENDATIONS

Included with this report are Appendix A - IPS Mockup Acceptance Test Plan and Appendix B - IPS Underwater EVA Trainer Maintenance Manual. Appendix A includes a set of procedures for IPS EVA tasks which, though not a final set of procedures, gives insight into IPS EVA operations. Appendix B is a maintenance manual for use by JSC personnel to keep the IPS trainer operational.

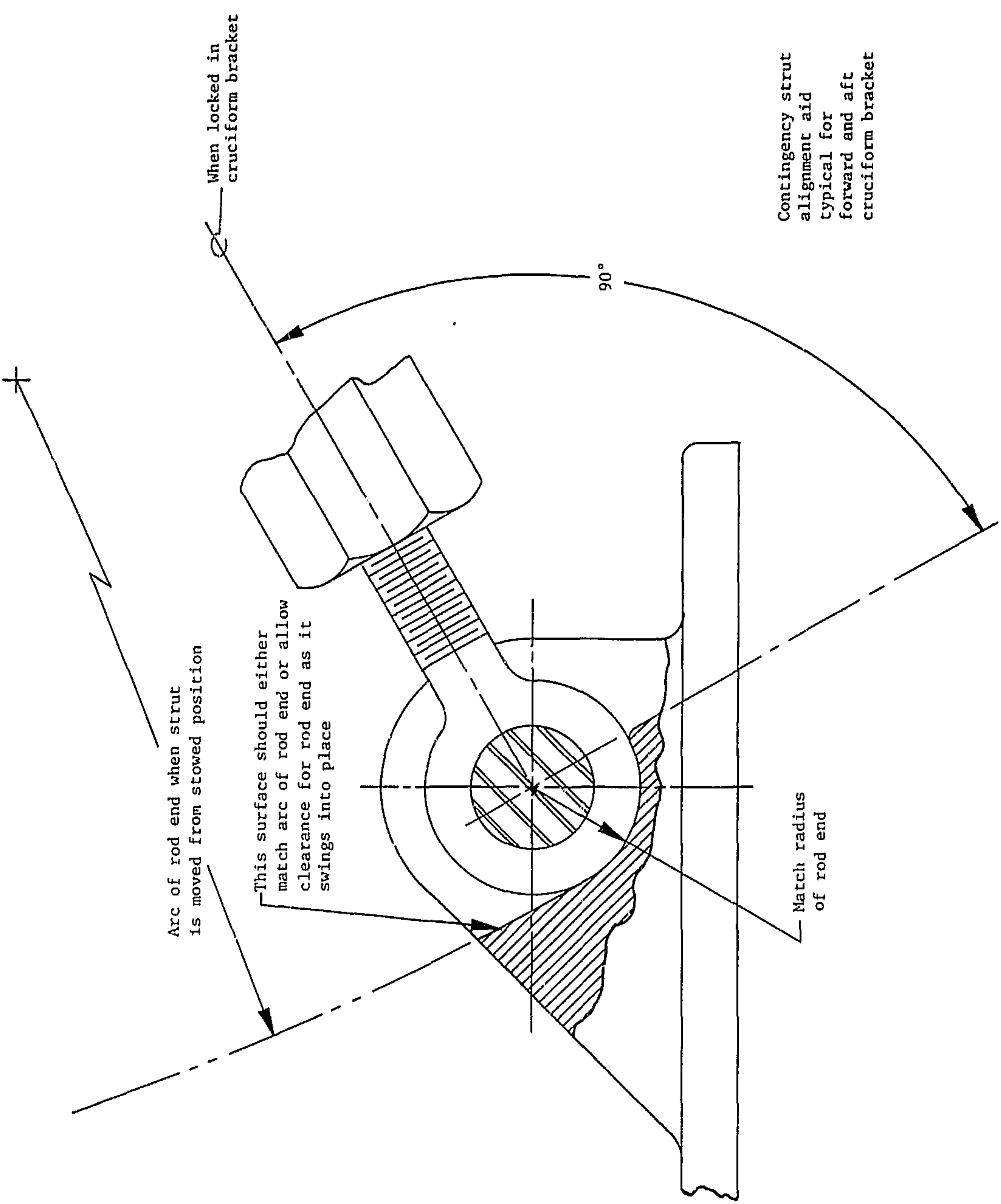

FIGURE 7: CONTINGENCY STRUT ALIGNMENT AID

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ACRONYMS AND ABBREVIATIONS

CCP	Charge and Current Probe
COR	Contracting Officer's Representative
DCIU	Digital Control and Interface Unit
EPF	Equipment Platform
EVA	Extravehicular Activity
FPEG	Fast Pulse Electron Generator
GSS	Gimbal Support Structure
IPS	Instrument Pointing System
JSC	Johnson Space Center
MLI	Multilayer Insulation
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NBS	Neutral Buoyancy Simulator
OSP	Optical Sensor Package
PAR	Payload Attachment Ring
PCA	Payload Clamp Assembly
PCU	Payload Clamp Unit
PGSM	Payload Gimbal Separation Mechanism
PRD	Payload Rentention Device or Passive Radiation Detector
PVC	Polyvinyl Chloride
SL-2	Spacelab Two Mission
SRPA	Spherical Retarding Potential Analizer
STS	Space Transportation System
VCAP	Vehicle Charging and Potential
VFI	Verification Flight Instrumentation
WETF	Weightless Environment Test Facility

1. INTRODUCTION

1.1 BACKGROUND

This acceptance test is to be conducted as partial fulfillment of Contract NAS8-35480, Development of Spacelab Instrument Pointing System (IPS) Mockup (see Figure 1), by Essex Corporation. The objective of the test is to demonstrate in the Marshall Space Flight Center (MSFC) Neutral Buoyancy Simulator (NBS) that the Essex-prepared IPS Mockup functions to the satisfaction of the NASA contract monitor. The acceptance test will bring any problems with the mockup to the attention of Essex for repair or reconfiguration. Following acceptance of all mockup hardware by the contract monitor, the mockup will be shipped to Johnson Space Center (JSC) for training simulations as well as simulations involving further development of EVA support hardware items and procedures.

1.2 OBJECTIVES

The first days of testing will involve scuba-equipped test subjects. The test subjects will follow procedures set forth in Section 3 which will demonstrate that mockup hardware is functional and that hardware interface characteristics are correct. Foot restraints, assembly aids and tools will be used by the test subjects as needed.

The latter days of testing will involve pressure suit equipped personnel as test subjects. For this set of tests, the procedures set forth in this test plan may be adhered to or the test subjects may follow current IPS EVA crew procedures, submitted by the contract monitor as they are updated.

The objectives of these latter tests are to further verify mockup hardware function and to allow the contract monitor to become familiar with mockup fidelity and any mockup peculiarities.

This test plan is not intended to describe the detailed crew activities but describes the tasks necessary to demonstrate the operation of the IPS training equipment.

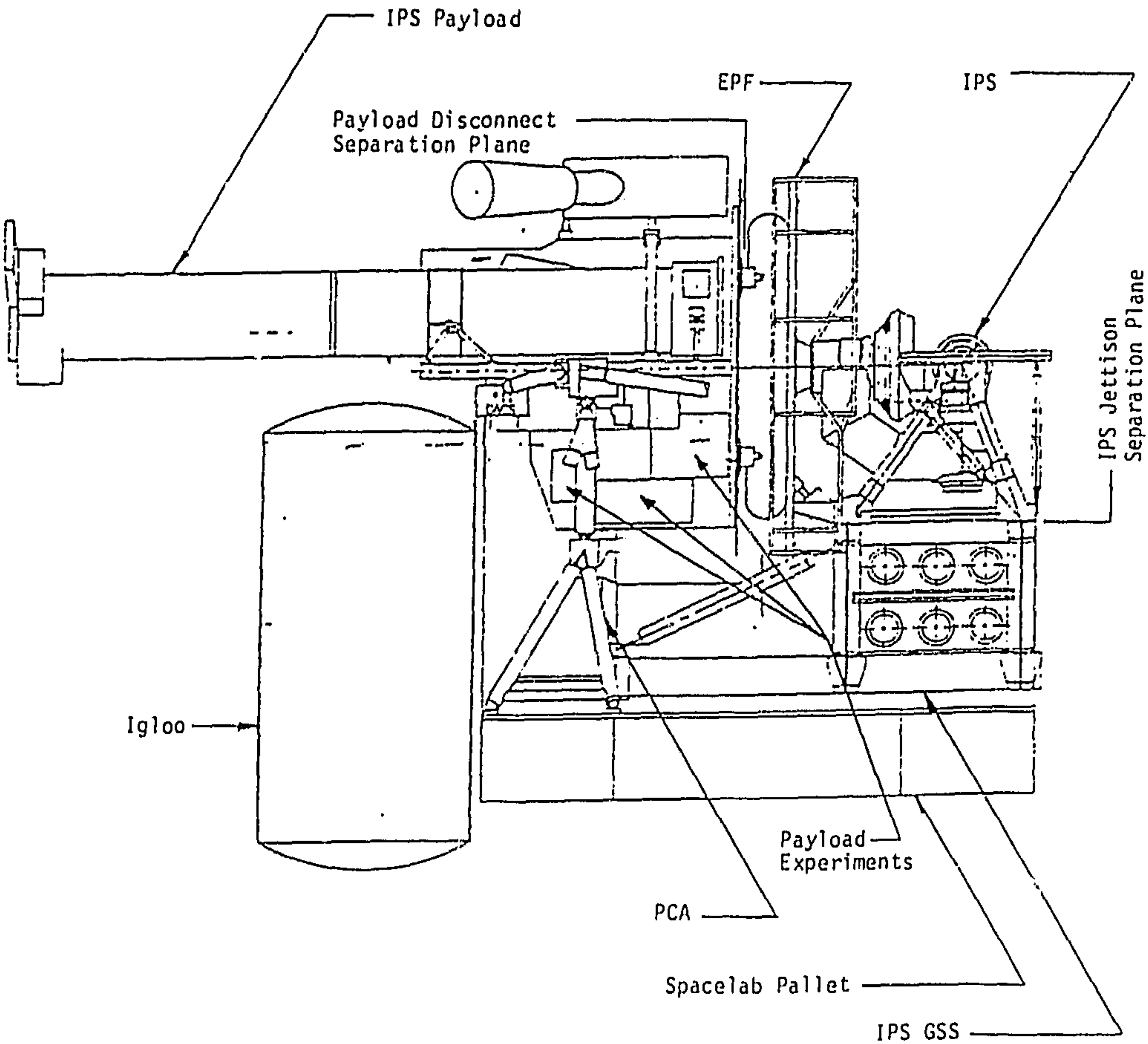

Figure 1: IPS Mockup

2. TEST SUMMARY

2.1 TEST EQUIPMENT

The test will involve the following Essex-prepared mockup hardware (See Figure 1):

<u>IPS Mockup</u>

- o Spacelab Pallet
- o IPS GSS
- o IPS
- o IPS Payload (Cruciform/Instrument Assembly)
- o Payload Clamp Assembly (PCA)
- o Igloo
- o Pallet Experiments

<u>EVA Support Tooling</u>

- o PCA Actuation Tool

2.2 ASSEMBLY AIDS

Required aids for the acceptance test will consist of:

<u>MSFC-Supplied Aids</u>

- o Adjustable foot restraints (two sets) as required for use by test subjects during testing
- o Floating crane (for positioning IPS mockup)
- o EVA ratchet wrench
- o Payload Retention Devices (PRD)(2)
- o Loop Pin Puller

<u>Essex-Supplied Aids</u>

- o Flotation and weights (various sizes for fine adjustments of mockup buoyancy).

