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LUNAR ROVING VEHICLE MAGNETIC TESTS

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GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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LUNAR ROVING VEHICLE

MAGNETIC TESTS

J. C. Boyle
Test and Evaluation Division
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October 1971

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

This is the final report on the magnetic testing of the Lunar Roving Vehicle

AUTHORIZATION

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LUNAR ROVING VEHICLE

MAGNETIC TESTS

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LUNAR ROVING VEHICLE MAGNETIC TESTS

J. C. Boyle
Test and Evaluation Division

SUMMARY

The qualification model of the Lunar Roving Vehicle (LRV) was tested in the Spacecraft Magnetic Test Facility (SMTF) at the GSFC Magnetic Test Site.

Magnetic field measurements were made, both with the vehicle in its "as received" state and also subsequent to final deperm treatment. These measurements, together with information supplied to GSFC regarding the magnetic moment of the astronaut's Extravehicular Mobility Units (EMU's) were used to calculate 0.5 nanotesla (gamma) contours around the LRV. The results were as tabulated:

LRV Status	EMU's	Max. 0.5 NT Dist. — Feet	
		Horizontal	Vertical
As Received	0	42.5	41.9
As Received	1	44.7	44.1
As Received	2	46.8	46.2
Post Deperm	0	30.9	30.9
Post Deperm	1	34.8	34.8
Post Deperm	2	38.0	38.0

In arriving at the above results, it was assumed that the magnetic dipole moment vectors of the EMU's were aligned with the direction of measurement for each point on the contour. Distances were measured from the center of gravity of the LRV.

Magnetic field measurements were also made with various items of LRV equipment operational. No significant changes were noted, except during operation of the vehicle wheels.

CONTENTS

	Page
SUMMARY	v
INTRODUCTION	1
TEST DESCRIPTION	1
Test Set Up	1
Procedure	2
TEST RESULTS	2
CONCLUSIONS	4
PERSONNEL	4

APPENDIXES

Appendix		Page
A	Description of Facility	A-1
B	Computational Techniques	B-1
C	Cronology of Events	C-1
D	Preliminary Report of Environmental Test	D-1

ILLUSTRATIONS

Figure		Page
1	LRV in Spacecraft Magnetic Test Facility Mounted on Wooden Frame and Support Dolly	5
2	Strip Chart Record Showing Field Due to Front Wheel Rotation	6
3	LRV Test Team	7

ILLUSTRATIONS (Continued)

Figure		Page
A-1	LRV in Spacecraft Magnetic Test Facility with Operator at Controls	A-3
A-2	LRV in Spacecraft Magnetic Test Facility, Rear End View	A-4
A-3	LRV in Spacecraft Magnetic Test Facility, Side View	A-5
A-4	LRV in Spacecraft Magnetic Test Facility Showing Deployment of Facility Probes	A-6
A-5	LRV in Spacecraft Magnetic Test Facility Positioned for Horizontal Axis Deperming	A-7
A-6	LRV in Spacecraft Magnetic Test Facility Showing LPM and Cable Deployed	A-8
B-1	LRV Qualification Model - Magnetic Moment Extrapolation	B-6
D-1	LRV Horizontal Plane 0.5 Nanotesla (Gamma) Contour - Initial State	D-9
D-2	LRV Vertical 0.5 Nanotesla (Gamma) Contour - Initial State	D-10
D-3	LRV Horizontal Plane 0.5 Nanotesla (Gamma) Contour - Post Final Deperm	D-11
D-4	LRV Vertical 0.5 Nanotesla (Gamma) Contour - Post Final Deperm	D-12

TABLE

Table		Page
1	LRV Dipole Moment History	3

LUNAR ROVING VEHICLE
MAGNETIC TESTS

INTRODUCTION

Apollo 16 is to include a Lunar Portable Magnetometer (LPM) which will be carried on the LRV for the purpose of measuring the magnetic field at a number of positions on the lunar surface during the traverse.

When magnetic field measurements are to be made, the LRV will be stopped and the astronauts will carry the LPM far enough from the vehicle to ensure that it is measuring only the field of the moon itself, and that the contribution from the LRV is negligible (0.5 nanoteslas or less).

The purpose of this test was to determine the distance that the LPM must be carried away from the vehicle so that the field due to the LRV and to the astronauts themselves (since their EMU's are magnetic) is 0.5 nanoteslas or less. This will also determine the minimum length of cable to be supplied between the LPM sensor and the electronics box on the LRV.

TEST DESCRIPTION

Test Set-up

The tests were conducted in the GSFC Spacecraft Magnetic Test Facility. This facility utilizes a 12.8 meter (42 foot) diameter Braunbek coil system to produce a controlled magnetic field of high uniformity over a large central volume. The facility is described in Appendix A.

During the test a special wooden frame, designed specifically for this test, was used to support the LRV. The frame, in turn, rested upon a non-magnetic dolly. This assemblage, illustrated in Figure 1, could be rolled on tracks into or out of the coil system. When centered in the coil, the assemblage rested upon a turntable, thereby permitting it to be rotated through 360°. The height of the assemblage was such that the center of gravity of the LRV was at the center of the coil system. In the zero degree position (before rotation) the front end of the LRV faced north.

Four triaxial fluxgate probes were used to take magnetic data. These probes were in line, and located to the north at distances of 3.81, 4.57, 5.33, and 6.1 meters (12.5, 15, 17.5 and 20 feet) from the coil center. The height of the array was the same as that of the center of gravity of the LRV (127 cm (50 inches) above the deck).

Signals from the probes were hard wired to the Operations and Instrumentation Building (Bldg 304) where they were recorded as analog traces on strip charts and in digital coding on magnetic tape (MADAS).

Procedure

The basic activities were as follows:

a. Magnetic field measurements in initial state.

b. Exposure to 1 millitesla (10 gauss) in line with the initial dipole moment component in the horizontal plane.

c. Post exposure magnetic field measurements.

d. Deperm sequence. This consisted of several deperm treatments at different azimuthal positions of the LRV. The maximum field level was 1.5 milliteslas (15 gauss) at 60 Hz. A final deperm treatment was given with the LRV rotating. Hand tools were also depermed.

e. Post deperm magnetic field measurements.

f. Stray fields. This consisted of powering up the LRV, its subsystems, and payload equipment, while simultaneously taking magnetic field measurements. Magnetic measurements were also made with the front wheels rotating.

g. Post stray magnetic field measurements.

h. Calculation of LPM deployment distance.

The details of these procedures are covered in reference 1. The computational techniques are discussed in Appendix B.

TEST RESULTS

Magnetic field measurements as recorded on strip chart and magnetic tape are available at the GSFC Magnetic Test Site. Selections from these data have been incorporated into the GSFC Preliminary Report, Appendix D. Appendix D also includes curves of the 0.5 nanotesla contours in both the horizontal and vertical planes (Figures D-1 through D-4). These contours show that the maximum distance from the LRV center of gravity to the 0.5 nanotesla contour was 46.8 feet. This corresponded to the "as received" magnetic state of the LRV Qualification Model and includes the magnetic moment vectors of two astronaut EMU's on the LRV oriented directly toward the deployed sensor.

The dipole moments as calculated for the various magnetic states of the LRV are given in Table I.

Table I

LRV Dipole Moment History

LRV Status	Moment in Milliampere Meters Squared (pole cm)			
	M_x	M_y	M_z	M_t
As Received	4,888 N	1,778 W	0	5,200
Post, 1 Millitesla (10 Gauss Exp.)	54,050 N	19,665 W	0	57,500
Post 1.5 Millitesla (15 Gauss) Final Deperm	2,000 S	0	0	2,000
Perm + Maximum Stray	2,000 S	0	0	2,000
Post Front Wheel Operation	1,346 S	777 E	0	1,554
Final State	1,032 S	1,032 E	0	1,460

These moments indicate the LRV to be quite susceptible to magnetic fields, the moment increasing by a factor of 11 after a 1 millitesla exposure.

Difficulty was experienced in achieving an adequate deperm. Several reorientations of the LRV were made to deperm in different directions without achieving much better than the "as received" magnetic state. The final deperm treatment was given with the vehicle rotating and resulted in a reduction of the perm moment to 2,000 milliampere meters squared (2,000 pole cm) as compared to the initial value of 5,200. Hand tools were depermed separately.

The stray moments due to operation of various equipments as called for in the test procedure were insignificant. However, when the front wheels of the LRV were activated, alternating fields were produced. A typical record is shown in Figure 2. The alternating fields indicate the presence of magnetic material rotating with the wheels. Furthermore, the record also exhibits a modulation of the alternations. This is interpreted as due to a slight difference in rotational rate between the two front wheels, causing their moments to alternately reinforce and nullify one another. The record also indicates that the wheel moments were reinforcing one another fully, prior to the rotational testing and to a lesser extent after rotation. The reduction in total moment (M_t) subsequent to wheel operation tends to bear this out.

Because of the ease with which the LRV was permed up, an addition was made to the procedure to check on how much it would re-perm after exposure to earth's field outside the coil. This was done subsequent to final deperm. No change was noted.

CONCLUSIONS

The LPM cable length of 50 feet appears to be adequate, on the assumption that the flight model is no more magnetic than the qualification model was in its initial state. Deperming of small portable items, such as the astronaut's hand tools is desirable.

The assumed orientation of the astronaut's EMU's produces the most pessimistic picture for the 0.5 nanotesla (gamma) contour. On the other hand, there is a rotating moment associated with the wheels as evidenced by operation of the front wheels. As the rear wheels were not operated, there is a possibility that their moment contribution could be greater at some other relative angular position. Also, the front wheels were only powered under idling conditions. It is not known whether there would have been a greater remanent magnetization had they been operated under full load conditions.

