LEAM DVT MECHANICAL FUNCTIONAL TEST

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ILLUSTRATIONS

1.0 INTRODUCTION

A functional test of the mechanical features used for release of folding mechanisms and deployment of the LEAM experiment was performed on the DVT model prior to installation of the electronics. Deployment tests were performed with suited subjects using the LEAM mock-up at the crew engineering laboratory in January (prior to this test) and aboard a KC-135 in May (subsequent to this test). This test was performed on 7 May 1971 using both the LEAM and Crew Engineering laboratories. Problem areas recorded during the January test with the mock-up were written into the DVT test procedures to allow LEAM engineering to ascertain whether the problem still existed with the DVT hardware, or was peculiar to hardware differences between the two models. Problem areas or comments recorded during the KC-135 test with the mock-up are discussed and resolved in this report.

The attendees for this test were as follows:

LEAM Qual and Flight Model Project Engineer - R. Johnson
LEAM Design Supervisor - J. Mitchell
LEAM Manufacturing Supervisor - C. Vos
Crew Engineering Representatives - L. Marrus
T. Kuechenmeister
LEAM Mechanical Engineering Supervisor - P. Pilon

2.0 OBJECTIVES

1. To evaluate the mechanical design of the UHT Socket, legs, and the gnomon assemblies and their release systems.

2. To evaluate the deployment, its sequence, and the locations of the UHT pull pin, lanyard assembly for leg and gnomon release, the bubble level, and the compass rose.

3. To evaluate the strength of the outer structure assembly for deployment loadings.

4. To evaluate the dust cover and release system, except for reefing line cutter firing (which will be done later with the electronics installed).

3.0 TEST ARTICLE

The test article was the LEAM DVT model, P/N 2347700 (X_1), without the electronics or the two dual sensors which contained the parylene films. The experiment, not including that portion of the cable resting on the surface, weighed approximately 8 pounds. This compares to a flight weight (with partial cable weight) of approximately 14 pounds, and a lunar deployment weight of less than 2.5 pounds.

4.0 TEST EQUIPMENT

The following equipment were used for this test:

1. A pair of scissors
2. An ALSEP Universal Handling Tool (UHT)
3. The crew engineering sandbox.
4. A polaroid camera with black and white film.
5. A log book

5.0 TEST DATA

The test data consisted of notes in the log book concerning problem areas and comments from attendees as well as polaroid pictures showing the LEAM during various stages of deployment.

6.0 TEST SEQUENCE

6.1 DEPLOYMENT MECHANISMS TESTS

With non - suited subjects the following tests were performed in the LEAM laboratory:

1. With the LEAM in the stowed position (see Figure 6-1), the UHT was inserted and then removed several times.
2. Holding the UHT with the LEAM suspended (see Figure 6-2):
   a. the locations of the UHT socket, the velcro pads, and the pull pin were evaluated;

b. the pull pin was removed (see Figure 6-2). note: the legs were folded for this test unlike that shown in Figure 6-2.

3. Holding the UHT with the LEAM suspended as shown in Figure 6-3 (UHT socket not released):

   a. the lanyard velcro location and lanyard design were evaluated;

   b. the legs were released;

   c. the gnomon was released.

6.2 DEPLOYMENT SEQUENCE TESTS

The next tests were performed with non suited subjects in the crew engineering laboratory at the sandbox. With the LEAM sitting on the floor in a stowed position similar to Figure 6-4 (no ALSEP pallet) the deployment sequence was performed as follows:

1. The UHT was inserted into UHT socket.
2. The LEAM was lifted and the UHT socket pull pin removed.
3. The LEAM was rotated until the UHT socket locking pin engaged.
4. The lanyard pull-ring was pulled releasing the legs and gnomon.
5. The LEAM was lowered to the lunar surface and levelled (see Figure 6-5).
6. The UHT was removed (see Figure 6-6).

6.3 DUST COVER SYSTEM TESTS

For the final tests, the LEAM was placed in the deployed position on a table in the LEAM laboratory and the dust cover and release system design evaluated. The tests were performed as follows:

1. The design of the dust cover over the thermal radiator mirrors was evaluated.

2. Using a pair of scissors the nylon cord on the mirror dust cover was severed at the squib location.

3. The design of the two dust covers over the three sensors were evaluated.

4. Using a pair of scissors the nylon cords on the two sensor dust covers were severed at the squib location.

5. With the two sensor dust covers re-strung using a single continuous nylon cord to hold the two covers, instead of two individual cords as used in the previous test, the previous test, 6.3-4, was repeated twice.

7.0 TEST RESULTS AND REDESIGN

As the test proceeded, problem areas which arose were noted with corrective action discussed by the attendees. Subsequently, redesign activity has corrected all of these problem areas for the flight model design. Also noted in the following discussion, for completeness, are any subsequent redesign actions concerning items tested regardless of whether or not the redesign activity resulted from this particular test.

7.1 DEPLOYMENT MECHANISMS EVALUATION TESTS

7.1.1 UHT Pivot Socket Evaluation (Tests 6.1-1 and 6.1-2)

<u>Test Results:</u>

1. The UHT socket insert design was satisfactory for engagement/disengagement of the UHT.

2. Location of the velcro pad for the pull pin on the west side is satisfactory. Likewise locating it on the east side as on the mock-up worked well, i.e., the pin can be easily pulled from either side.

3. The velcro pad holding the UHT pull ring in place need not be sewn to the pull ring (see Figure 6-1), i.e., the velcro pad can be allowed to fall to the lunar surface. The same holds for the velcro on the lanyard.