2.3 SUPPORT PERSONNEL

Two Essex utility divers will be required for making hardware adjustments and buoyancy adjustments during the tests.

One MSFC test conductor will be required to instruct test subjects and record test data.

2.4 VIDEO EQUIPMENT

Stationary underwater video cameras and one swim camera will be required to provide acceptance test viewing capability to the test conductor and the contract monitor.

2.5 TEST SUBJECTS

Two scuba-equipped test subjects will be required for the first series of tests. Two pressure suit-equipped test subjects will be required for the latter tests. Test subjects will be equipped with MSFC-supplied A7LB suits.

2.6 INITIAL EQUIPMENT SETUP (see Figure 1)

The initial mockup configuration will consist of the Spacelab pallet located in the cargo bay mockup with the four trunnions (2 port and 2 starboard) located at station nos. 793.7 and 852.7. The IPS and IPS Payload will be configured in the launch (stowed) configuration (as shown in Figure 1). The IPS mockup will be installed by MSFC and Essex personnel.

3. TEST PROCEDURES

The IPS Mockup Acceptance Test procedure tasks are listed below. A detailed test plan is included as Appendix A.

3.1 IPS JETTISON TASKS

3.1.1 Actuate manual harness separation mechanism
3.1.2 Actuate four jettison bolts
3.1.3 Jettison IPS

3.2 PAYLOAD DISCONNECT TASKS

3.2.1 Remove Equipment Platform (EPF) thermal covers (5)
3.2.2 Demate umbilical disconnects
3.2.3 Actuate manual span band release
3.2.4 Jettison payload

3.3 MANUAL PCA CLAMP ACTUATION TASKS

3.3.1 Actuate multiple clamp actuation mechanism
3.3.2 Actuate individual clamp actuation mechanism

3.4 MANUAL PAYLOAD GIMBAL SEPARATION MECHANISM (PGSM) RETRACTION TASKS

3.4.1 Attach PGSM payload retention device (PRD) to EPF handrail standoffs and IPS
Payload
3.4.2 Pull IPS payload into engagement with EPF

Appropriate support tooling will be used by test subjects as they undergo operational procedures listed in Paragraphs 3.1 through 3.4.

4. DATA COLLECTION REQUIREMENTS

The test conductor will observe the operation of all IPS hardware items as acceptance test procedures are performed and record test results. Any unexpected results or observations will be recorded by the test conductor. No time data will be required for the acceptance test.

5. SAFETY CONSIDERATIONS

As the IPS mockup is tilted with the floating crane, all underwater personnel should be clear of the structures.

In the event of any non-functioning hardware items, Essex personnel should be notified immediately to determine the nature of the malfunction.

If the RMS mockup is used in conjunction with the acceptance test, safety procedures should be adhered to as presented in Standard Operating Procedure for this item.

APPENDIX A-A

Detailed IPS Mockup Acceptance Test Procedures

IPS MOCKUP ACCEPTANCE TEST PLAN

Date: ______ Test Director: ______ Test Subject 1: ______
Run No.: ______ Test Conductor: ______ Test Subject 2: ______

Task: 3.1 IPS Jettison - conditions: IPS failed in low position with insufficient clearance for flyaway

Tools & Assembly Aids Required: EVA ratchet, 5/16" hex drive socket, foot restraints (2)

STEP NO.	TEST SUBJECT 1	TEST SUBJECT 2	SUPPORT PERSONNEL	RESULTS	COMMENTS
	o Egress Airlock o Translate to Stowage Area o Obtain Foot Restraint and Jettison Tools - Ratchet Wrench - IPS Extension o Translate to Pallet Sill adjacent to IPS using Port PLDB Handrail o Install Foot Restraint for access to jettison bolts o Translate to Harness Separator and Actuate H.S. o Verify H.S. Separated o Translate to Foot Restraint and ingress o Unstow ratchet and extension and remove port jettison bolts (may require repositioning foot restraints)	o Egress Airlock o Translate to Stowage Area o Obtain Foot Restraint o Translate to Pallet Sill adjacent to IPS using Starboard PLBD Handrail o Install Foot Restraint for stabilization of released IPS o Ingress Foot Restraints and stabilize IPS using EPS Handrails o Stabilize IPS			

IPS MOCKUP ACCEPTANCE TEST PLAN

Date: ____________ Test Director: ____________________________ Test Subject 1: ____________________________

Run No.: __________ Test Conductor: ___________________________ Test Subject 2: ____________________________

Task: 3.1 IPS Jettison - conditions: IPS failed in low position with insufficient clearance for flyaway (Cont.)

Tools & Assembly Aids Required: EVA ratchet, 5/16" hex drive socket, foot restraints (2)

STEP NO.	TEST SUBJECT 1	TEST SUBJECT 2	SUPPORT PERSONNEL	RESULTS	COMMENTS
	o Egress Foot Restraints, remove restraints and reposition on starboard side				
	o Ingress restraints and remove jettison bolts on starboard side of IPS (may require repositioning restraint)				
	o Guide IPS out of Payload Bay	o Guide IPS out of Payload Bay			

IPS MOCKUP ACCEPTANCE TEST PLAN

Date: ____________ Test Director: ____________________________ Test Subject 1: ____________________________

Run No.: ________ Test Conductor: ____________________________ Test Subject 2: ____________________________

Task: 3.2 Payload Disconnect - conditions: PGSM or PCA failed such that payload stowage cannot be accomplished. Payload can be restracted from PCA's and erected

Tools & Assembly Aids Required: EVA ratchet, loop pin puller, foot restraints (2)

STEP NO.	TEST SUBJECT 1	TEST SUBJECT 2	SUPPORT PERSONNEL	RESULTS	COMMENTS
	o Egress Airlock o Translate to Stowage Area o Obtain Foot Restraint & Tools - Essex Ratchet - Loop Pin Puller o Translate via DLB Door H/R to Location Adjacent to erected IPS o Install Foot Restraint and Ingress F/R	o Egress Airlock o Translate to Stowage Area o Obtain Foot Restraint o Translate via PLB Door H/R to Location Adjacent to Erected IPS o Install Foot Restraint and Ingress F/R			

IPS MOCKUP ACCEPTANCE TEST PLAN

Date: ____________ Test Director: ____________________ Test Subject 1: ____________________

Run No.: ________ Test Conductor: ____________________ Test Subject 2: ____________________

Task: 3.4 Manual Payload Gimbal Separation Mechanism (PGSM Retraction) - conditions: IPS jammed against PCA housing or fully seated in PCA's and cannot be retracted. PCA's cannot be locked, both cases result in residual stored energy in PGSM springs

Tools & Assembly Aids Required: Payload Retention Device (PRD), foot restraints (2)

STEP NO.	TEST SUBJECT 1	TEST SUBJECT 2	SUPPORT PERSONNEL	RESULTS	COMMENTS
	o Egress A/L o Translate to Stowage Area o Obtain Foot Restraint and Payload Retention Device o Translate via PLBD Handrail to location adjacent to IPS equipment platform (EPF) o Install foot restraints o Ingress foot restraints o Install Payload Retention Device (PRD) to EPF Handrail o Extend PRD hook to attachment ring at IPS payload attachment flange (PAF) and install	o Egress A/L o Translate to Stowage Area o Obtain foot restraint and payload retention device o Translate via PLBD handrail to location adjacent to IPS EPF o Install foot restraints o Ingress foot restraints o Install PRD to EPF handrail o Extended PRD hook to attachment ring at IPS PAF and install			

IPS MOCKUP ACCEPTANCE TEST PLAN

Date: ______________ Test Director: ______________________________ Test Subject 1: ______________________________
Run No.: __________ Test Conductor: _____________________________ Test Subject 2: ______________________________

Task: 3.3 Manual PCA Clamp Actuation - conditions: Payload clamp actuator failed or shear pin in actuator gearbox failed such that key bolt or bolts not locked

Tools & Assembly Aids Required: PCA actuation tool, foot restraint

STEP NO.	TEST SUBJECT 1	TEST SUBJECT 2	SUPPORT PERSONNEL	RESULTS	COMMENTS
	o Egress airlock o Translate to stowage area o Obtain foot restraints and IPS EVA crank o Translate to payload clamp actuator area o Install foot restraints o Ingress restraints o Remove thermal blanket from EVA actuator I/F o Install crank on the crank I/F required by condition (all, left, right, bottom) o Turn crank as required until clamp condition required verified at OAFD				

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ACRONYMS AND ABBREVIATIONS

CCP	Charge and Current Probe
COR	Contracting Officer's Representative
DCIU	Digital Control and Interface Unit
EPF	Equipment Platform
EVA	Extravehicular Activity
FPEG	Fast Pulse Electron Generator
GSS	Gimbal Support Structure
IPS	Instrument Pointing System
JSC	Johnson Space Center
MLI	Multilayer Insulation
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NBS	Neutral Buoyancy Simulator
OSP	Optical Sensor Package
PAR	Payload Attachment Ring
PCA	Payload Clamp Assembly
PCU	Payload Clamp Unit
PGSM	Payload Gimbal Separation Mechanism
PRD	Payload Rentention Device or Passive Radiation Detector
PVC	Polyvinyl Chloride
SL-2	Spacelab Two Mission
SRPA	Spherical Retarding Potential Analizer
STS	Space Transportation System
VCAP	Vehicle Charging and Potential
VFI	Verification Flight Instrumentation
WETF	Weightless Environment Test Facility

INTRODUCTION

The following mechanisms which are found on the IPS WETF trainer must function correctly in order to provide proper EVA simulation. As described herein, some require routine maintenance, some must be reset prior to each simulation and some simply require that support personnel have a working knowledge in order to make repairs in the event of a failure.

This manual gives a description of what the maintenance items are and how maintenance is carried out. The illustrations give knowledge of the mechanism configurations and show internal working parts. Table I gives information on adjustment requirements for all of the mechanisms.