PERSONNEL

Following is a list of persons and their specific responsibilities in carrying out the magnetic testing of the LRV:

Palmer Dyal	Principal Investigator	ARC
C. L. Parsons	Facility Coordinator	GSFC
Ed Baca	Test Manager	MSC

E. A. Vincent	Test Coordinator	Boeing Co.
Dave Pendley	ASPO Representatives	MSC
John Alter	MSVC Representative	MSFC
J. B. Thomas	Lunar Surface Equipment Project Engineer	MSC
Dave Ditmar	R&QA Representative	MSC

In addition to the above, personnel of the GSFC Magnetic Test Site, the GSFC Manned Flight Support Directorate, MSC, MFSC, and ARC participated in this test.

Figure 3 is a group photo showing the members of the Test Team at the GSFC Spacecraft Magnetic Test Facility.

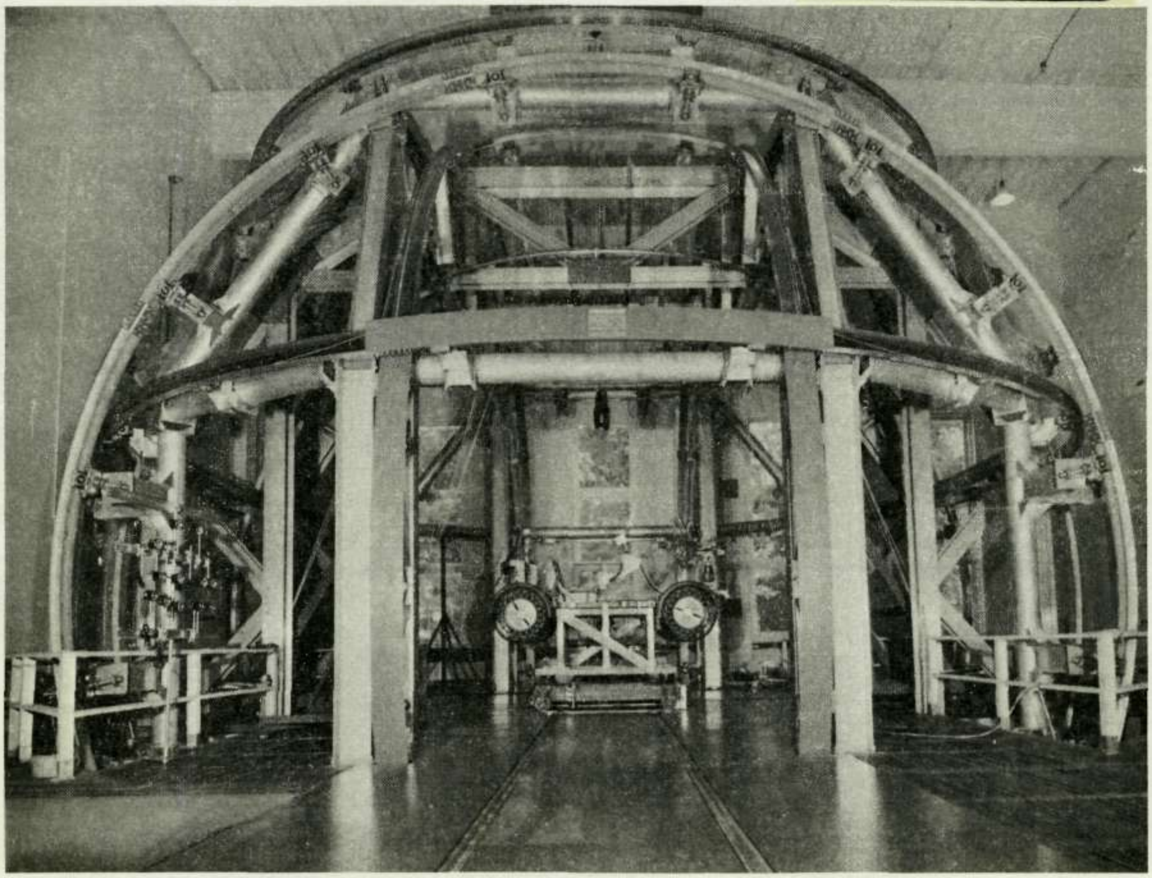

Figure 1. LRV in Spacecraft Magnetic Test Facility Mounted on Wooden Frame and Support Dolly