4. The removal of the pull pin is extremely difficult due to the high shear forces on the pin.

5. The location of the pull pin ring is adequate for engagement by the finger of a suited subject. The pull ring should be painted international orange.

Redesign Actions:

1. The velcro pad on the pull ring is a loose item on the flight model.

2. The UHT socket pull-pin engagement was redesigned for the flight model as shown in Figure 7-1 (even though the results of the KC-135 test showed that removal of the pull pin was much simpler with 1/6 G).

   a. The pull pin engagement was rotated 90°, i.e., the pull pin is pulled in the N-S direction (Figure 7-1) instead of the E-W direction (Figure 6-1).

   b. The pin was rotated to an angle relative to the lunar surface in order to keep the pull force normal to a radius from the socket pivot axis. (Figure 7-1).

   c. The engagement hole in the bracket fixed to the outer structure was made oblong and also countersunk in order to ensure a bearing engagement of the balls instead of a shear engagement on the pin (Figure 7-2).

   d. To ensure that the balls are properly oriented, locating flats are machined both on the pin and the socket.

7.1.2 Leg and Gnomon Release Evaluation (Test 6.1-3)

Test Results:

1. The location of the lanyard pull ring and velcro pad has adequate access.

2. The velcro pad holding the lanyard cord should be in-line with the force vectors required to pull the leg and gnomon release pins.

3. The legs release system works satisfactorily.

4. The gnomon release pin at times "hung-up" and could not be removed. The gnomon shaft length seemed too short and the pivot spring rate too low. A picture of the gnomon and release clip is shown as Figure 7-3.

Redesign Actions:

1. The lanyard pad in the DVT model is in-line with the pull direction for the leg release pin. (The mock-up had the velcro pad on the north end, see Figure 6-1, where as the DVT has it on the west side, see Figure 7-3). The gnomon will be turned so that it stows at an angle running northwest and aligning the pull direction for gnomon release with the pull direction for leg release (See Figure 7-2).

2. The gnomon length was increased to allow more clearance on the west edges of the experiment, the pivot spring rate was increased, and the release clip replaced by a velcro pad.

7.2 DEPLOYMENT AND DEPLOYMENT SEQUENCE EVALUATION (TESTS 6.2)

Test Results:

1. The socket height and UHT socket release pull pin locations are satisfactory.

2. The rotation of the experiment about the UHT socket and the locking mechanisms worked satisfactorily. The pull pin release, as previously noted, was again difficult (see 7.1.1). One comment was made that the astronaut might grab the experiment anywhere to rotate it. Could more sensor protection be designed into the system?

3. Switching hands for the leg release operation, (if astronaut holds the UHT in right hand for experiment rotation) is no problem. The lanyard pull ring location and lengths are satisfactory. The leg release is satisfactory, but the outer housing should be indexed to show the lanyard orientation for pulling of the lanyard (see 7.1.2). As previously noted (7.1.2) the gnomon release clip should be relocated in line with the leg release pin. The sequence of release, legs first or gnomon first, presents no problem either way.

4. The following comments were noted. The legs could hit the astronauts suit during deployment. Be sure the spring rate on leg pivot ensures locking before he lowers the experiment to the surface (see Figure 7-4). The outer structure seems weak around the UHT mounting bracket. During levelling, Figure 7-5, the housing structure appeared weak around the leg pivots. (The comments from the KC-135 test on the mock-up state that the legs are weak).

5. The location of the Bubble level was satisfactory. Two comments on the compass rose were noted. Black on a white background is preferred. If the glare from aluminumized teflon is more than from aluminized mylar, can the dust cover material be changed to mylar?

<u>Redesign Action:</u>

1. No change was made to protect the sensors from astronaut damage.

2. A leg release index line will be on the flight model outer housing. The leg pivot spring rate was increased. The outer housing was strengthened around the UHT socket and leg mounts by use of ribs and doublers. (Figures 7-1, and 7-2).

3. The aluminized teflon has the aluminum side inboard on the dust covers and the glare is less than the aluminized mylar. The compass rose will remain as is, unless evidence that this is a problem arises. The original design was aluminized mylar, but the mechanical performance during an earlier engineering test dictated the change to aluminized teflon.

7.3 DUST COVER SYSTEM EVALUATION (TEST 6.3)

Test Results:

1. The length of mirror dust cover was satisfactory. The mirror release worked satisfactorily when the cord was severed at the squib. However, sometimes it spiraled over the Up/West sensor dust cover and could be a potential problem when the sensor dust covers are released. (See Figure 7-6).

2. The East sensor dust cover design is satisfactory except for the cords at the base which should have more span between them to ensure that the dust cover lays flat on the housing. (Figure 7-2)

3. The Up/West sensor dust cover does not cover the Up sensor properly.

4. The release of the two dust covers failed when each cover had a separate nylon cord holding the squib end of the covers. The two cords would bind at various locations where they crossed. When one continuous cord was used, they worked both times (the cord was severed at each squib separately). The dust covers rolled up satisfactorily. (See Figures 7-6 and 7-7).

Redesign Action:

1. The dust covers were checked on a layout of the flight model assembly and redesigned in size and tie-down as shown on Figures 7-1 and 7-2. Both sensor dust covers have four separate eyelets, two at each end, with a larger span between eyelets. The squibs are rotated 90° in a vertical position as shown in Figure 7-2, thus assuring no cross over of wires. The sensor dust covers will be retained at the leg ends using both eyelets as shown in Figures 7-6 and 7-7.