The mechanisms described in this manual are listed below:

1. IPS Gimbal Joints

2. IPS Jettison Bolts

3. Harness Separator

4. Payload Release (Manual Span Band)
   4.1 Payload Release (Diver Task)

5. Electrical Connectors

6. Payload Clamp Assembly (PCA)
   6.1 PCA Actuator
   6.2 Payload Clamp Units (PCU)

7. IPS Contingency Struts

8. Payload Gimbal Separation Mechanism (PGSM)

9. Experiment 7

1. IPS Gimbal Joints (See Figure 1)

The three gimbal joints allow the IPS to be positioned about three axes of rotation. Each of the three joints are provided with a diver-operated lock which consists of a 3.00 in. x 3.00 in. bronze friction block which may be tightened with the Lock Bolt using a 1" open end wrench. Periodically, the Lock Bolt should be removed and have a small amount of grease applied to its threads.

Each of the gimbal joints consists of a 10.75 in. o.d. pipe turning inside a 12.75 in. o.d. pipe with a bronze bearing ring permanently attached to the outer pipe. Since a loose fit exists between the bearing ring and the inner pipe, it is unlikely that maintenance of the joints will be required. In the event that a joint becomes stiff, however, grease may be forced into the joint from the outside. It is not recommended that the joints dismantled unless a major problem occurs.

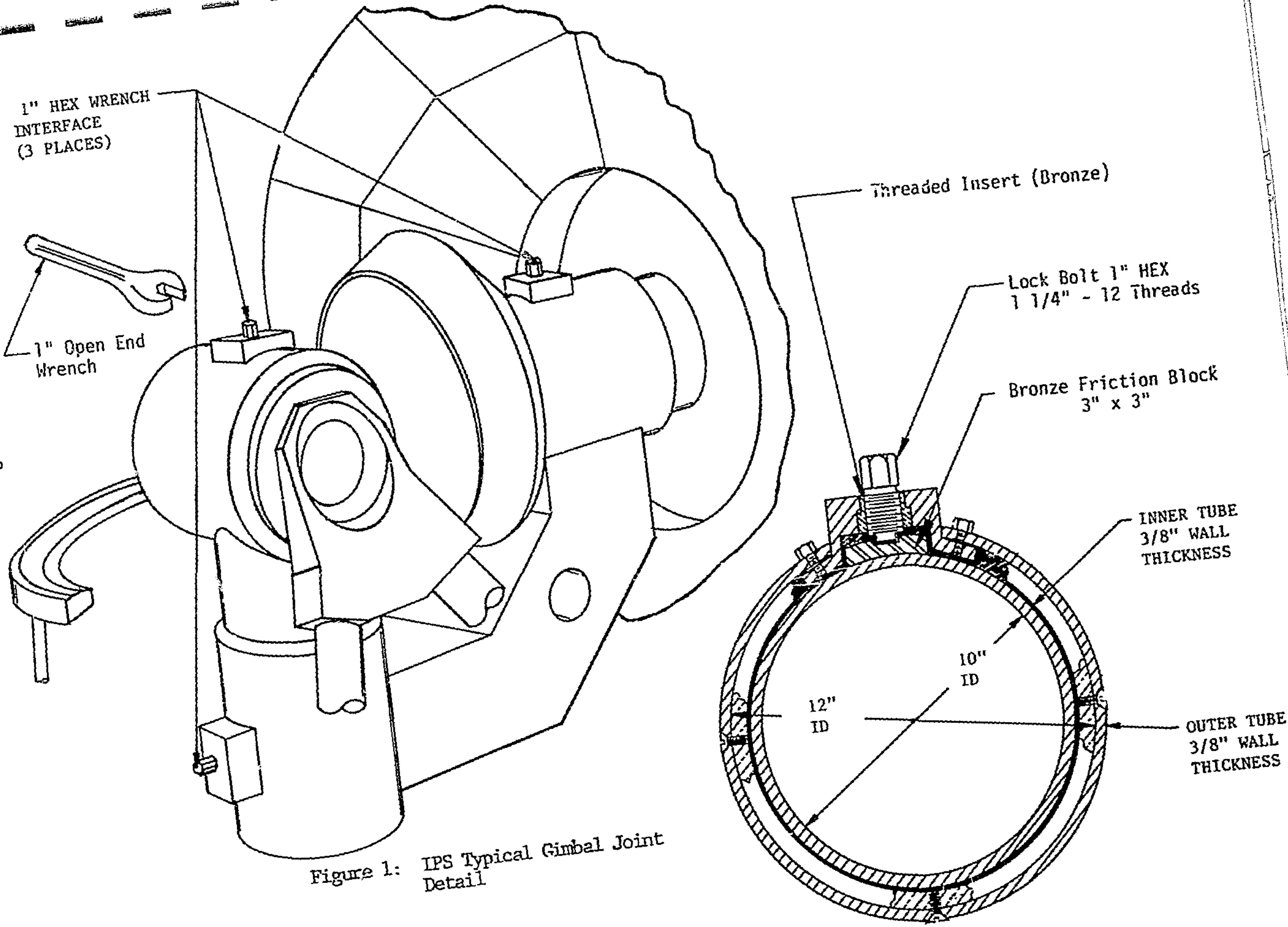


Figure 1: IPS Typical Gimbal Joint Detail

2. IPS Jettison Bolts (See Figures 2 and 3)

There are a total of four jettison bolts (2 forward, 2 aft) which attach the IPS gimbal system to the gimbal support structure. The bolts are used in an EVA task of separating the gimbal system from the support structure for IPS jettison. They are captive and permanently attached to the gimbal system.

The trainer jettison bolts are fabricated of 17-4 ph stainless steel hardened to 45 Rockwell. They have a 7/16-20 thread series and are activated by a 5/16" allen-head wrench (Jettison Tool). When attached they are screwed into a threaded bronze block mounted in a large aluminum block on top the support structure. The bolts are contained at each corner of the gimbal base by a red-anodized aluminum housing. They turn in a bronze cup and are spring loaded so they retract from the gimbal support structure when loose. A tool guide is mounted above the jettison bolt housing. The guide is mounted with four screws with shim washers used as needed to provide proper alignment for insertion of the jettison tool.

Since the jettison bolts are torqued to 45 ft. lbs. during a simulation, they are prone to failure. In the past, the failure has occurred in the head of the bolt and has involved either breakage of the head or rounding out of the 5/16" internal hex.

Since failure of the jettison bolt usually renders the jettison tool useless in removing the bolt from the gimbal support structure (GSS) it is necessary to dismantle the mockup before removing the bolt. This procedure is best done underwater since the IPS gimbal mockup is neutrally buoyant and its weight will not cause a hinderance.

To remove a failed bolt, first loosen all non-failed bolts with the jettison tool so they are free from the GSS. Then the aluminum block on top of the GSS to which the failed bolt is attached must be removed from the GSS by removing four 5/16" bolts. When this is done the IPS gimbal system will be free to lift off the GSS. The block should then be "unscrewed" from the jettison bolt using a large (approx. 4" jaws) wrench. The tool guide should then be removed with care taken to document the number of shim washers and their location under the guide. The jettison bolt housing may then be removed by removing two 1/4 in. nuts and bolts. The jettison bolt, bronze cups, and spring will then be free to be removed.

In replacing the jettison bolt, the bolt, bronze cups, spring and housing should first be reinstalled. The jettison bolt should then be bolted securely to the block which was removed from the GSS. The other three jettison bolts should then be bolted to the GSS. With the other bolts attached, the block will be properly aligned for re-attachment to the GSS by replacing four 5/16" bolts. With the newly replaced jettison bolt securely attached to the block, replace the bronze collar and the tool guide with the shim washers and screws but do not tighten. Insert the jettison tool through the tool guide and into the jettison bolt. While making sure the jettison tool is centered in the tool guide, tighten the screws attaching the guide. Remove and replace the jettison