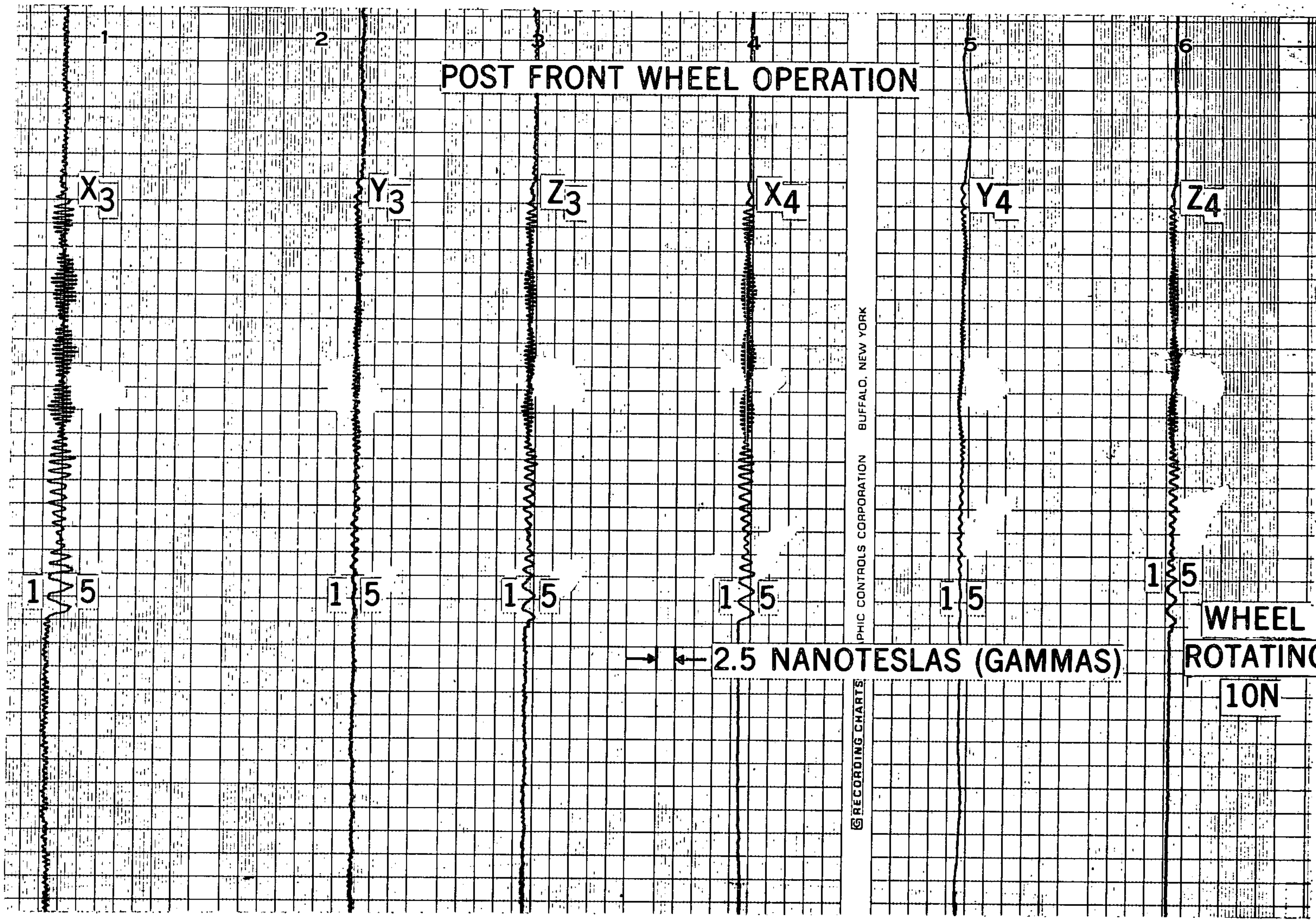

Figure 2. Strip Chart Record Showing Fields Due to Front Wheel Rotation

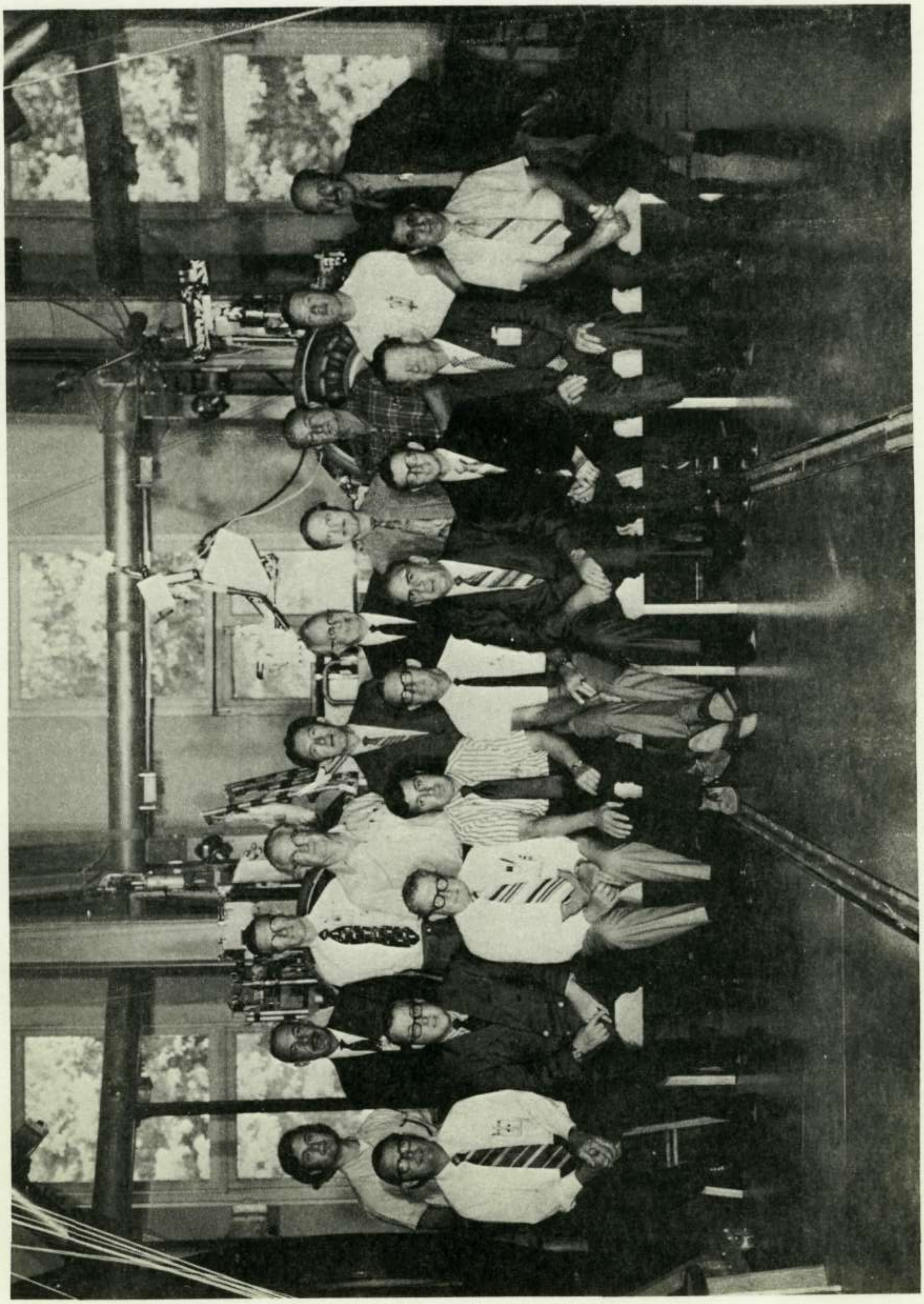

Figure 3. LRV Test Team

APPENDIX A

DESCRIPTION OF FACILITY

APPENDIX A

DESCRIPTION OF FACILITY

The Spacecraft Magnetic Test Facility (SMTF) provides a controlled magnetic environment in which to carry out magnetic tests of spacecraft or spacecraft components. The 12.8 meter (42 feet), 3 axis coil system permits the establishment of zero field or of a field of any desired magnitude and direction with a maximum of 60 microteslas (60,000 gammas). Current regulated power supplies provide stability of ±1 nanotesla (gamma) over a 24 hour period while the coil geometry provides uniformity of field within 0.6 nanoteslas (gammas) over a spherical volume of 0.98 meter (3.2 feet) radius. Three earth's field magnetometers and associated control systems provide automatic compensation for the daily variation of earth's field.

In addition to the generation of static magnetic fields, the coil currents may be programmed so as to produce a resultant vector which will rotate about any desired axis through the center of the coil system at a maximum rate of 100 radians per second. The magnitude of the rotating vector has a maximum limit of 60 microteslas (60,000 gammas).

The facility is also equipped with a 22,240 newton (5,000 pound) capacity overhead hoist, a 8896 newton (2,000 pound) capacity hydroset for gentle handling of delicate spacecraft, a track system and dolly for transporting the spacecraft from the trucklock to the center of the coil system and a turntable at the coil center which is powered to rotate the spacecraft through 360 degrees while it is centered in the coil. The turntable is equipped with an angle encoder so that angular position and magnetic measurements may be synchronized. In addition, a gimbal is available with which to produce rotation of the spacecraft about a horizontal axis.

Fields up to 2.5 milliteslas (25 gauss) for perming and deperming the spacecraft along one axis can be provided by means of a portable helmholtz coil pair of 2.7 meters (9 feet) diameter. There is also available a 1.5 meter (5 foot) diameter coil for applying such fields along a second axis of the smaller spacecraft.

The facility is equipped with a highly sensitive torquemeter located directly below the turntable, which permits the direct measurement of torques resulting from the interaction between the magnetic moment of the spacecraft under test and the field produced by the coil system itself. The torquemeter can be rigged to accept loads of 22,240 newtons (5,000 pounds) and to measure torques to an accuracy of 50×10^{-7} newton meters (50 dyne cm).

Four tri-axial fluxgate type magnetometers are available and may be used simultaneously to provide meter display, strip chart records or digital print-out records. The positions of the magnetometer probes may be varied to suit the particular needs of the individual spacecraft or subsystem under test.

A number of photographs taken during the conduct of the tests are shown in Figures A-1 through A-6.