2. The mirror dust cover tie-down is the same as the sensor dust covers except that it is retained at only one eyelet, the outboard eyelet on the west side (see Figure 7-6). The inboard eyelet is replaced by a loop retainer on the housing(Figure 7-2) allowing the dust cover to fall into a vertical position along the north corner.

8.0 RECOMMENDATIONS

It is recommended that the redesign actions stated herein be verified by repeating this type of test on the qual model.

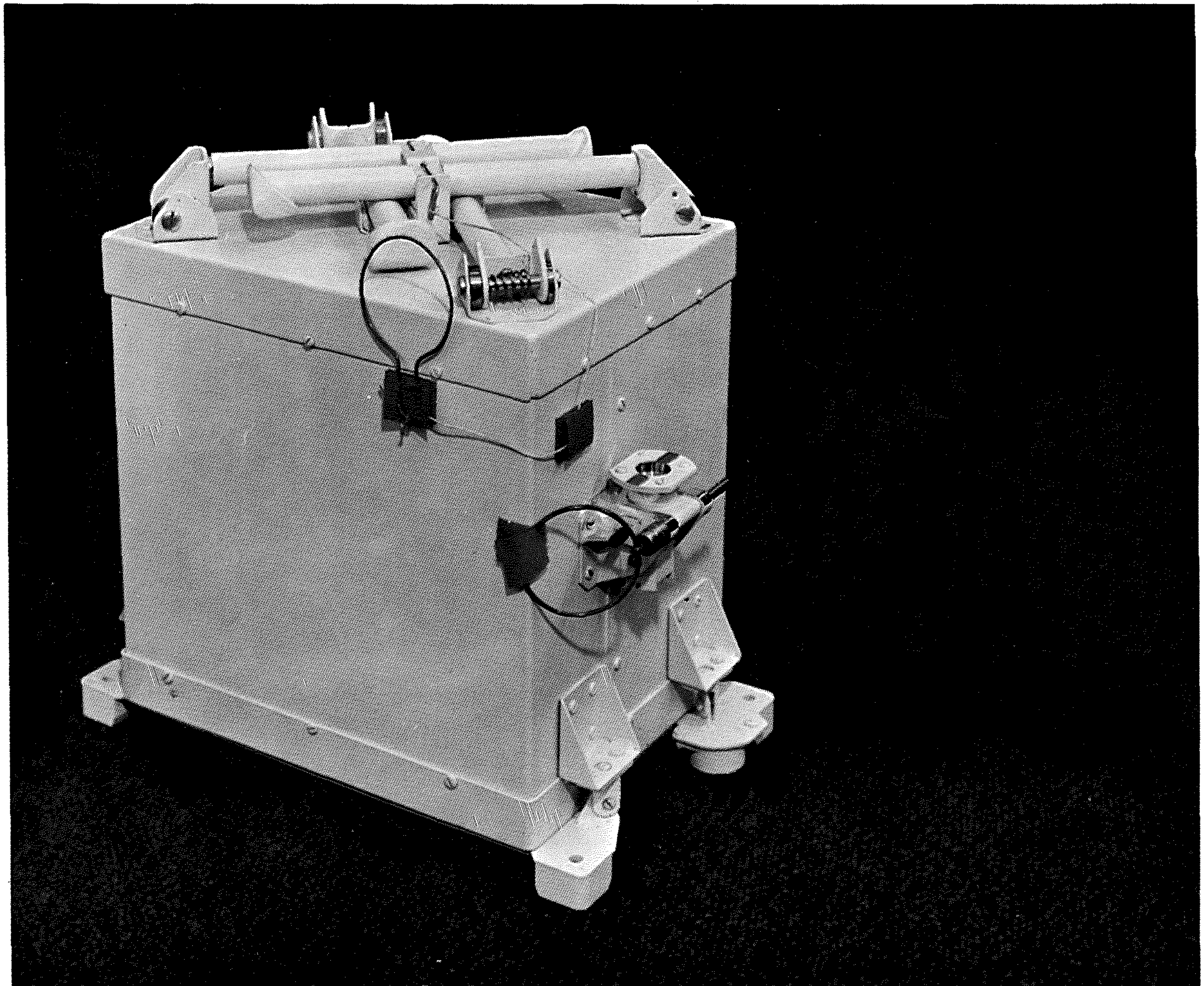

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FIGURE 6-1 LEAM MOCK-UP STOWED POSITION