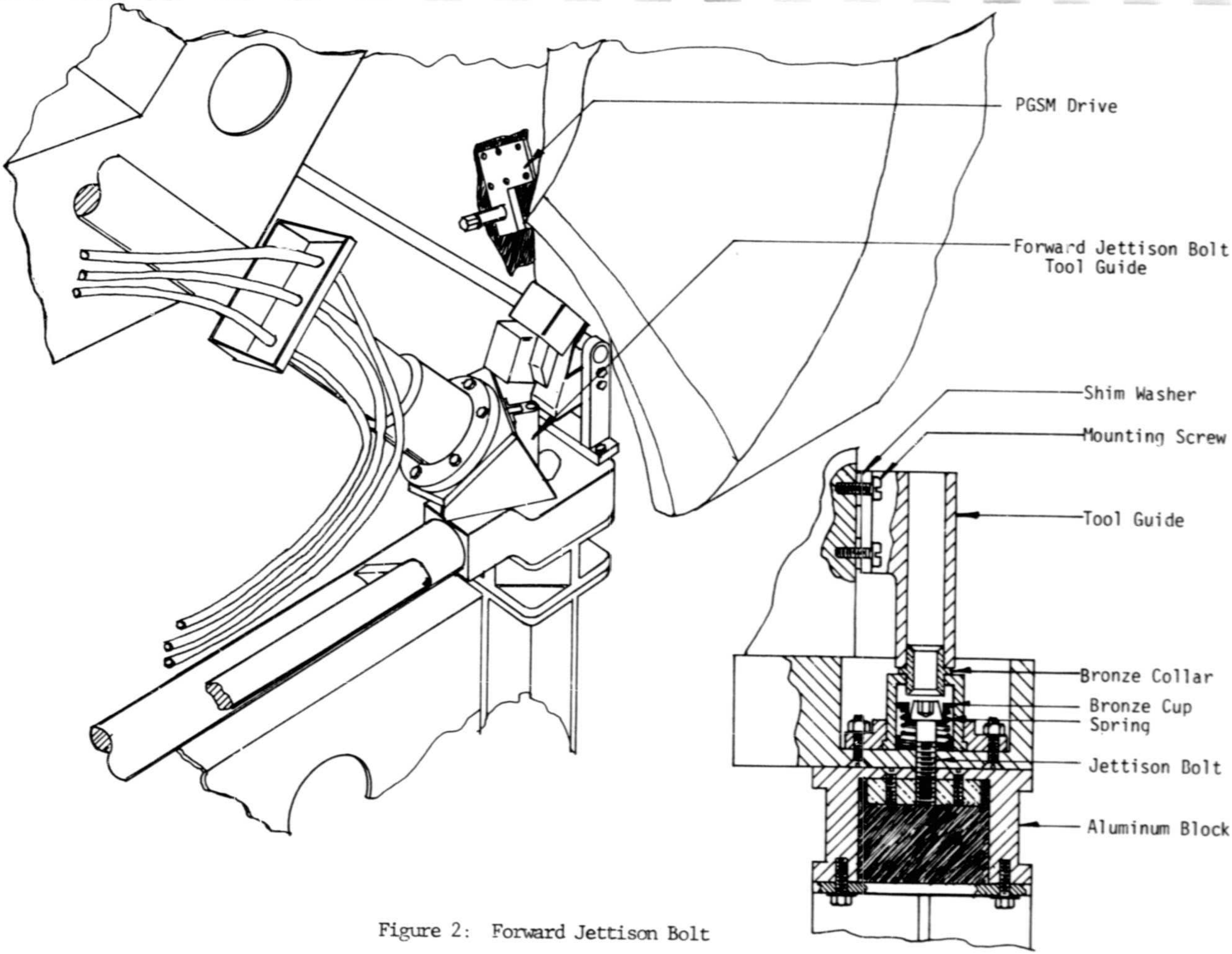


Figure 2: Forward Jettison Bolt

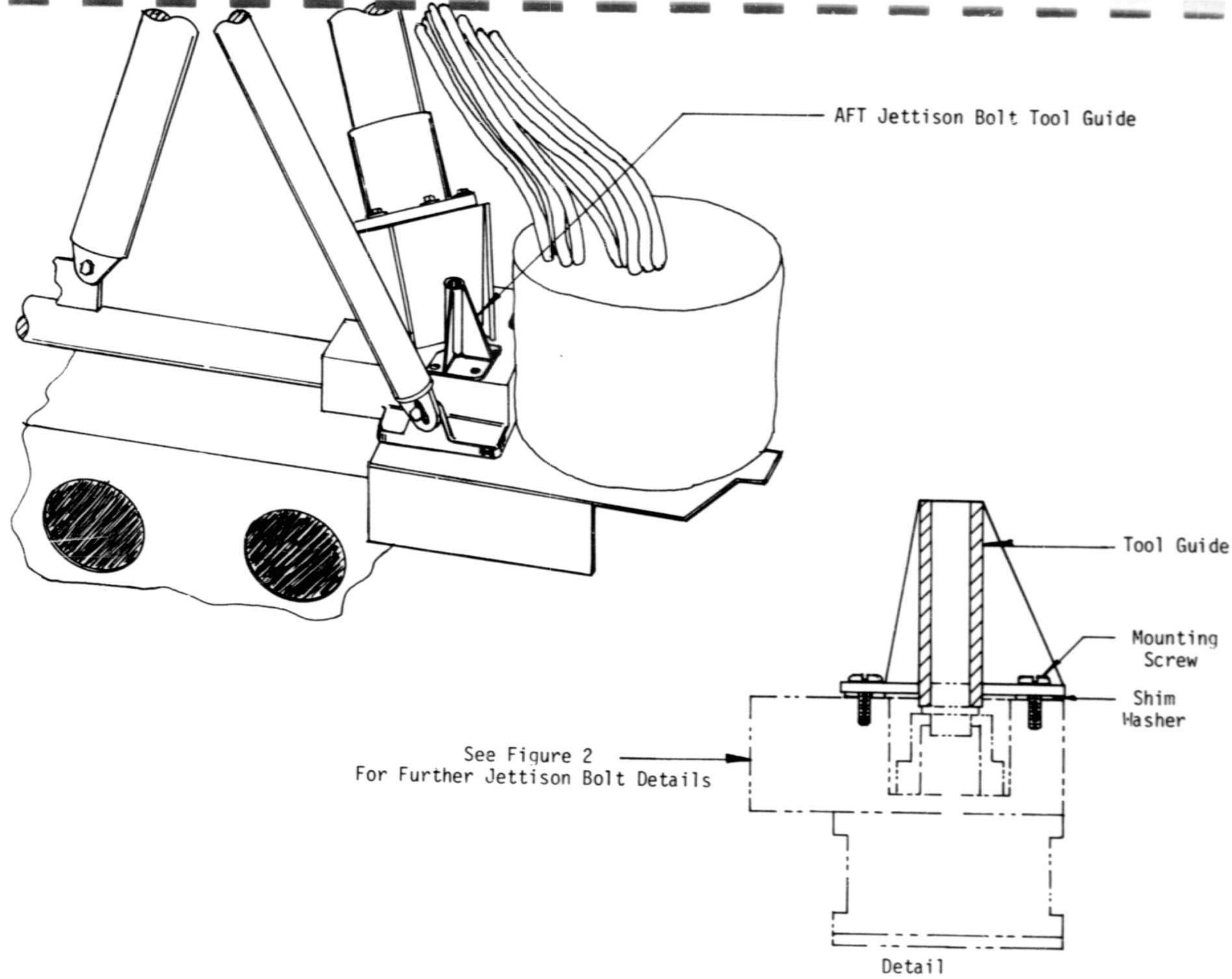


Figure 3: AFT Jettison Bolt

tool to make sure the guide allows the tool to drop smoothly into the jettison bolt head. If any resistance exists, loosen the tool guide mounting screws and move the guide until proper alignment is achieved, completing jettison bolt changeout.

Jettison bolt threads should be greased periodically. During storage of the trainer, the jettison bolts should be snug but not overtightened. Just prior to simulations, the jettison bolts should be torqued to 45 ft. lbs. according to Table 1.

3.0 HARNESS SEPARATOR (See Figure 4)

The harness separator is a "dummy" mechanism in that it only provides the proper motion and "feel" which gives the EVA test subject the impression of using the actual harness separator. Table 1 gives data for activation of the harness separator.

The "Pip-Pin" should be internally lubricated and working smoothly. The force required to move the handle is adjustiable by means of tightening or loosening the spring detent according to Table 1 on the bottom of the mechanism and should be approximately 7 lbs.

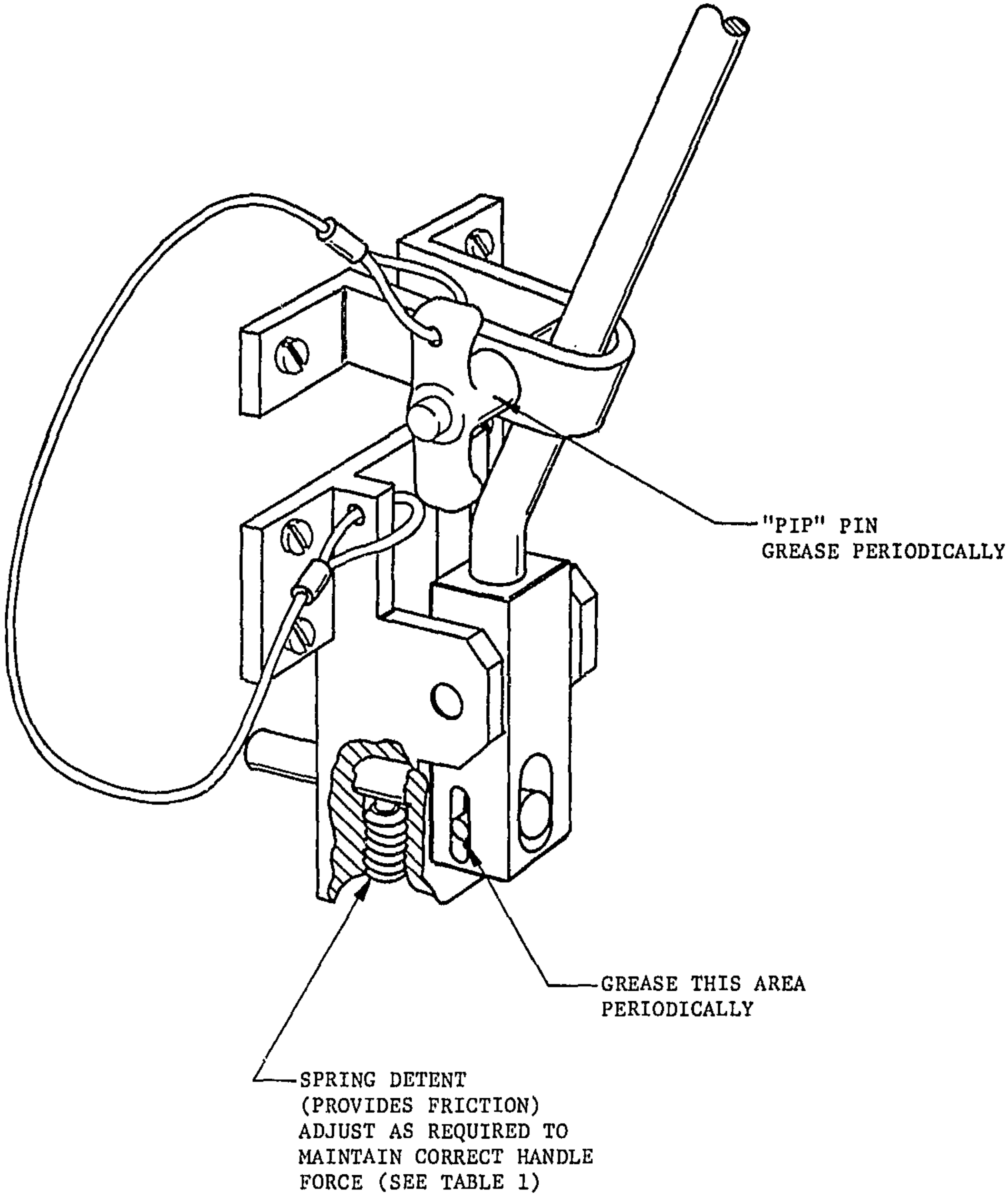


FIGURE 4: HARNESS SEPARATOR
(LOCATED ON LOWER RIGHT-HAND
SIDE OF IPS GIMBAL SYSTEM

4. PAYLOAD RELEASE (Manual Span Band) (See Figure 5)

Like the harness separator, the manual span band is also a "dummy" type mechanism. It consists of a female 3/8 in. square drive which interfaces with an Essex EVA ratchet wrench. By turning the drive, a threaded bronze block travels between two stops. The EVA task involves turning the mechanism clockwise to activate. Therefore, the mechanism should always be turned counterclockwise to the stop prior to a simulation.

This mechanism should be greased periodically to insure smooth operation. The torque value should be checked and adjusted periodically according to Table 1. Spring detents provide friction on the shaft and may be tightened or loosened to adjust torque value. Periodically the mechanism should be dismantled and lubricated.

4.1 PAYLOAD RELEASE (Diver Task)
(See Figure 6, also reference Figure 11)

The diver task involved with the Payload Release mechanism simulates what should take place when the test subject operates the dummy Manual Span Band. When the test subject indicates that the Span Band has been operated, it is the support diver's job to release the payload from the IPS using the mechanism provided. The mechanism consists of three cables which pull the three latches, located at the PGSM's (See Paragraph 8), open and allow the payload to separate from the IPS.