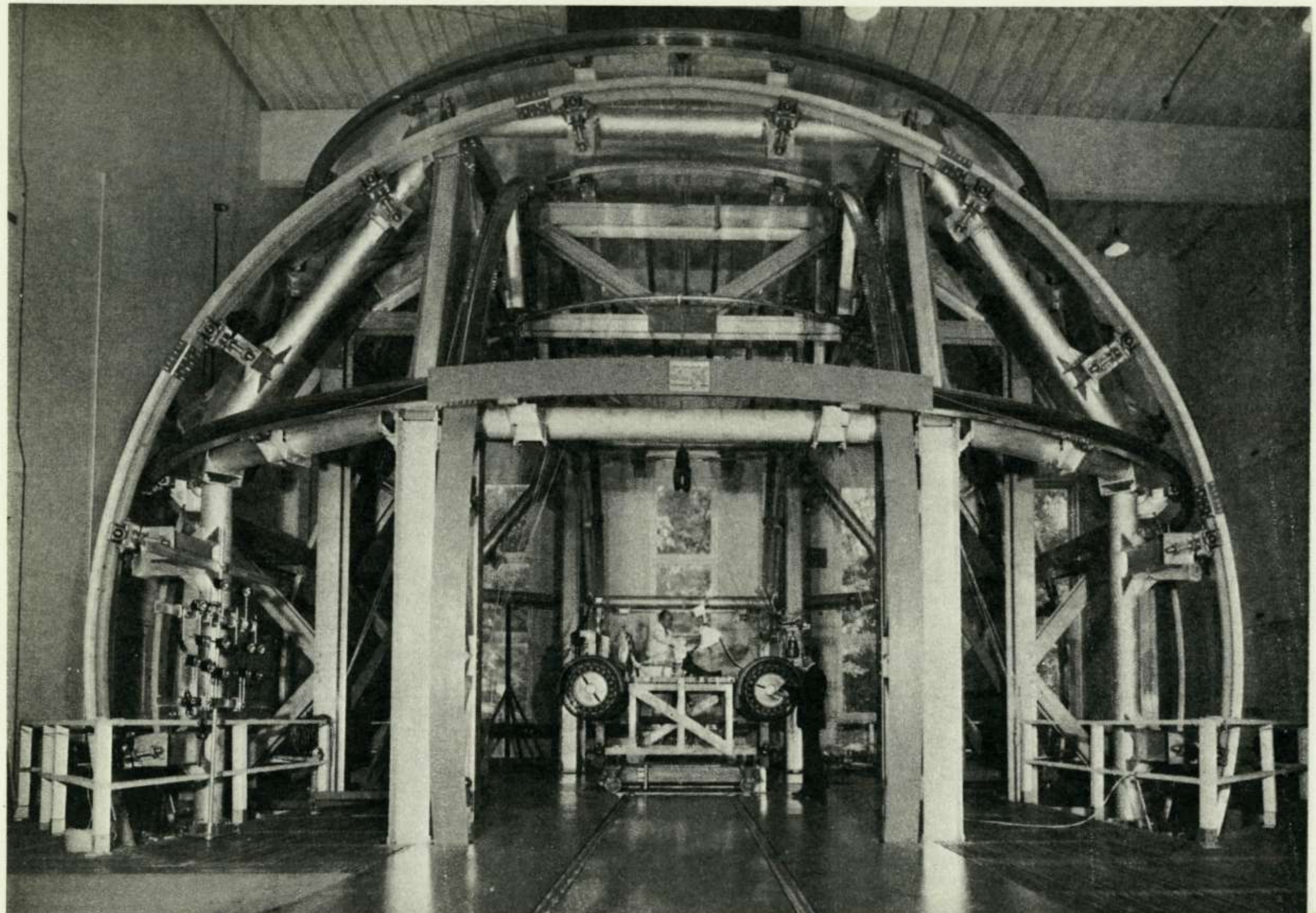

Figure A-1. LRV in Spacecraft Magnetic Test Facility with Operator at Controls

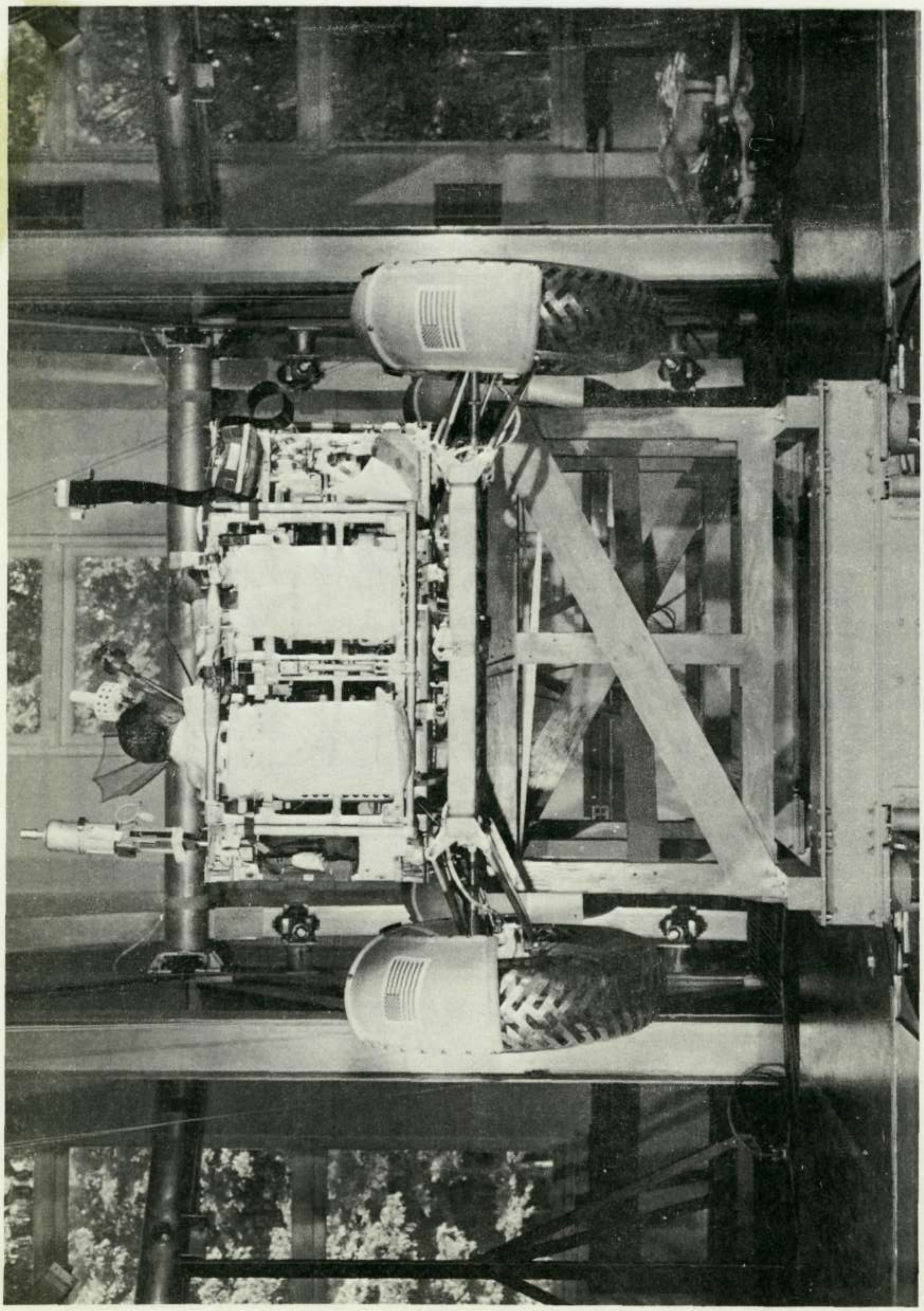

Figure A-2. LRV in Spacecraft Magnetic Test Facility, Rear End View

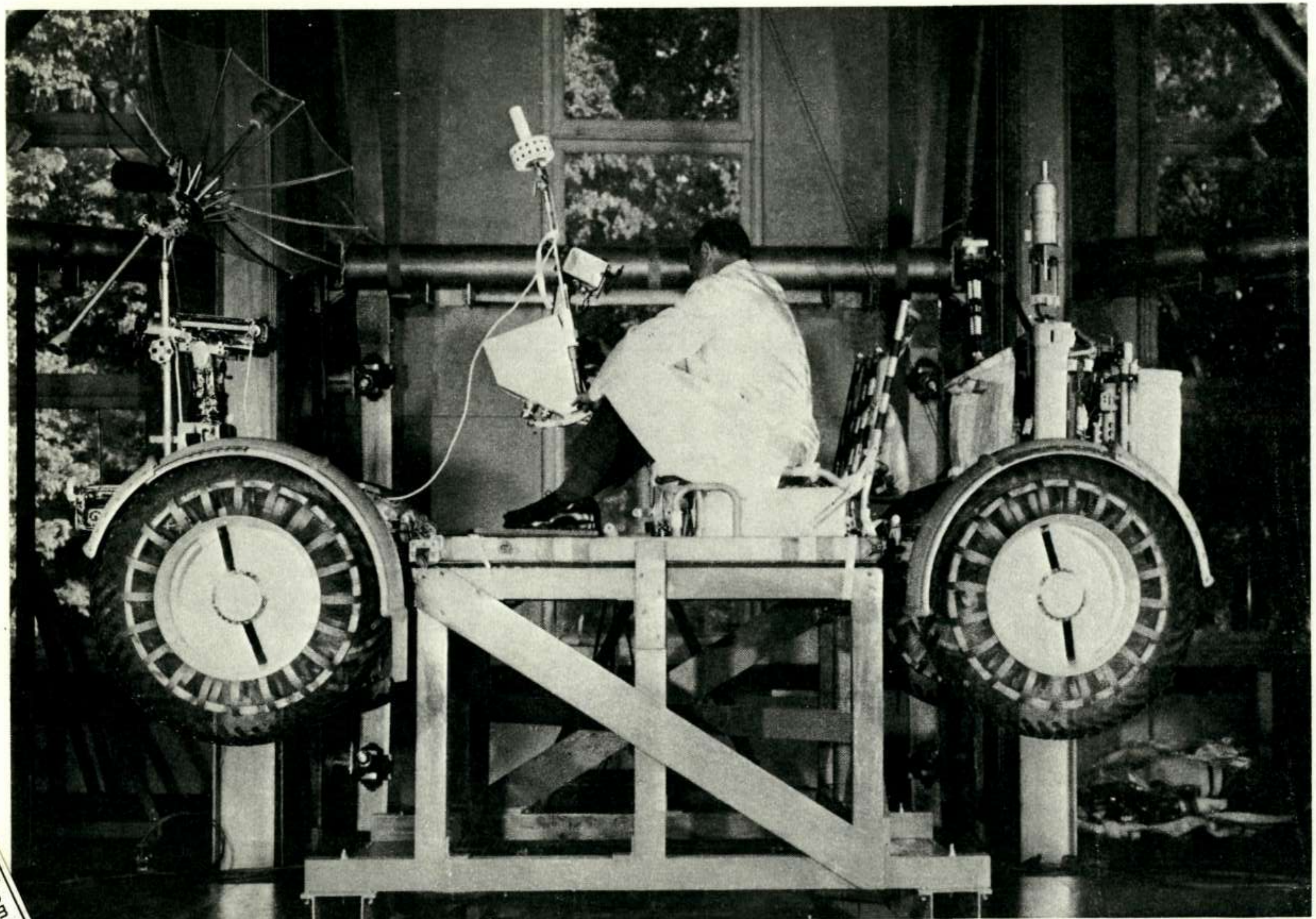

Figure A-3. LRV in Spacecraft Magnetic Test Facility, Side View

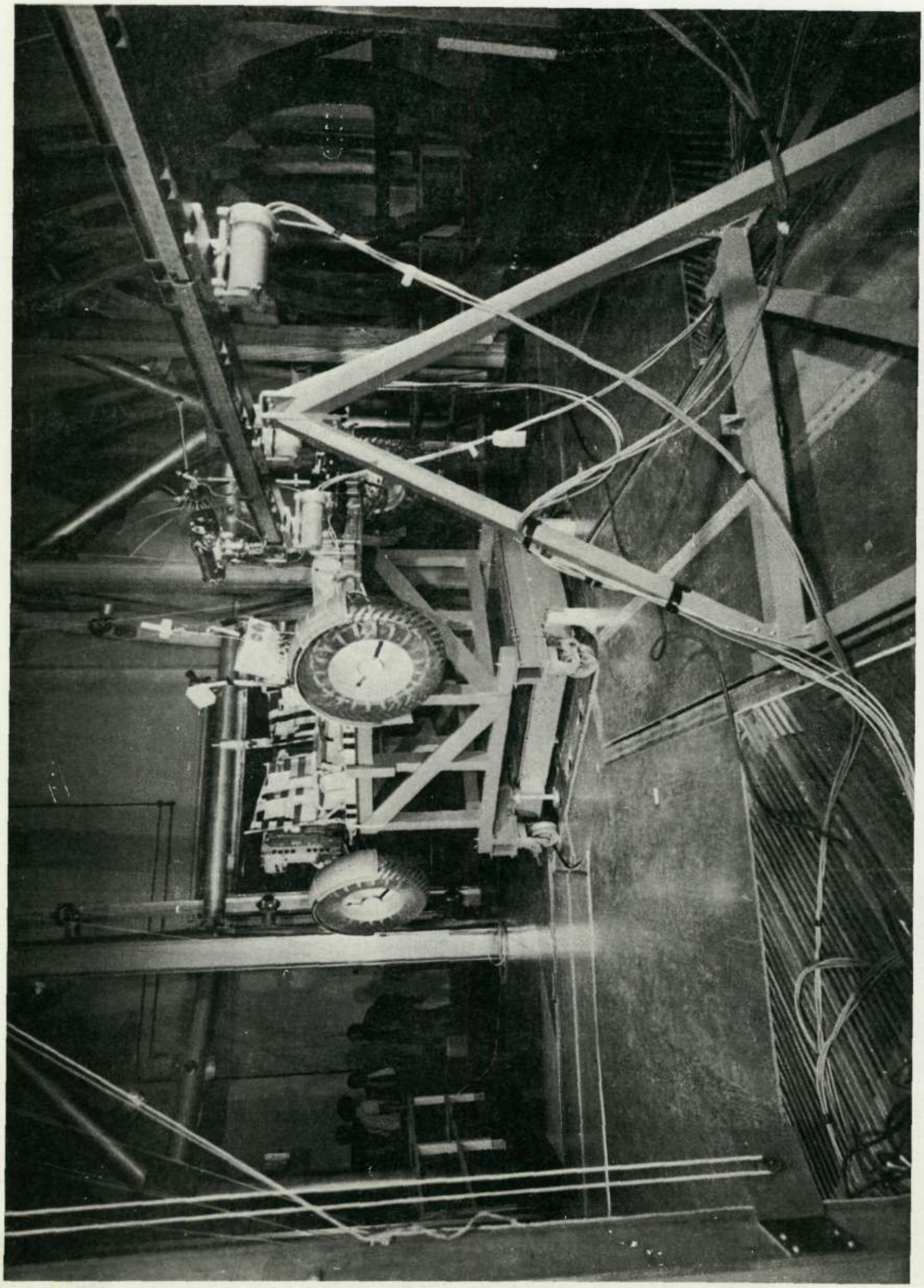

Figure A-4. LRV in Spacecraft Magnetic Test Facility Showing Deployment of Facility Probes

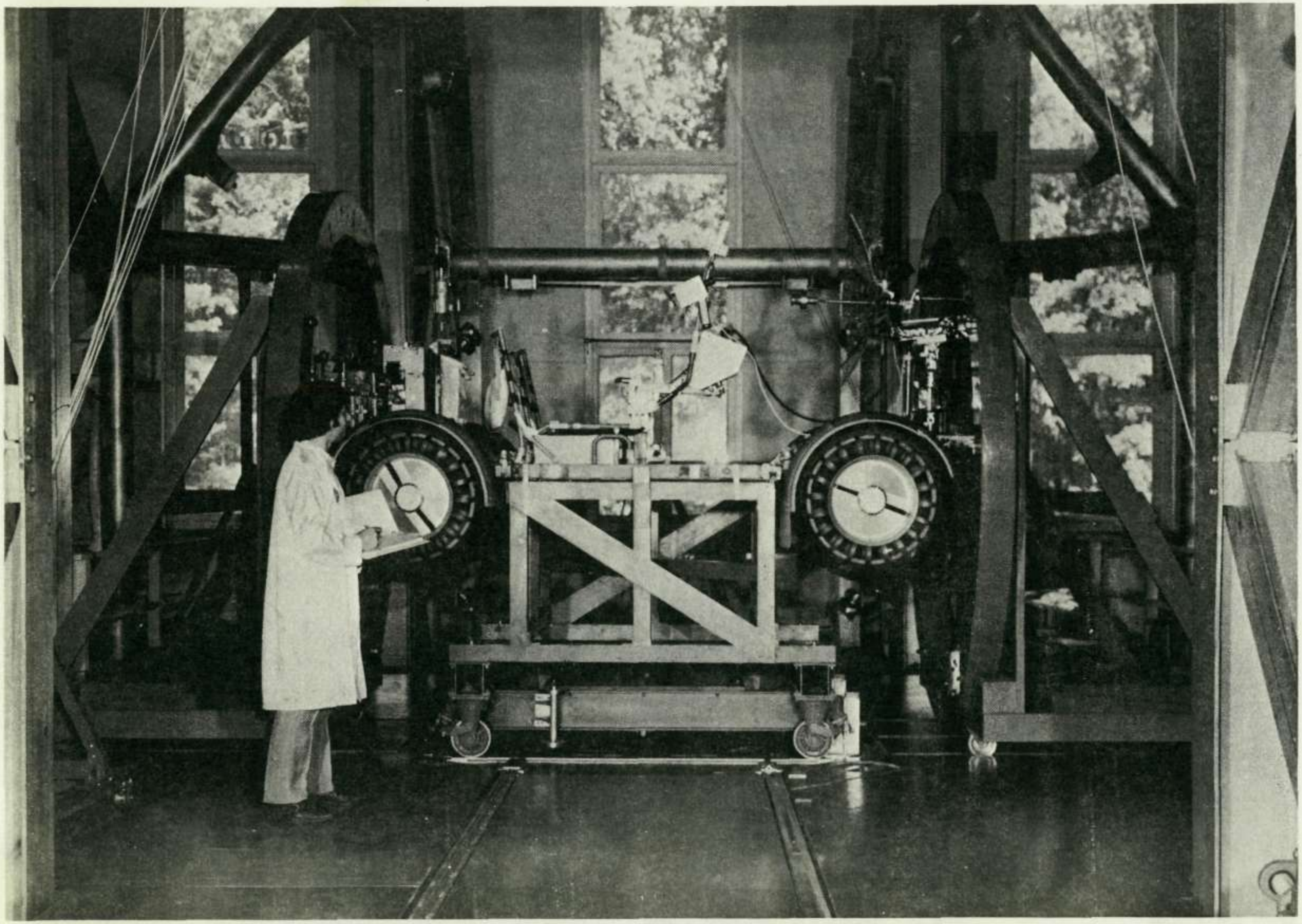

Figure A-5. LRV in Spacecraft Magnetic Test Facility Positioned for Horizontal Axis Deperming

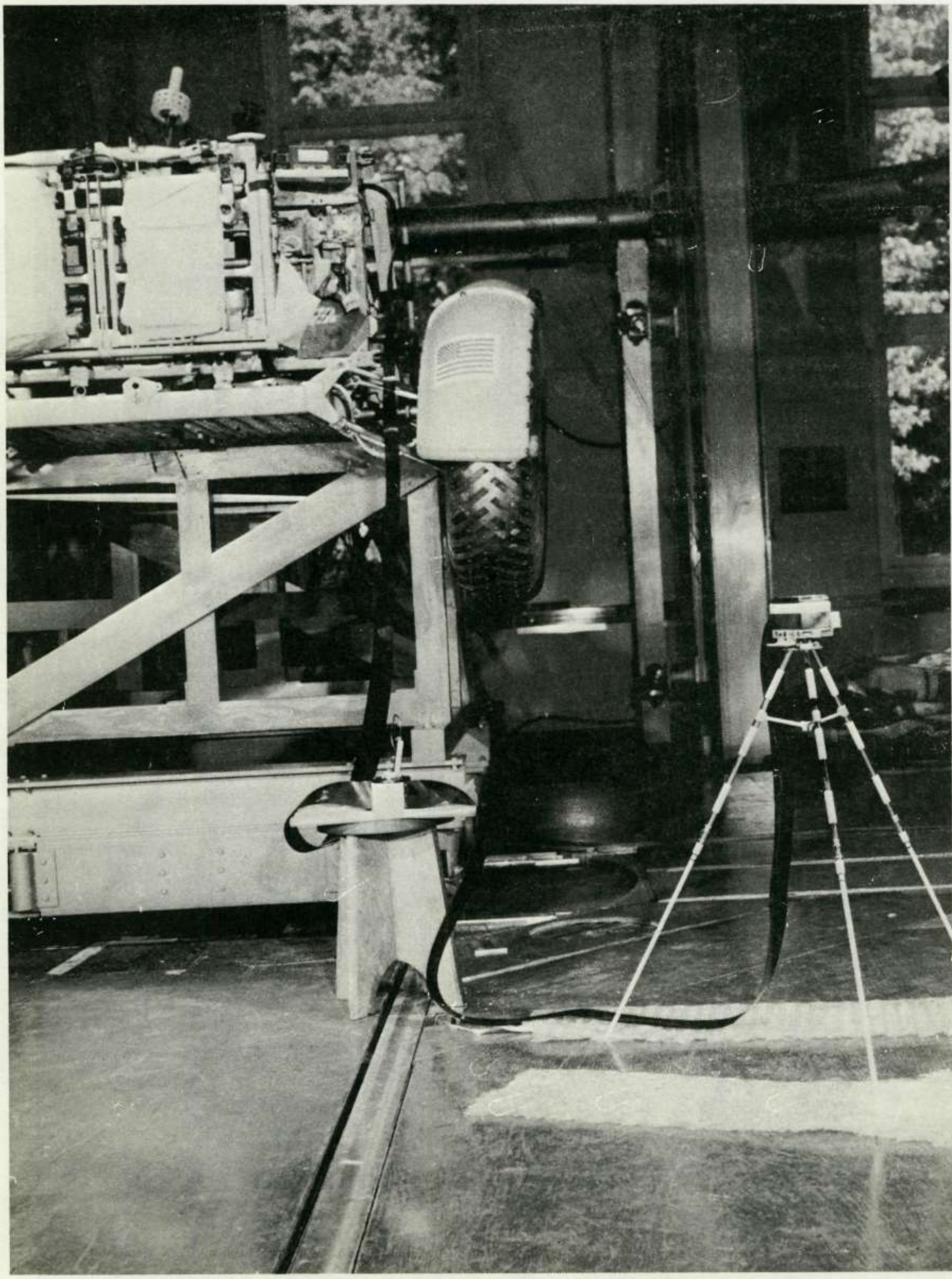

Figure A-6. LRV in Spacecraft Magnetic Test Facility Showing LPM and Cable Deployed

APPENDIX B

COMPUTATIONAL TECHNIQUES

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COMPUTATIONAL TECHNIQUES

During the conduct of the tests, estimates were made of the dipole moment of the LRV, assuming that the fields measured were due to a theoretical dipole. The total moment in the XY plane was calculated from peak to peak magnetic field readings, using the expression:

$$M_{xy} = \frac{(H_x) \text{ p-p } r^3 \times 10^{-5}}{4}$$

where

M_{xy} = dipole moment in milliampere meters squared (pole cm)

$(H_{xy})_{p\text{-}p}$ = peak to peak value of magnetic field intensity in nanoteslas (gammas)

r = probe distance in centimeters

Computations based on this technique yielded moment values that were too high due to multipole distortions. As a result, the closest probe gave the highest value, with the moment decreasing with probe distance. The values lay along a curve which was extrapolated to obtain the actual dipole moment value.