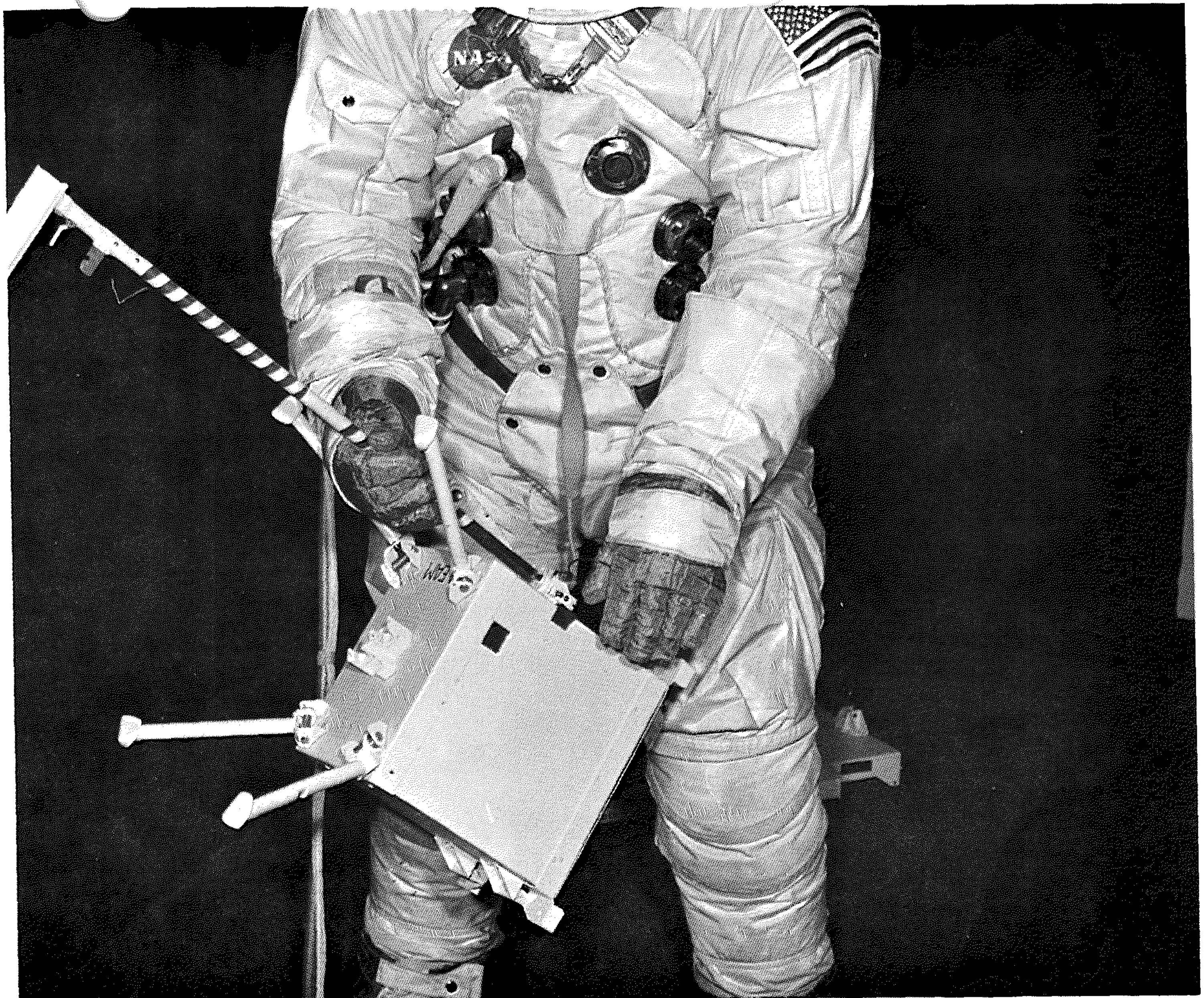

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FIGURE 6-2 LEAM MOCK-UP—UHT SOCKET PULL PIN TEST

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FIGURE 6-3 LEAM MOCK-UP-LEG RELEASE TEST