Care should be taken to pull all three cables simultaneously so the payload will separate cleanly without binding or locking onto the IPS. All three cables should be routed neatly with no kinks or tangles. If any cables become damaged they should be replaced. While the payload is separated, the support diver should check that the return springs are functional and that the latches work smoothly.

When the payload is pulled back into engagement by the support divers (at least two will be required) the latches should be checked and manually locked if the return spring does not move the latch into the fully locked position.

Other than keeping activation cables neatly routed and free from kinks there are no specific out-of-water maintenance tasks involved with the payload release.

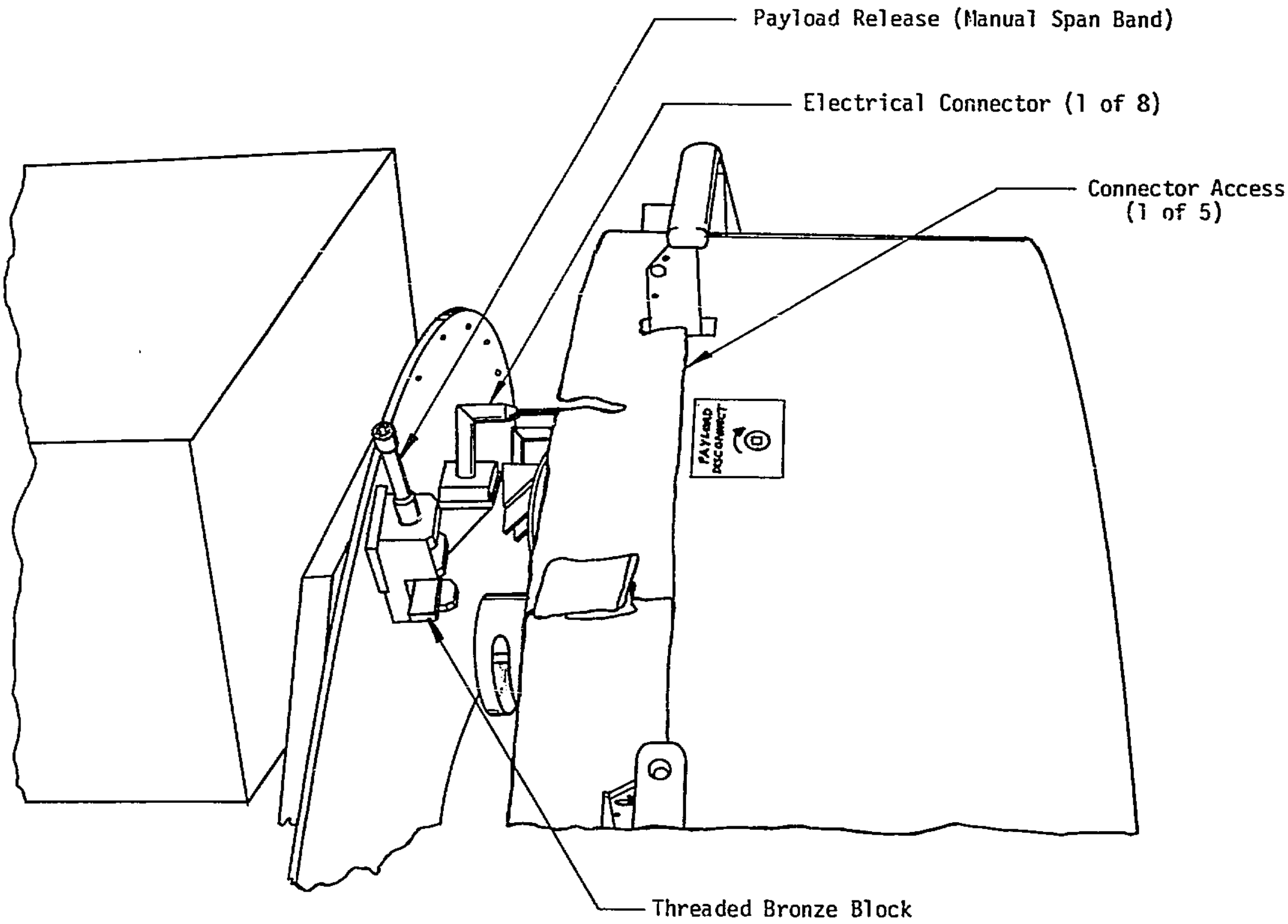


Figure 5: Manual Span Band

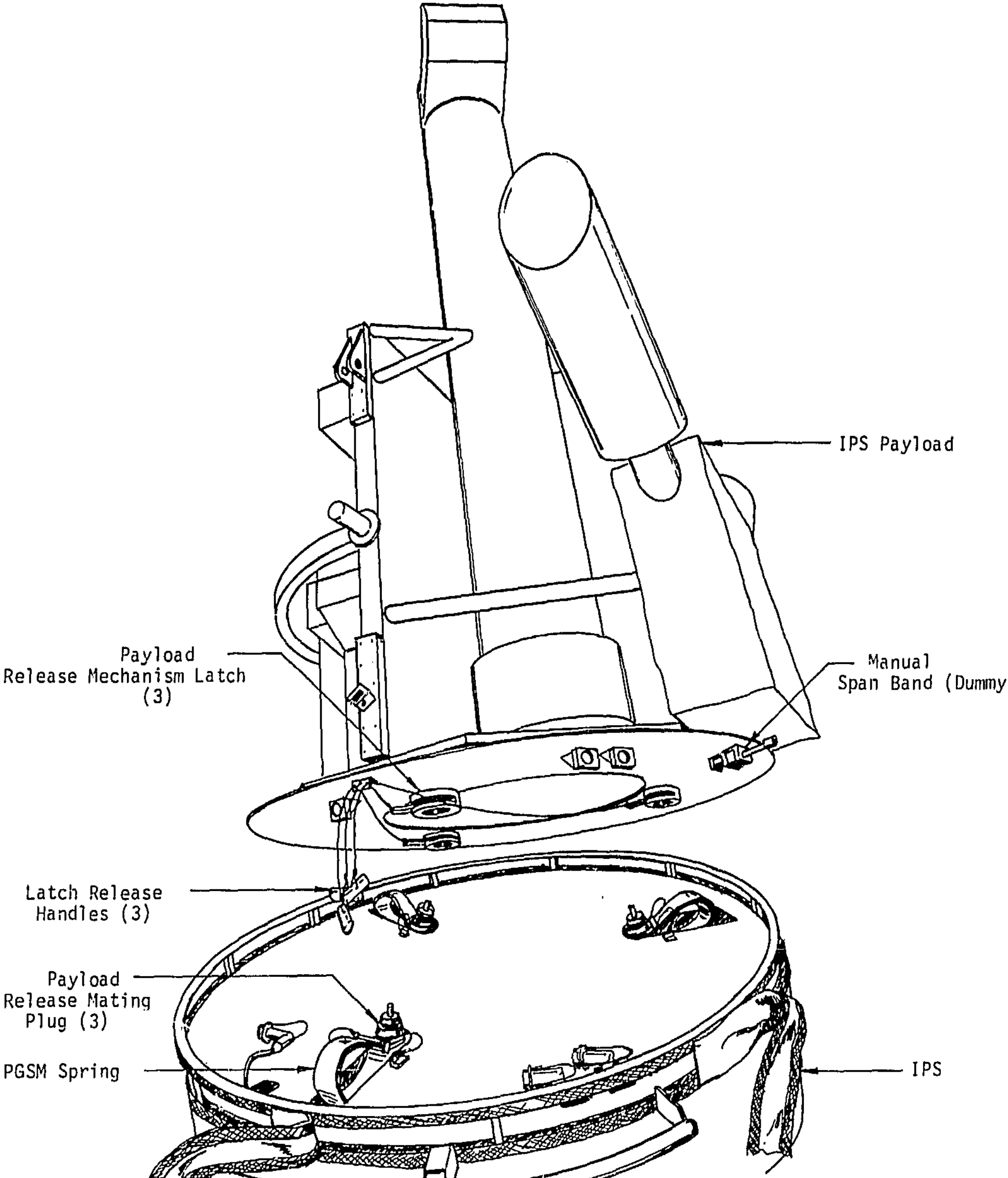


Figure 6: Payload Release

5. ELECTRICAL CONNECTORS (See Figure 7 also reference Figures 5, 6)

During IPS testing the electrical connectors (8) will be disconnected by the test subjects using the loop in puller. The mating block is fitted with two spring detents. These detents should be adjusted to provide proper force (as specified in Table 1) for demating the connector. The connector should be lubricated periodically.

Since the cable is caused to bind and kink by the loop pin puller, it has a very short life expectency. The cable can be replaced by removing two #4-40 screws holding it in place.

To access the connectors, velcro covers (5) must be pulled away. Eventually the corners will need to be fitted with new velcro (Scotchmate Dual Lock Fastener).