As a consequence of noise in the MADAS system, computer generated dipole moments based on the near field program were unreliable. The reported results, Figure B-1, therefore, are based on the far field extrapolation method.

Having determined the dipole moment of the LRV, the 0.5 nanotesla (gamma) contour may be calculated as follows:

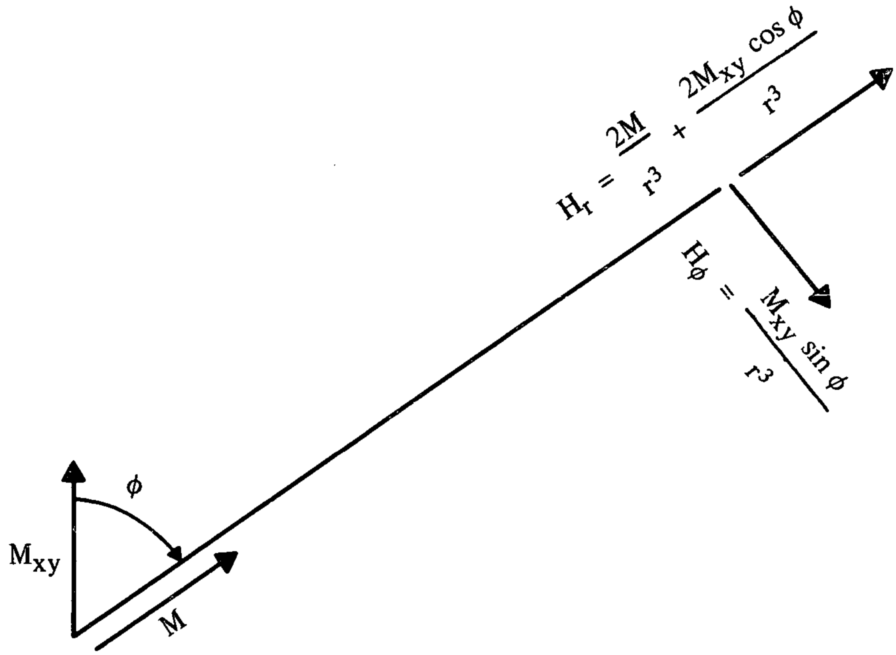
Data indicate the Z component of moment of the LRV to be negligible. The field due to the dipole moment in the XY plane (M_{xy}) may be written as

$$\overline{H} = \frac{2M_{xy} \cos \phi}{r^3} \hat{r} + \frac{M_{xy} \sin \phi}{r^3} \phi$$

If we add to this the field due to the astronaut's EMU and we direct the moment of the EMU (M) along the radius vector, we have

$$\overline{H} = \left(\frac{2M}{r^3} + \frac{2M_{xy}\cos\phi}{r^3}\right)\hat{r} + \frac{M_{xy}\sin\phi}{r^3}\phi$$

This situation is depicted in the following sketch:



The resultant field is

$$H = \left(H_r^2 + H_\phi^2\right)^{1/2} = \left[\left(\frac{2M}{r^3} + \frac{2M_{xy}\cos\phi}{r^3}\right)^2 + \left(\frac{M_{xy}\sin\phi}{r^3}\right)^2\right]^{1/2}$$

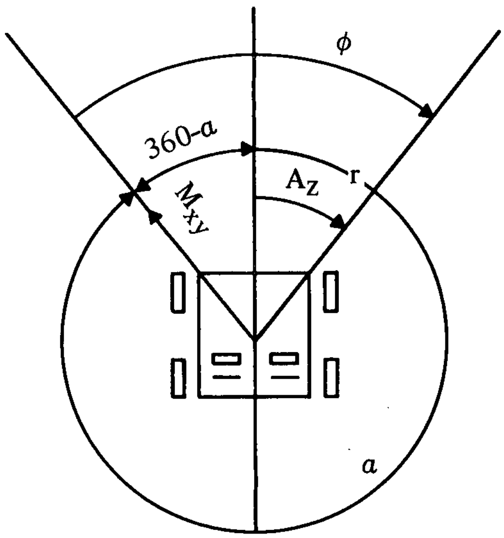
$$H = \frac{1}{r^3}\left\{\left[2(M + M_{xy}\cos\phi)\right]^2 + (M_{xy}\sin\phi)^2\right\}^{1/2}$$

Solving for r^3, we have

$$r^3 = \frac{1}{H} \left\{ \left[2(M + M_{xy} \cos \phi) \right]^2 + (M_{xy} \sin \phi)^2 \right\}^{1/2} \tag{1}$$

Equation (1) was used to calculate the 0.5 gamma contours in the horizontal plane.

The azimuth angle is measured clockwise from the front of the LRV; as is the direction of the M_{xy} vector (a).



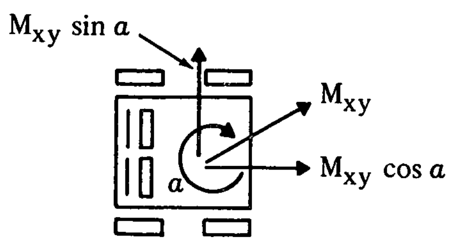
From the above diagram,

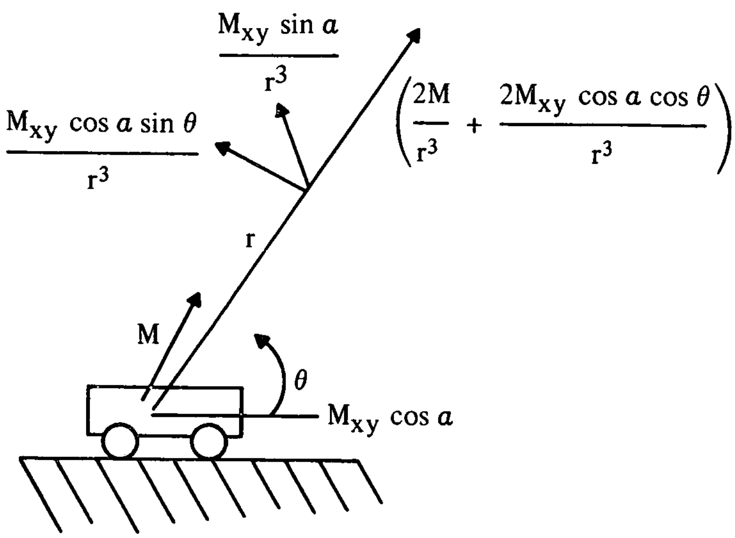
$$A_Z = \phi - (360 - a)$$

In the initial state, $a = 340°$. Therefore $A_Z = \phi - 20°$

In the post final deperm state, $a = 180°$ and $A_Z = \phi - 180°$

The 0.5 gamma vertical profile in the fore and aft plane was also calculated. The moment and field components involved are shown in the following sketches.





As in the horizontal case, the EMU moment (M) was assumed to be directed along the radius vector. In all cases, the sense of the vector was assumed to be aiding the moment component due to the LRV so as to present a worst case, thus giving the maximum distance out to the 0.5 gamma profile.