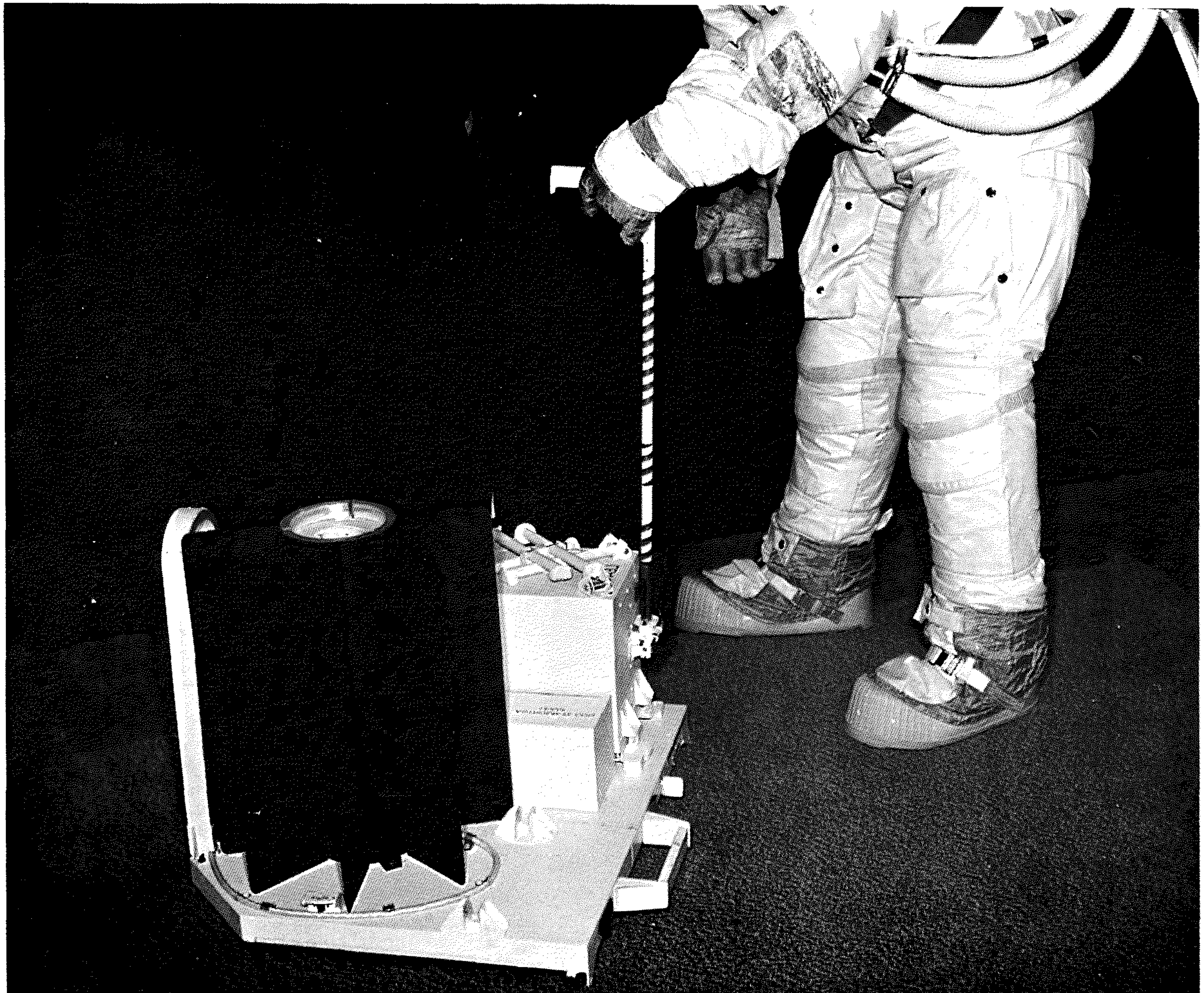

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FIGURE 6-4 LEAM MOCK-UP-STOWED ON PALLET

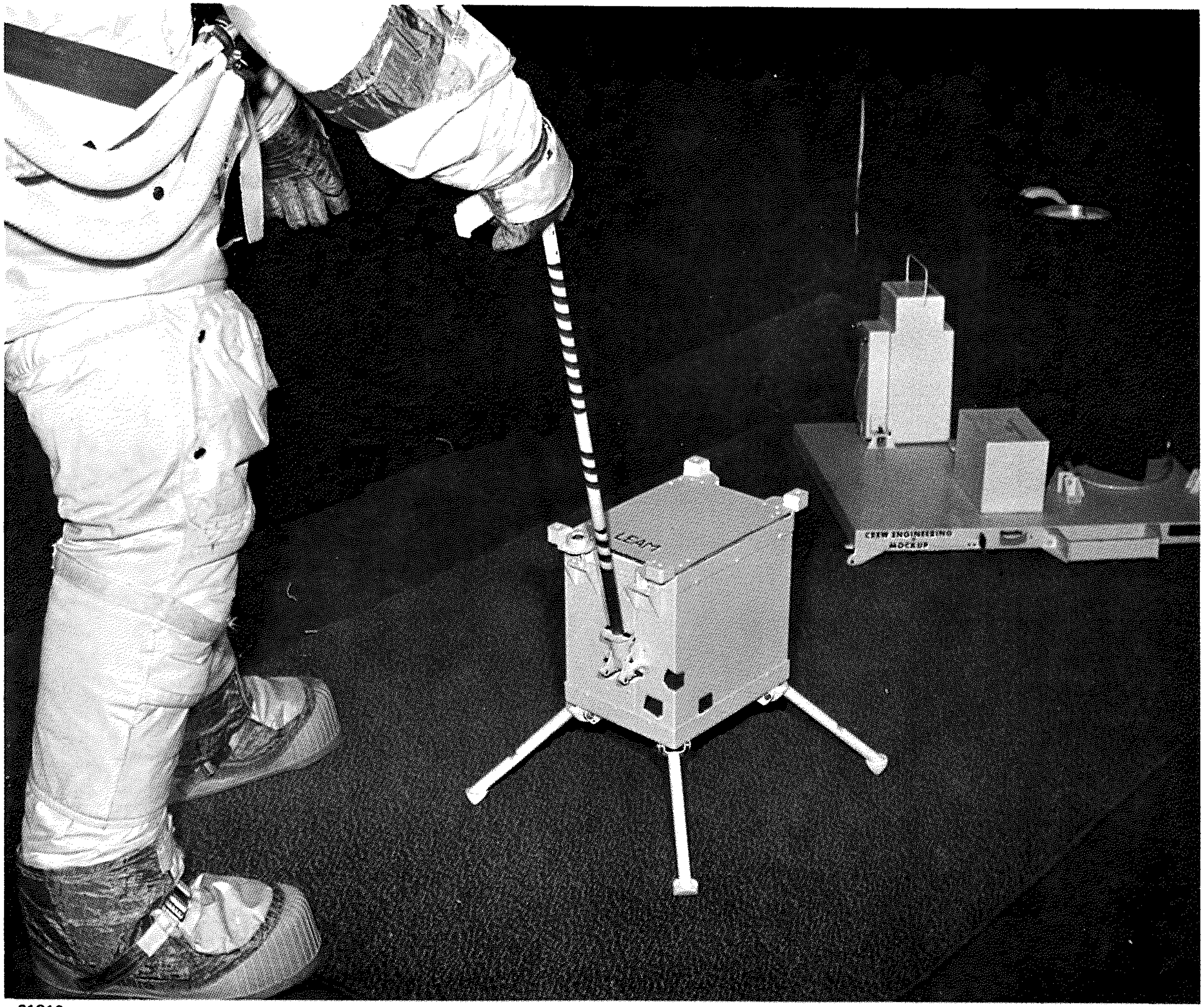

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FIGURE 6-5 LEAM MOCK-UP-LEVELING