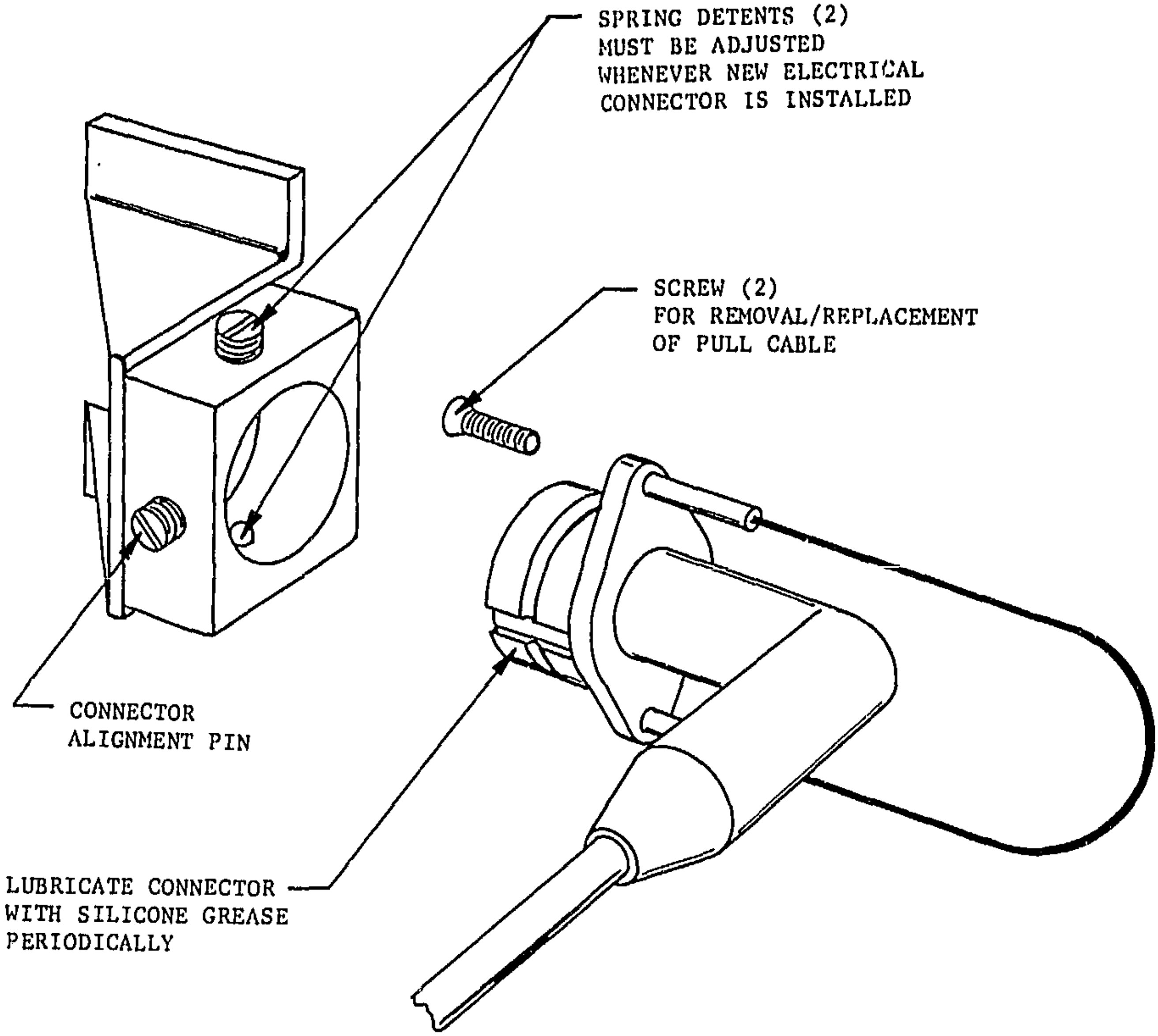


Figure 7: Electrical Connector Detail

6. PAYLOAD CLAMP ASSEMBLY (PCA)

6.1 PCA ACTUATOR (See Figure 8)

The PCA actuator is a dummy mechanism. A total of four EVA interfaces (1 common, 3 individual) must be adjusted to the proper torque values specified in Table 1. Since these mechanisms are fitted with nylon bearings, lubrication is not considered necessary unless they become stiff.

As with the electrical connectors, access is gained to the PCA actuator by removing a velcro cover. Velcro (Scotchmate Dual Lock Fastener) will need to be replaced on the cover as it wears out.

6.2 PAYLOAD CLAMP UNITS (PCU) (Reference Figure 9)

Each of the three PCU mockups represent the flight version PCU's in the open position, which allow the payload trunnions to slide in and out. For restraining the payload mockup while the IPS Trainer is being installed in or removed from the water, stainless steel pins (1 per clamp unit) are provided. These pins must be installed in the PCU's as shown in Figure 9, to prevent damage of the trainer.

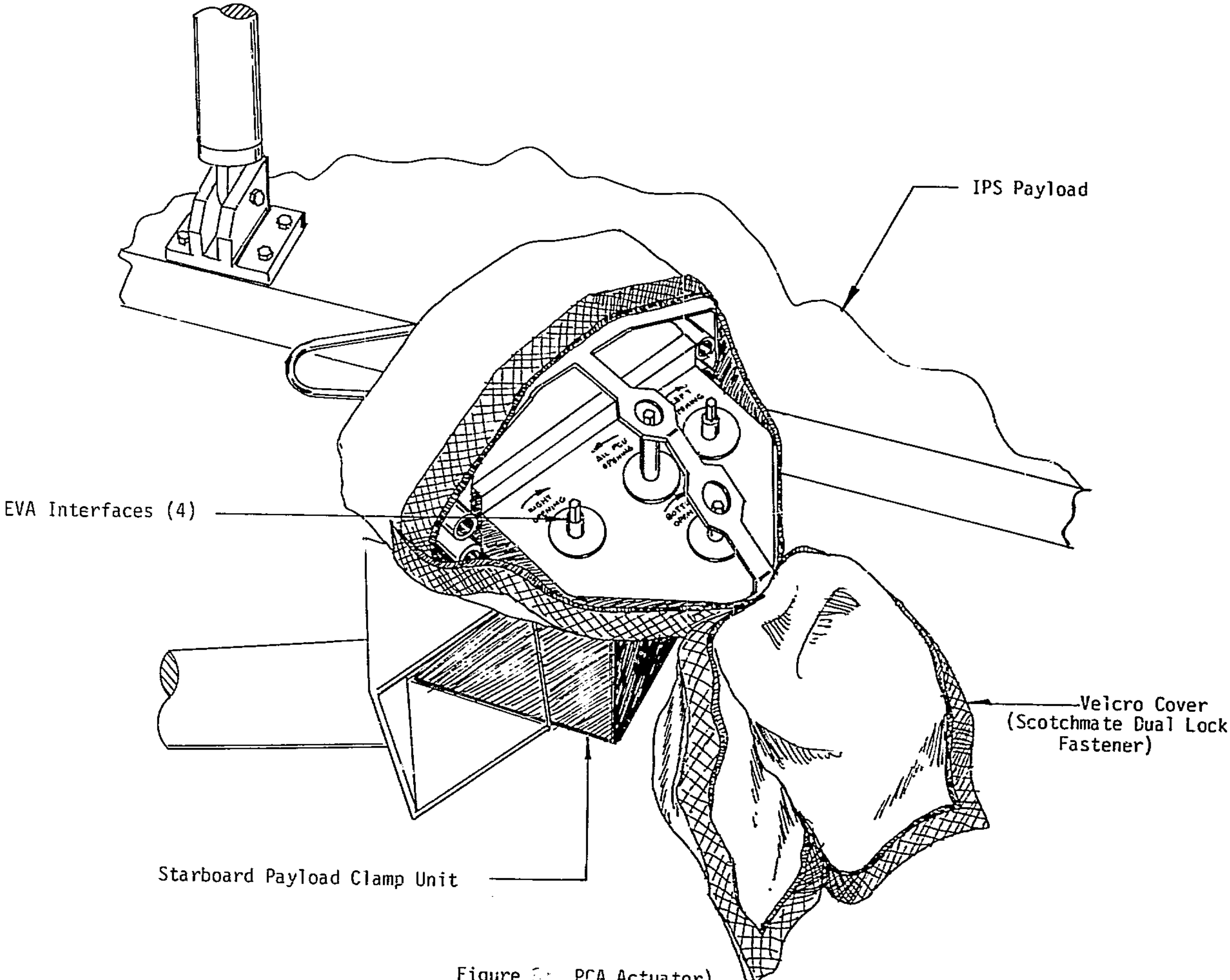


Figure [illegible] PCA Actuator)

7. IPS CONTINGENCY STRUTS (See Figures 9, 10)

The IPS mockup has two forward (Figure 9) and two aft (Figure 10) contingency struts. Both the forward and aft struts consist of a strut attached by a moving base at one end with a loose end which can attach to a stowage receptacle on the pallet or to the IPS payload cruciform by using a "Pip" pin. The strut length is adjustable by turnbuckles located at the loose end of the strut assembly.

All moving joints, turnbuckle threads and "pip" pins, should be lubricated periodically. Prior to simulations the contingency struts should be stowed in the stowage receptacle with jam nuts tightened down to a snug fit. The torque value for the jam nuts is 110 inch/pounds (9 foot/pounds).

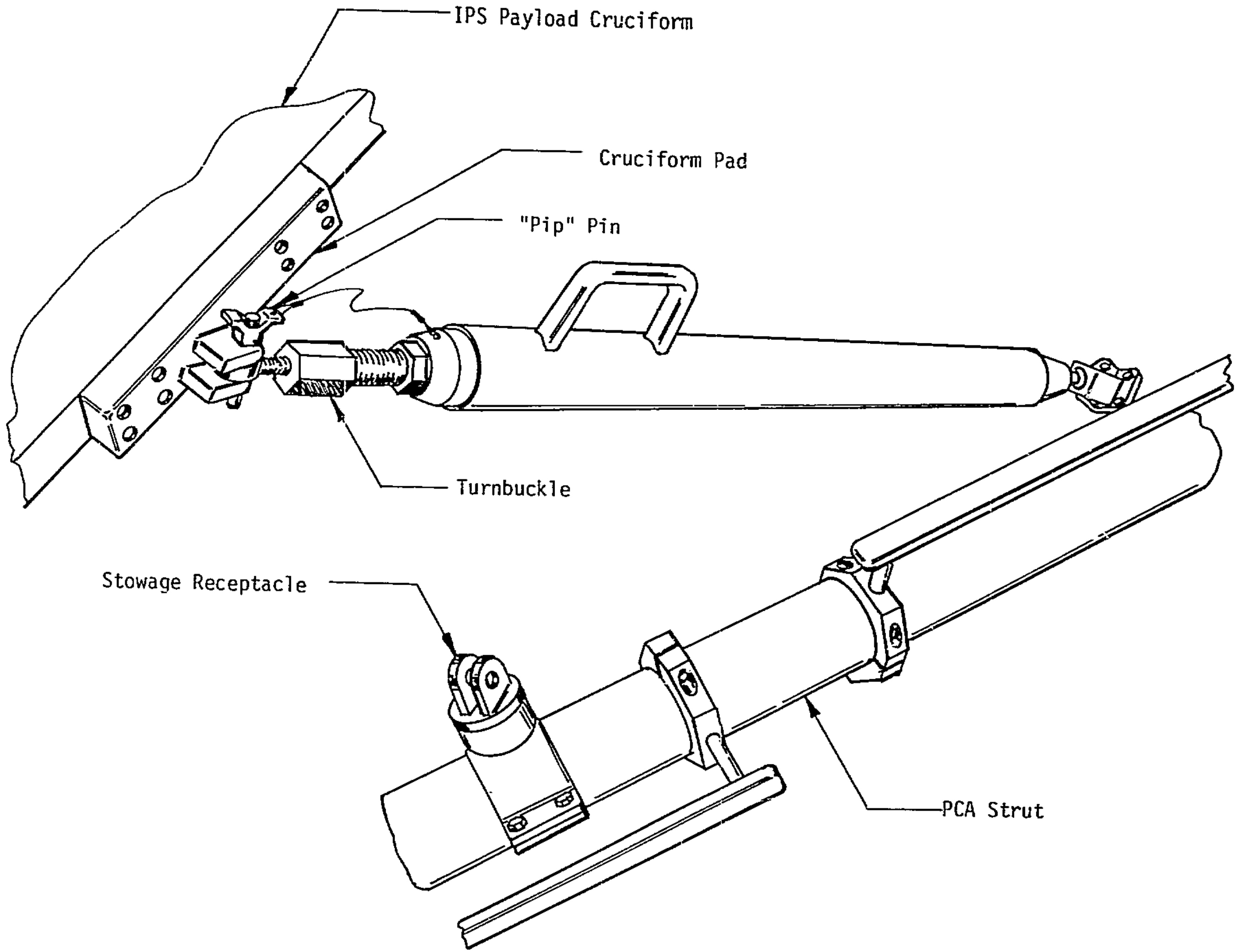


Figure 9 : AFT Contingency Strut
(Port Side Shown)