Three orthogonal field components are present in calculating the vertical profile. Thus we have

$$H = \left[\left(\frac{2M}{r^3} + \frac{2M_{xy} \cos a \cos \theta}{r^3}\right)^2 + \left(\frac{M_{xy} \cos a \sin \theta}{r^3}\right)^2 + \left(\frac{M_{xy} \sin a}{r^3}\right)^2\right]^{1/2} \quad (1)$$

Solving for r^3, we have

$$r^3 = \frac{1}{H}\left\{\left[2(M + M_{xy} \cos a \cos \theta)\right]^2 + (M_{xy} \cos a \sin \theta)^2 + (M_{xy} \sin a)^2\right\}^{1/2} \quad (2)$$

The numerical values for the quantities appearing in equations (1) and (2) were as listed below:

Initial State	Post Final Deperm
M_{xy} = 5200 mA-m^2 (pole-cm)	M_{xy} = 2000 mA-m^2 (pole-cm)
a = 340°	a = 180°
θ = 0 to 180°	θ = 0 to 180°
H = 0.05 x 10^{-5} milliteslas (0.5 gauss)	H = 0.05 x 10^{-5} milliteslas (0.5 gauss)
M = 857.5 (1 EMU)	M = 857.5 (1 EMU)
M = 1715 (2 EMU's)	M = 1715 (2 EMU's)
θ = 0 to 360°	θ = 0 to 360°
A_z = 0 to 360°	A_z = 0 to 360°

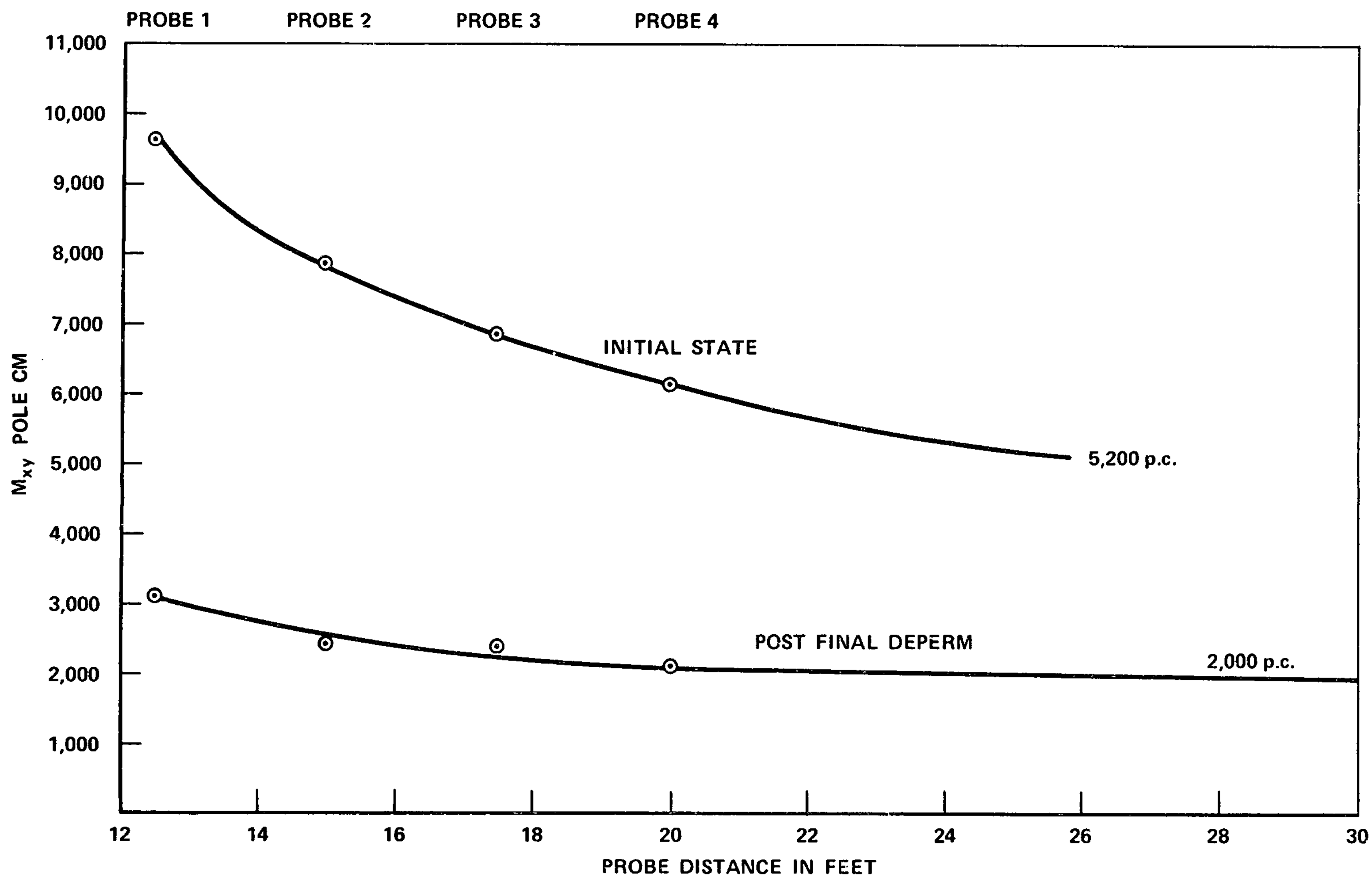


Figure B-1. LRV Qualification Model – Magnetic Moment Extrapolation

APPENDIX C

CHRONOLOGY OF EVENTS

APPENDIX C

CHRONOLOGY OF EVENTS

Friday, 10 September 1971

LRV arrived at Magnetic Test Site at 3:00 P.M.

Vehicle set up on test stand, check out and RF link established.

Monday, 13 September 1971

Measured initial permanent magnetism as received.

Exposed vehicle to 1.0 millitesla (10 gauss) field.

Three deperm treatments from 1.5 millitesla (15 gauss) initial level at 60 Hz.

Tuesday, 14 September 1971

Four additional deperm treatment from 1.5 millitesla (15 gauss) at 60 Hz.

Measured stray fields due to operation of various equipments, including front wheels.

Remeasured perm moment.

Testing completed 4:32 P.M.

Wednesday, 15 September 1971

Official photographs taken of LRV and members of test team.

LRV departed magnetic Test Site at 3:00 P.M.

APPENDIX D

PRELIMINARY REPORT OF AN ENVIRONMENTAL TEST

APPENDIX D

PRELIMINARY REPORT OF AN ENVIRONMENTAL TEST

9.3 Permanent Magnetization (non-operating)

9.3.1 Initial Permanent Magnetization

9.3.1.1 Establish zero field and re-zero the magnetometers by setting in the necessary compensation. Calibrate the magnetometers. Then move the LRV into the coil system. (Note: Antenna may have to be retracted and extended in order to place in coil.)

9.3.1.2 Align the LRV at the zero degree reference position with front of LRV facing north.

9.3.1.3 Record the field observed at each detector with the LRV in the zero degree reference position.

Zero Reference Field

Probe Position	Distance to Probe	Component	B (Gamma)
1	12.5'	x	+15.0
		y	- 4.0
		z	0.0*
2	15.0'	x	+ 6.0
		y	- 2.0
		z	+ 1.0*
3	17.5'	x	+ 2.5
		y	- 0.5
		z	—
4	20.0'	x	+ 1.5
		y	—
		z	—

*Average Field

9.3.1.4 Rotate the LRV 360 degrees in azimuth, indexing the recorders at each 10 degree increment of rotation while recording field changes at all detectors. Examine the chart recordings and determine the peak-to-peak value (Delta B) and the direction of maximum field and record below.

Chart Ref.	Probe Position	Distance to Probe	Component	ΔB	B(Gamma) perm $= \frac{\Delta B}{2}$
	1	12.5'	x	70.0	35.0
			y	47.0	23.5
			z	11.0	05.5
	2	15.0'	x	33.0	16.5
			y	23.5	11.8
			z	04.8	02.4
	3	17.5'	x	18.0	09.0
			y	10.0	05.0
			z	02.0	01.0
	4	20.0'	x	10.8	05.4
			y	—	—
			z	—	—

9.3.1.5 Remove the LRV from the coil system.

9.3.1.6 Recheck magnetometer zeros.

9.3.1.7 Remove and label chart recordings; fold and attach to procedure.

9.3.2 Post Exposure Magnetization

9.3.2.2 Perm the LRV by applying a 10 gauss, @ z-110° field along the axis of the LRV existing horizontal moment.

9.3.2.3 Align the LRV at the zero degree reference position with front of LRV facing north.

9.3.2.4 Record the field observed at each detector with the LRV in the zero degree reference position.

Post Exposure

Probe Position	Distance to Probe	Component	B (Gamma)
1	12.5'	x	-212.0
		y	+ 30.0
		z	0.0*

*Average Field

Post Exposure (Continued)

Probe Position	Distance to Probe	Component	B (Gamma)
2	15.0'	x	-140.0
		y	+ 75.0
		z	0.0*
3	17.5'	x	- 70.0
		y	+ 13.0
		z	0.0*
4	20.0'	x	3.7
		y	—
		z	—

*Average Field

9.3.2.5 Rotate the LRV 360 degrees in azimuth indexing the recorders at each 10 degree increment of rotation while recording field changes at all detectors. Examine the chart recordings and determine the peak-to-peak value (ΔB) and record below.

Probe Position	Distance to Probe	Component	ΔB	B(Gamma) Perm $= \frac{\Delta B}{2}$
1	12.5'	x	675.0	338.0
		y	140.0	70.0
		z	50.0	25.0
2	15.0'	x	360.0	180.0
		y	128.0	64.0
		z	21.0	10.5
3	17.5'	x	170.0	85.0
		y	64.0	32.0
		z	7.5	3.8
4	20.0'	x	110.0	55.0
		y	44.0	22.0
		z	6.0	3.0

9.3.2.6 Remove the LRV from the coil system.

9.3.2.7 Recheck magnetometer zeros.

9.3.2.8 Remove and label chart recordings; fold and attach to procedure.

9.3.3 Final deperm and survey for item with maximum residual perm.

9.3.3.1 Move the LRV into the deperm coil system (Fig. 4).

9.3.3.2 Deperm the LRV in a diminishing field with initial magnitude of 25 gauss (at 60 Hz) along the perming axis of the LRV.

9.3.3.3 Deperm the LRV in a diminishing field with initial magnitude of 25 gauss along a horizontal axis as required.

9.3.3.4 Align the LRV at the zero degree reference position with front of LRV facing north.

9.3.3.5 Record the field observed at each detector with the LRV in the zero degree reference position.

Zero Reference Field

Probe Position	Distance to Probe	Component	B (Gamma)
1	12.5'	x	16.0
		y	- 0.5
		z	0.0*
2	15.0'	x	+ 7.0
		y	- 0.5
		z	0.0*
3	17.5'	x	+ 4.0
		y	+ 0.2
		z	—
4	20.0'	x	+ 2.5
		y	—
		z	—

*Average Field

9.3.3.6 Rotate the LRV 360 degrees in azimuth indexing the recorders at each 10 degree increment of rotation while recording field changes at all detectors. Examine the chart recordings and determine the peak-to-peak value (ΔB) and record below.