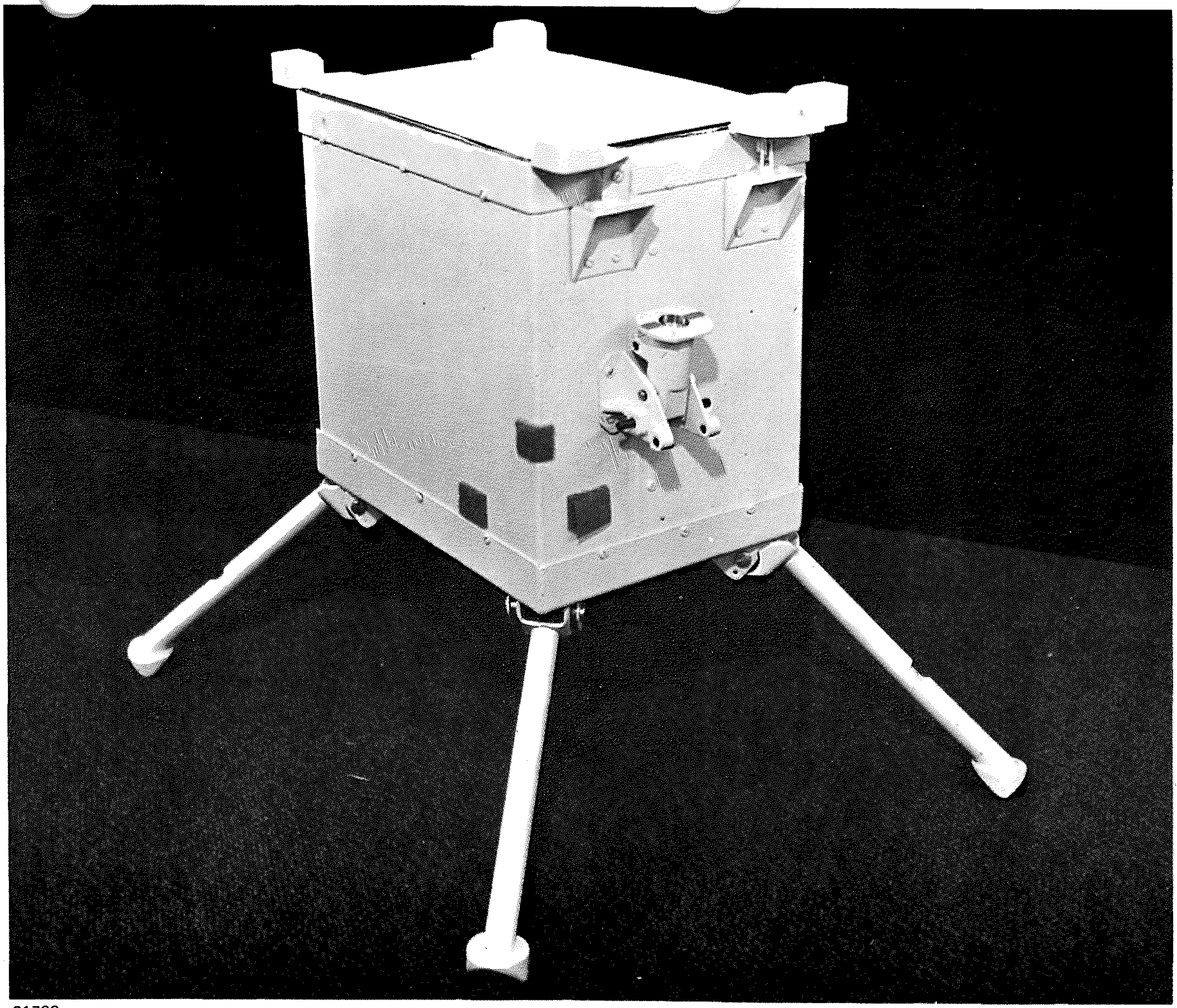

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FIGURE 6-6 LEAM MOCK-UP DEPLOYED