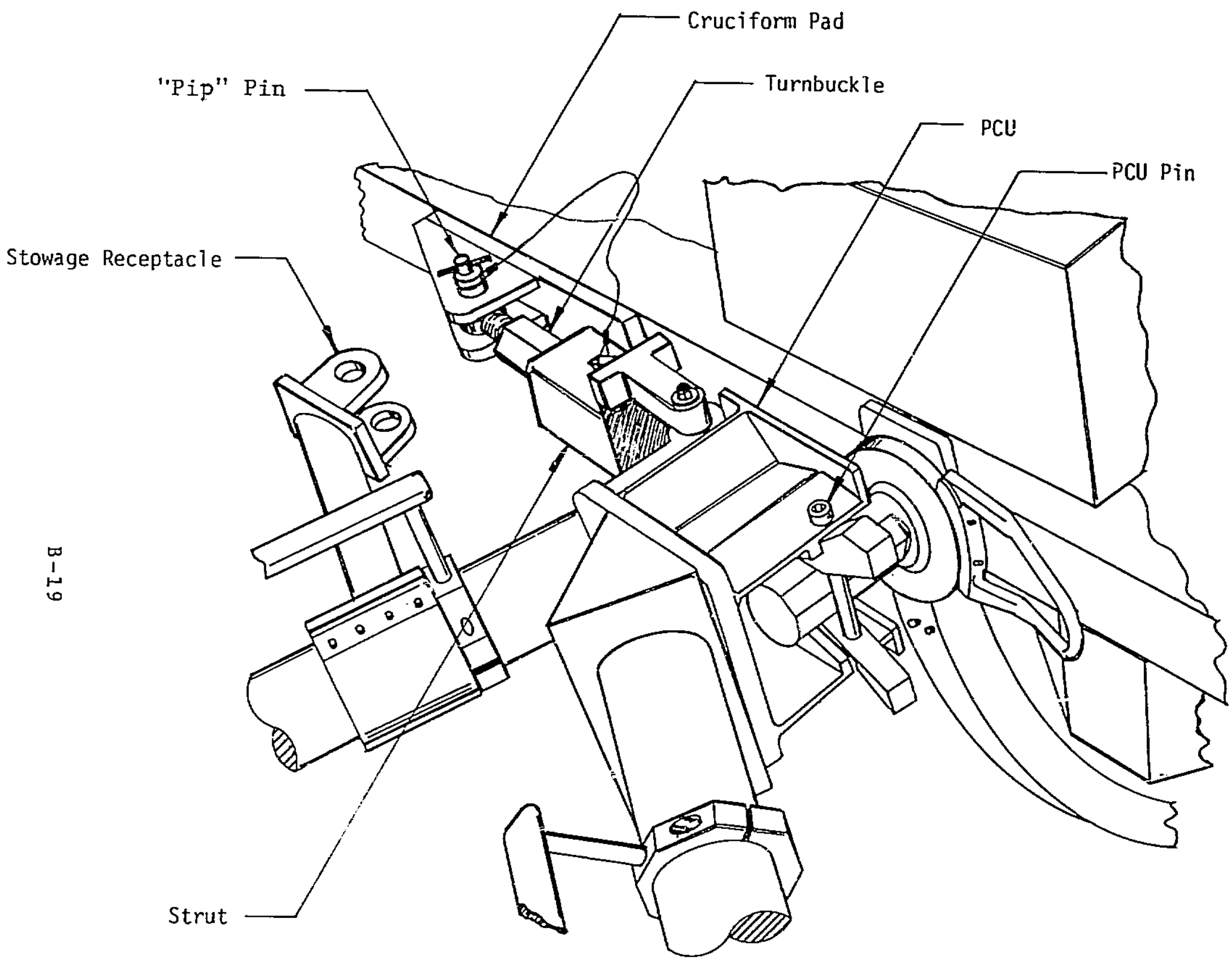


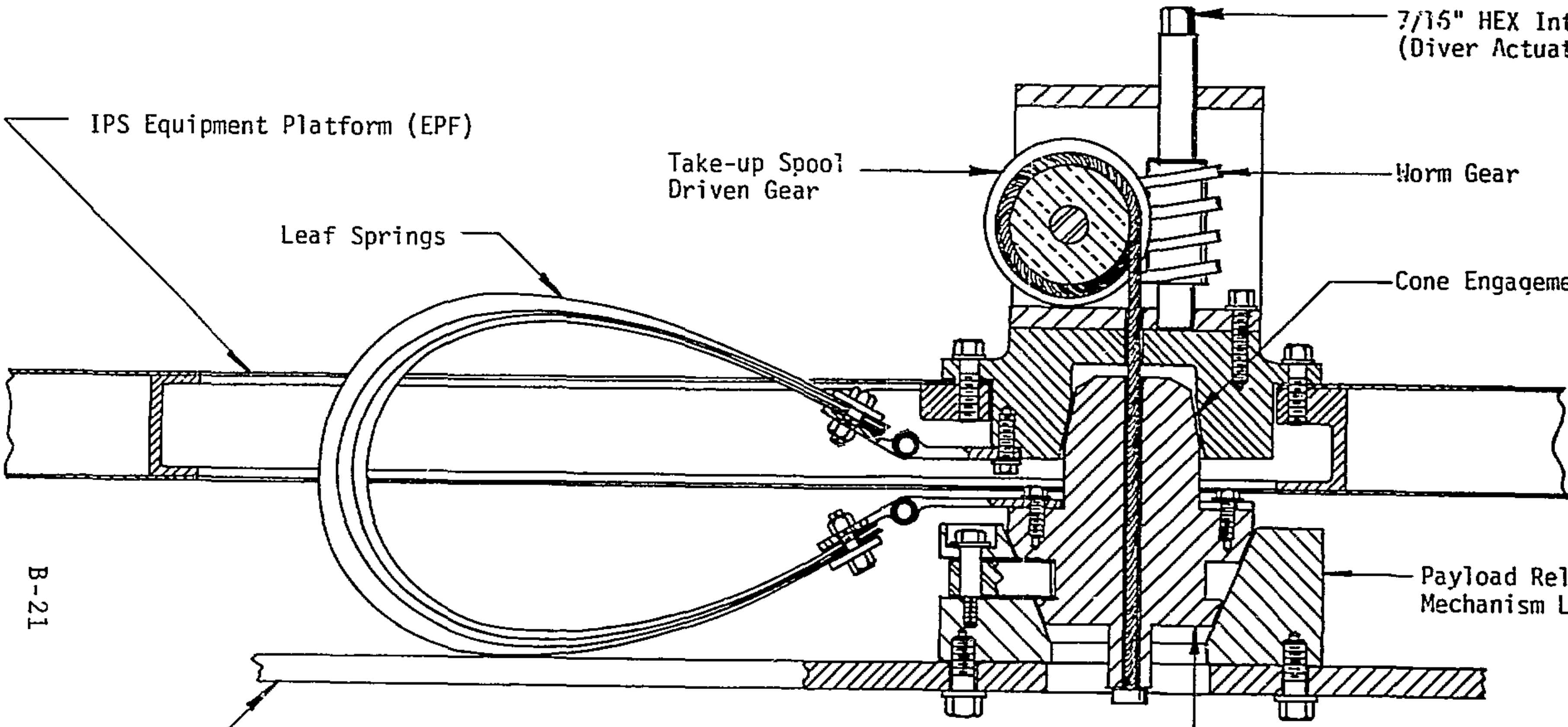
Figure 10 : Forward Contingency Strut (Port Side Shown)

8. PAYLOAD GIMBAL SEPARATION MECHANISM (PGSM) (Diver Task)
(See Figure 11 also reference Figure 6)

The mockup PGSM is representative of the motor driven PGSM of the flight version IPS. The PGSM arrangement consists of three individual PGSM's and is used to pull the payload from the payload clamps, approximately 7 inches, to engage with the IPS for pointing. The PGSM's consists of a male cone on the payload end and a female cone on the IPS end with a series of leaf springs of varying tension separating the two cones. A stainless steel cable is used to pull the cones together or separate them against the opposing force of the springs. The cable is wrapped around a take-up spool which is turned by a worm-and-driven gear arrangement. The mechanism is operated by a scuba diver using either a 7/16" wrench or one of the Essex prepared PGSM tools. A worm-and-driven gear arrangement was chosen for the PGSM's because it is not capable of being back-driven. There are two PGSM tools, one short and one long for operating the PGSM's. The short tool is used on the lower right-hand PGSM to accomodate limited space in the area.

In operating the PGSM's special care should be taken. The three PGSM's should be driven in sequence (ex. pull all PGSM's in half way before pulling any of them down all the way). This will prevent cables and springs from binding. Since the worm-and-driven gear arrangement has such a great mechanical advantage, the diver should be careful to only pull the cones into engagement and stop. A visual check should be used to verify engagement since the engagement will be almost imperceivable through the mechanism. DO NOT DRIVE THE PGSM MECHANISM AFTER THE CONES ARE ENGAGED OR THE DRIVE CABLE WILL BE BROKEN.

Maintenance of the PGSM's are as follows. Check the cable for freyed wires or kinks, and replace if it appears damaged. Lubricate the bearing surfaces with a spray-on lubricant without dismantling the mechanism. Dismantle the PGSM only if this action seems unavoidable.



	Approx. Spring Force Open	Approx. Spring Force Attached	No. of Leaves
Spring A (Port)	58 Lbs.	88 Lbs.	4
Spring B (Bottom Stbd.)	96 Lbs.	142 Lbs.	6
Spring C (Upper Stbd.)	60 Lbs.	90 Lbs.	4

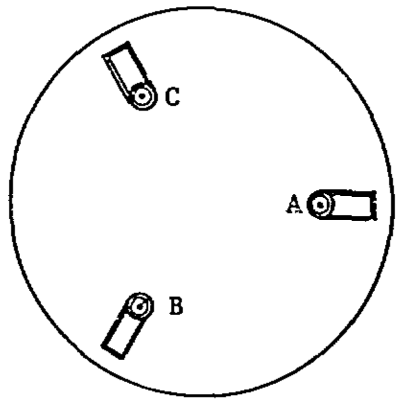


Figure 11: PGSM

9. EXPERIMENT 7 (See Figure 12, 13)

The Experiment 7 mockup consists of a pivoting and rotating telescope which is capable of being locked into place with an over-center lock mechanism (launch lock) located near the bottom. The pivoting and rotating joints consist of stainless steel shafts turning in bronze bearings. Lubrication of these joints is not considered necessary unless the joints become stiff.