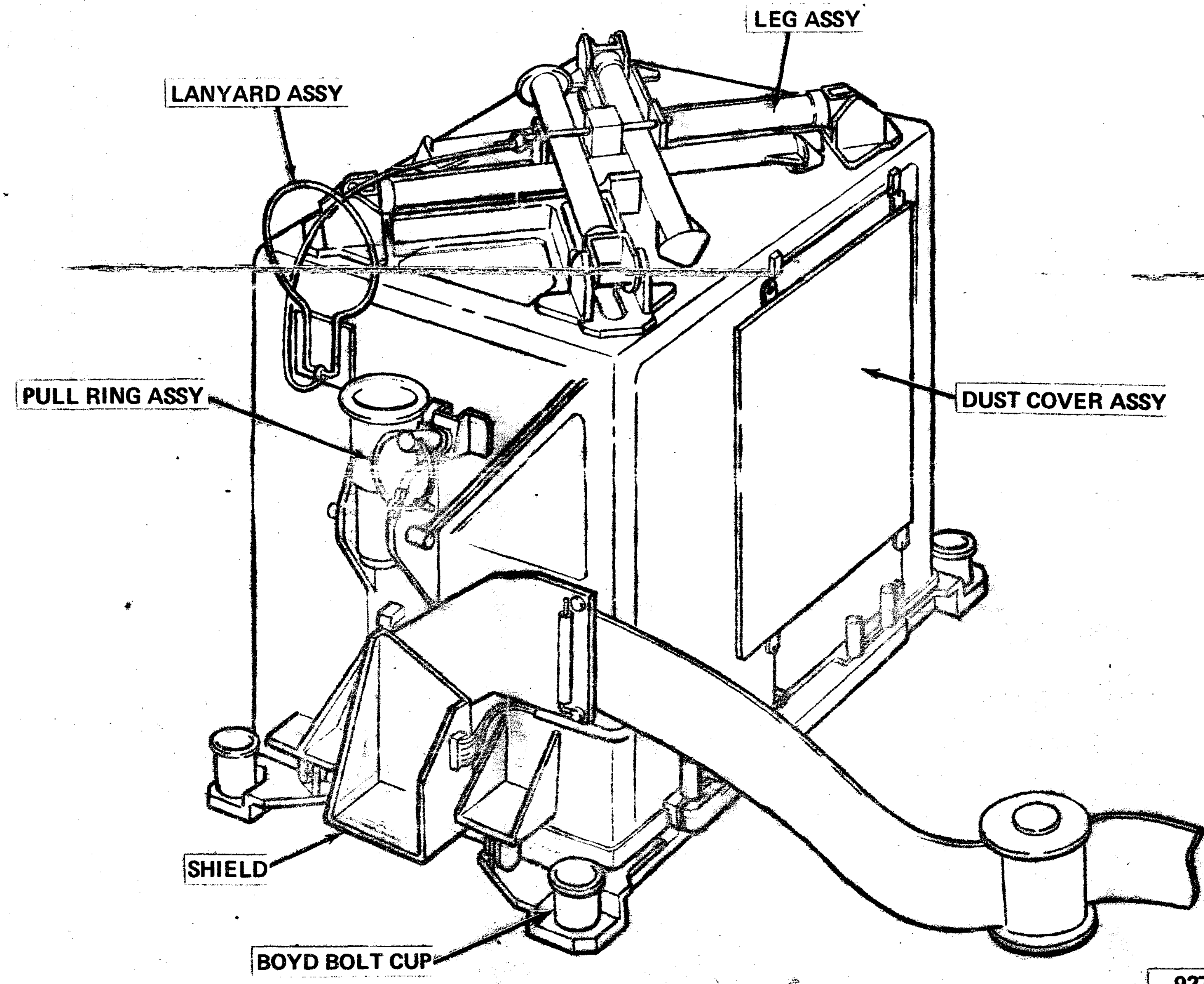

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FIGURE 7-1 LEAM EXPERIMENT, FLIGHT MODEL - STOWED

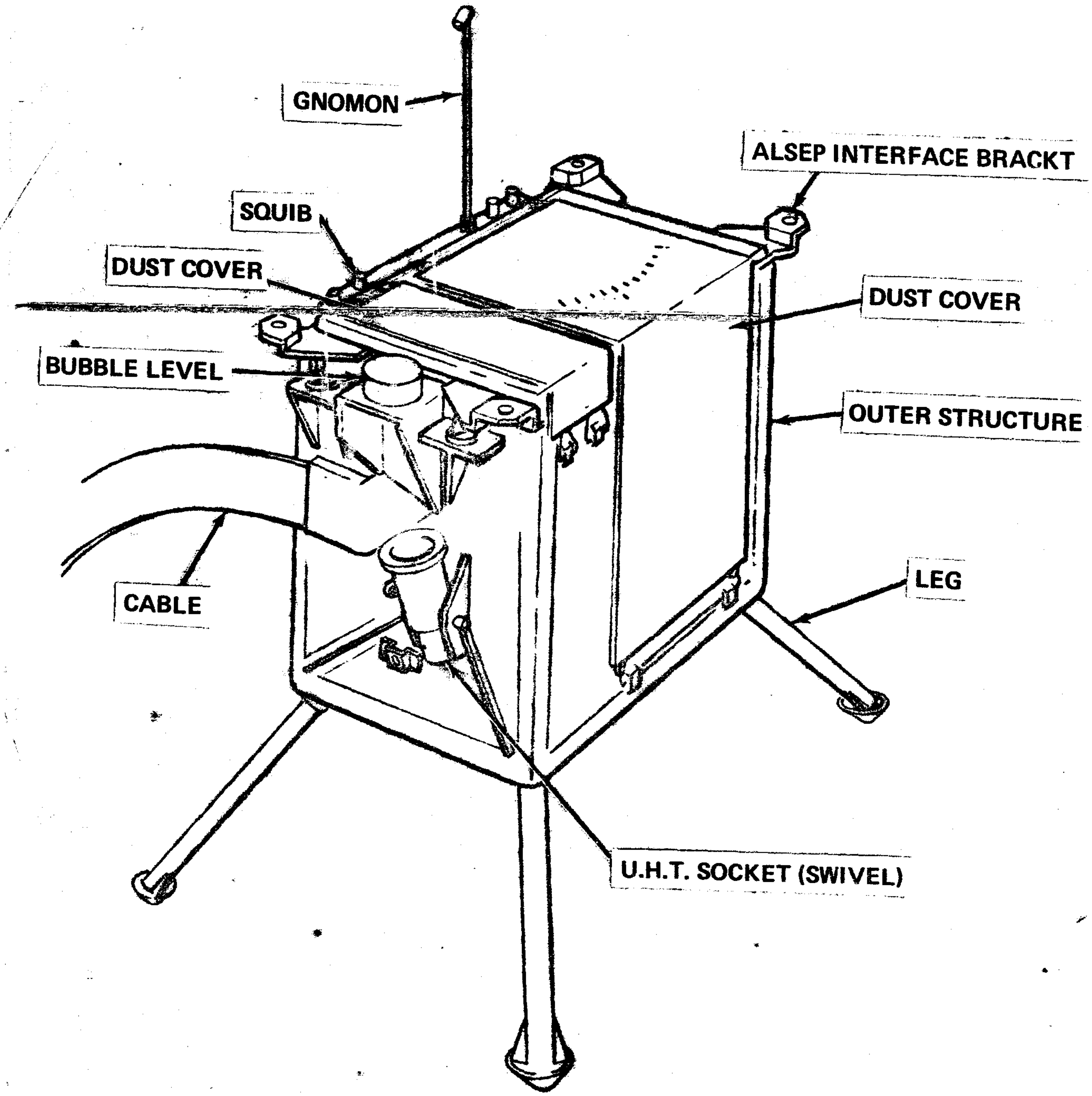

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FIGURE 7-2 LEAM EXPERIMENT, FLIGHT MODEL - DEPLOYED

Figure 7-3 Gnomon Release Design

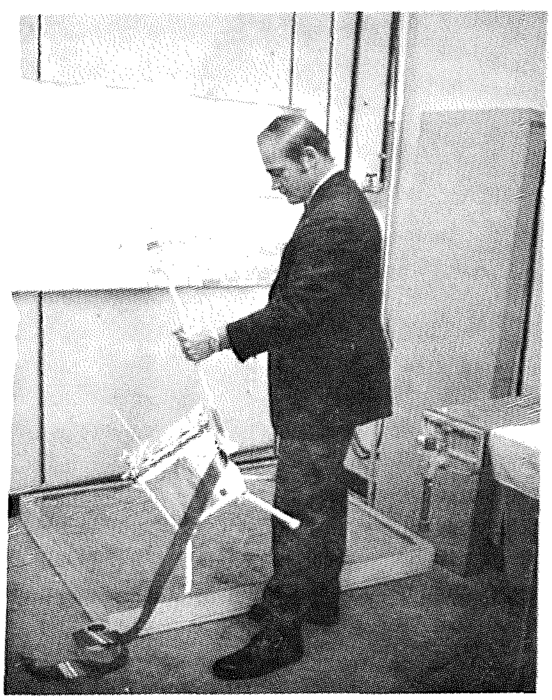

Figure 7-4 Gnomon and Leg Release

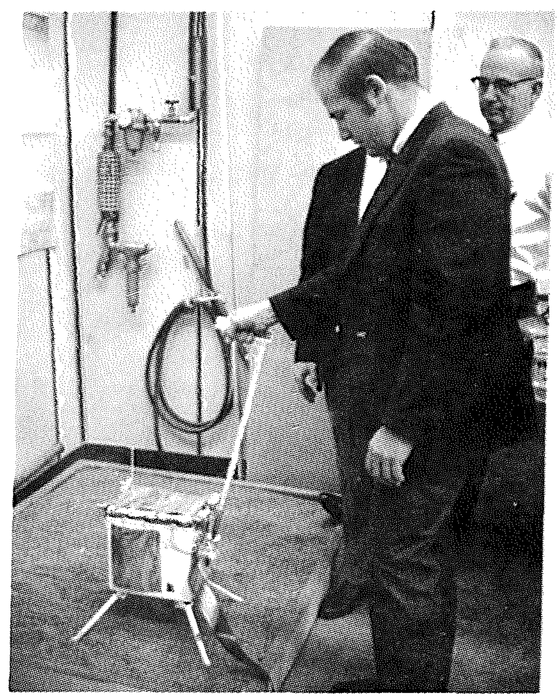

Figure 7-5 LEAM Leveling

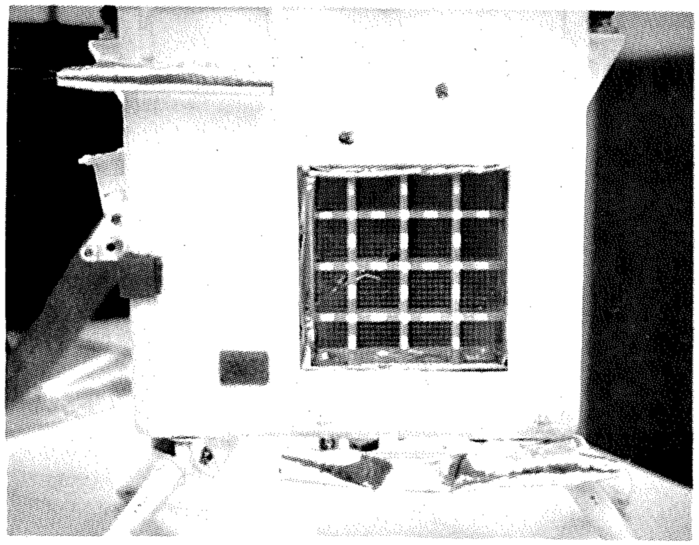

Figure 7-6 Dust Covers Deployed Mirror and Up/West Sensors

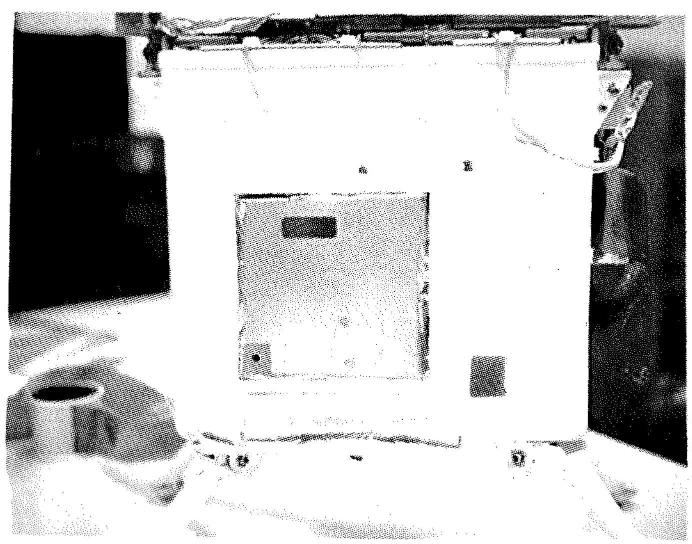

Figure 7-7 Dust Cover Deployed East Sensor