The locking mechanism consists of a handle with a trigger lock which, when released, allows the handle to rotate 24 degrees from one locked position to the other. Rotating the handle activates the over-center lock which clamps onto a tab (hammer) on the Experiment 7 base.

The mechanism should only be dismantled in the event of a major malfunction but should be externally lubricated with a spray-on lubricant on a periodic basis.

There are three areas which require adjustment on the latch mechanism. First, the over-center latch should be adjusted so that it clamps snugly onto the hammer at the experiment base. This adjustment can be made by using the 1/4-20 adjustment bolt which adjusts how far over-center the linkage can ride. It is not necessary to assign a specific force value to the adjustment of the clamp force, it can be adjusted to "feel".

The grip squeeze and handle rotation forces are based on actuation from the handle nominal grip center line as shown in the illustration. Grip squeeze force is given in Table 1 and is adjustable by the set screw on the inside of the handle. Handle rotation force is a function of the combined forces of the amount required to move the over-center latch past center (while the latch is clamping onto the hammer) and of the force applied by the pre-load spring. The actual force to move the latch over center is nonadjustable, so adjustment must be made to the pre-load spring. Force required to rotate the handle is given in Table 1.

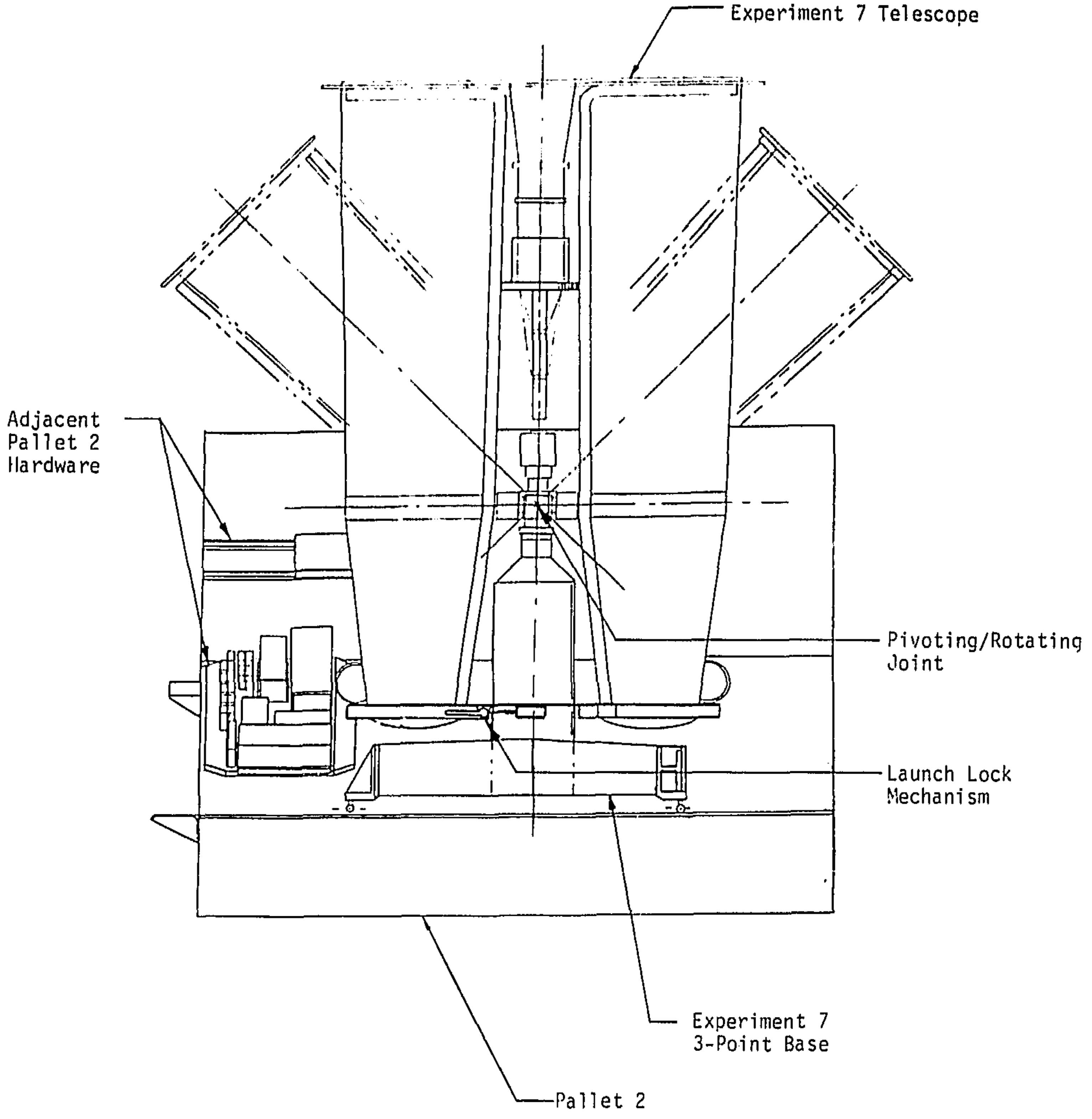


Figure 12: Experiment 7

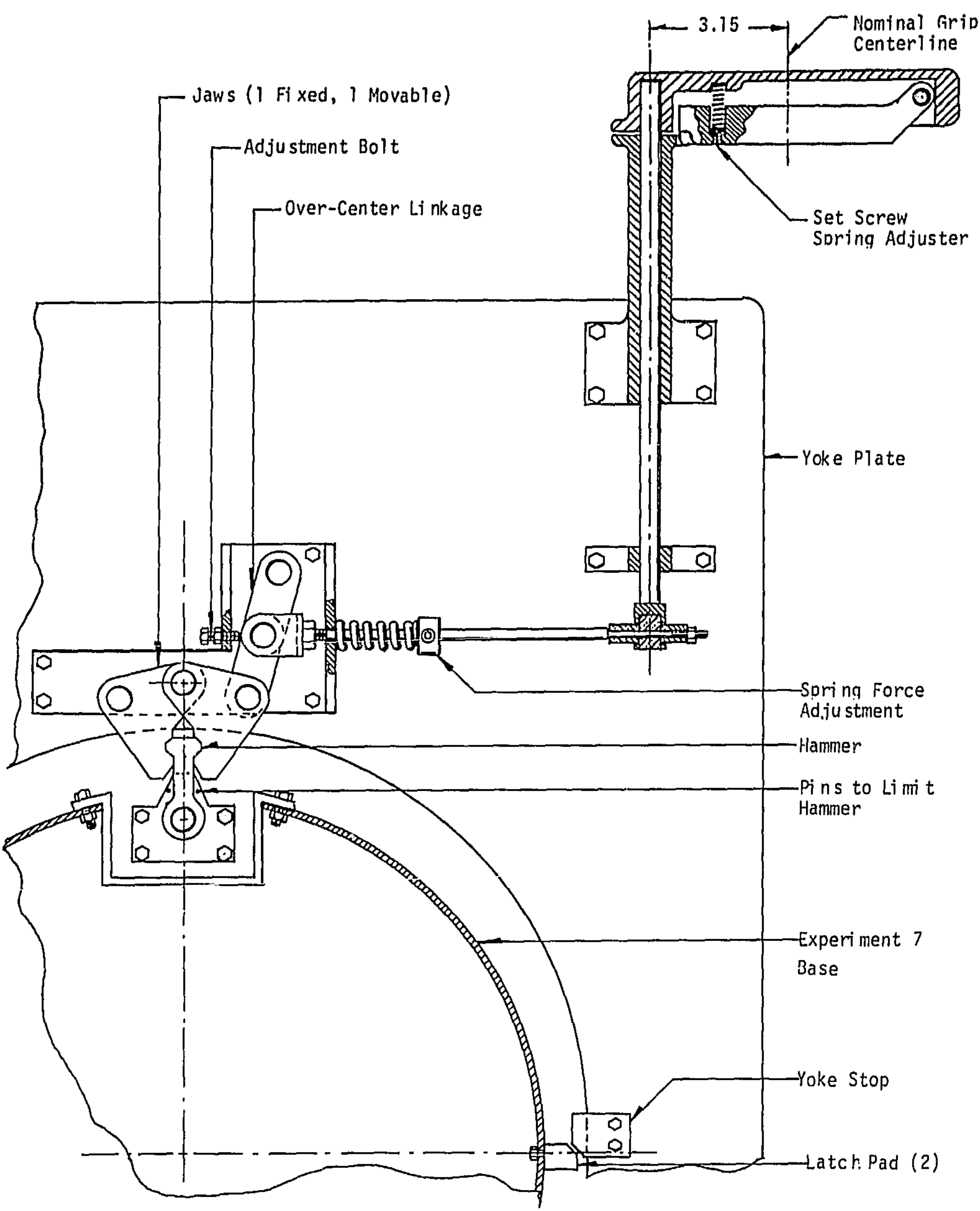


Figure 13: Experiment 7
Launch Lock Mechanism (Views Rotated for Clarity)

CONCLUSION

This manual has covered all areas of expected maintenace on the IPS trainer. If questions arise concerning other areas or information contained herein which needs further clarification, contact:

Richard Heckman (MSFC) - (205) 453-2168
Charles VanValkenburgh (Essex) - (205) 883-9849

	Rotational Motion			Logitudinal	
	Revs	Nm Torque (ft. lbs.)	Hand Force N (lbs.)	Travel mm (in.)	Force N (lbs.)
Jettison Bolts	10-12	62 (45)			
Harness Separator					
Pip-pin o Push Button O Pull Out				 4 (.16) 22 (.87)	 10 (2.25) 22 (4.95)
Harness Separator Handle				125 (4/90)	32 (7.19)
Lanyard Connectors (Elect. Connectors)				15 (.59)	Min. 31 (6.97) Max. 218 (49.00)
Payload Release	Min 8-10 Max 23	10 (7.25)			
PCA Single Activation	60	2 (1.45)	20 (4.50)		
PCA Common Activation	60	8 (5.80)	80 (17.98)		
Contingency Strut Jam Nuts		12.6 (9)			
Experiment 7 o Grip Squeeze o Handle Rotation			22.2 (5) (Approx.)	7.62 (.30)	13 (3) (Approx.)

TABLE 1: IPS WETF TRAINER

Mechanism Data