Probe Position	Distance to Probe	Component	ΔB	B(Gamma) perm = $\frac{\Delta B}{2}$
1	12.5'	x	22.0	11.0
		y	8.5	4.2
		z	1.5	0.8
2	15.0'	x	10.0	5.0
		y	4.5	2.2
		z	0.5	0.2
3	17.5'	x	6.5	3.2
		y	2.8	1.4
		z	0.0	0.0
4	20.0'	x	3.7	1.6
		y	—	—
		z	—	—

9.3.3.7 Remove the LRV from the coil system.

9.3.3.8 Recheck magnetometer zeros.

9.3.3.9 Remove the label chart recordings; fold and attach to procedure.

9.3.3.10 Find item of maximum perm by surveying each item on LRV with portable magnetometer, keeping sensor about 6 inches from each item. Identify the object.

9.4 Stray Field (Test articles-operating)

9.4.1 Establish zero field and rezero the magnetometers by setting in the necessary compensation. Calibrate the magnetometers, if required.

9.4.2 Align the LRV at the zero degree reference position with front of LRV facing north.

9.4.3 Power up LRV, LRV associated subsystems and payload electronic equipment which operate at a traverse station, via the following TPS documentation:

a. TPS # LRV-MPT-2. LRV PWR up/PWR Down/Operation.
b. TPS # LRV-MPT-1. LCRU Installation/Operation on LRV.
c. TPS # LRV-MPT-3. Camera 16 mm Installation/Operation on LRV.

9.4.4 Record the field observed at each detector with the LRV in the zero degree reference position.

Zero Reference Field

Probe Position	Distance to Probe	Component	B (Gamma)
1	12.5'	x	+15.0
		y	- 0.5
		z	- 1.0
2	15.0'	x	+ 7.0
		y	- 0.7
		z	0.0
3	17.5'	x	4.3
		y	—
		z	—
4	20.0'	x	2.3
		y	—
		z	—

9.4.5 Rotate the LRV 360 degrees in azimuth, indexing the recorders at each 10 degree increment of rotation while recording field changes at all detectors. Examine the chart recordings and determine the peak-to-peak value (ΔB) and record below.

Probe Position	Distance to Probe	Component	ΔB	$B(Gamma)_{perm} = \frac{\Delta B}{2}$
1	12.5'	x	21.0	10.5
		y	8.0	4.0
		z	1.5	0.8
2	15.0'	x	10.0	5.0
		y	4.5	2.2
		z	0.7	0.4
3	17.5'	x	6.0	3.0
		y	2.3	1.2
		z	0.0	0.0
4	20.0'	x	4.0	2.0
		y	—	—
		z	—	—

9.4.6 Find item of maximum stray field by surveying each item on LRV with portable magnetometer, keeping sensor about 6 inches from each item. Identify the object.

9.4.7 Repeat steps 9.4.1 thru 9.4.6a, reconfiguring 9.4.3b as follows:

9.4.3b LCRU/GCTA Power up and operation (LCRU on External power). TPS # LRV-MPT-1 test conductor will cue GCTA driver motors time duration.

Zero Reference Field

Probe Position	Distance to Probe	Component	B (Gamma)
1	12.5'	x	+15.0
		y	- 0.5
		z	- 1.0
2	15.0'	x	+ 7.0
		y	- 0.7
		z	0.0
3	17.5'	x	4.3
		y	—
		z	—
4	20.0'	x	2.3
		y	—
		z	—

Probe Position	Distance to Probe	Component	ΔB	B(Gamma) perm $= \frac{\Delta B}{2}$
1	12.5'	x	21.0	10.5
		y	8.0	4.0
		z	1.5	0.8
2	15.0'	x	10.0	5.0
		y	4.5	2.2
		z	0.5	0.2
3	17.5'	x	5.8	2.9
		y	2.3	1.2
		z	0.0	0.0
4	20.0'	x	3.8	1.9
		y	—	—
		z	—	—

9.4.8 Power down LRV, associated subsystems and payload electronic equipment as delineated in paragraph 9.4.3a, b, c.

9.4.9 Remove the LRV from the coil system.

9.4.10 Recheck magnetometer zeros.

9.4.11 Remove and label chart recordings; fold and attach to procedure.

9.5 Determination of LPM Deployment Distance

9.5.1 Use GSFC computer program to calculate LRV magnetic moment. Record the moment magnitude below:

$$M_{LRV} = 5200 \text{ pole centimeters}$$

9.5.2 Add to M_{LRV} the worst case total magnetic moment magnitude for two astronaut EMU's:

$$2M_{EMU} = 1.715 \times 10^3 \text{ pole-cm}$$

$$M_{tot} = M_{LRV} + 2M_{EMU} = 6915$$

9.5.3 Use M_{tot} to determine and plot a 0.5 gamma contour in the horizontal plane through the LRV center.

9.5.4 Use M_{tot} to determine and plot a 0.5 gamma contour in the vertical plane through the LRV center.

9.5.5 Record the maximum horizontal distance from the LRV center of gravity to the 0.5 gamma contour: 46.3 feet*. This is the minimum required LPM deployment distance from the LRV center.

*Initial state of qualification model. For post deperm this distance becomes 38.0 feet.

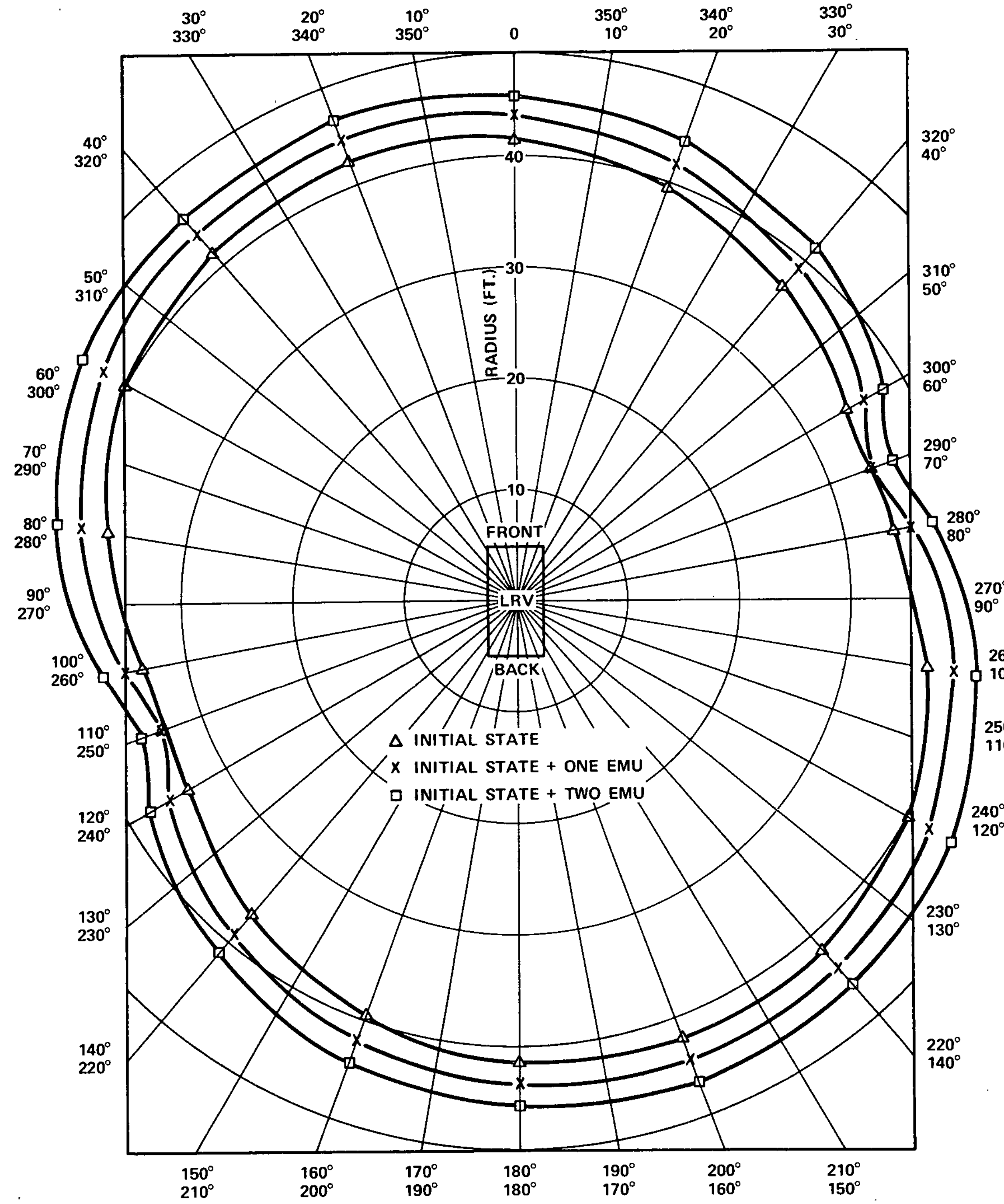


Figure D-1. LRV Horizontal Plane 0.5 Nanotesla (Gamma) Contour – Initial State

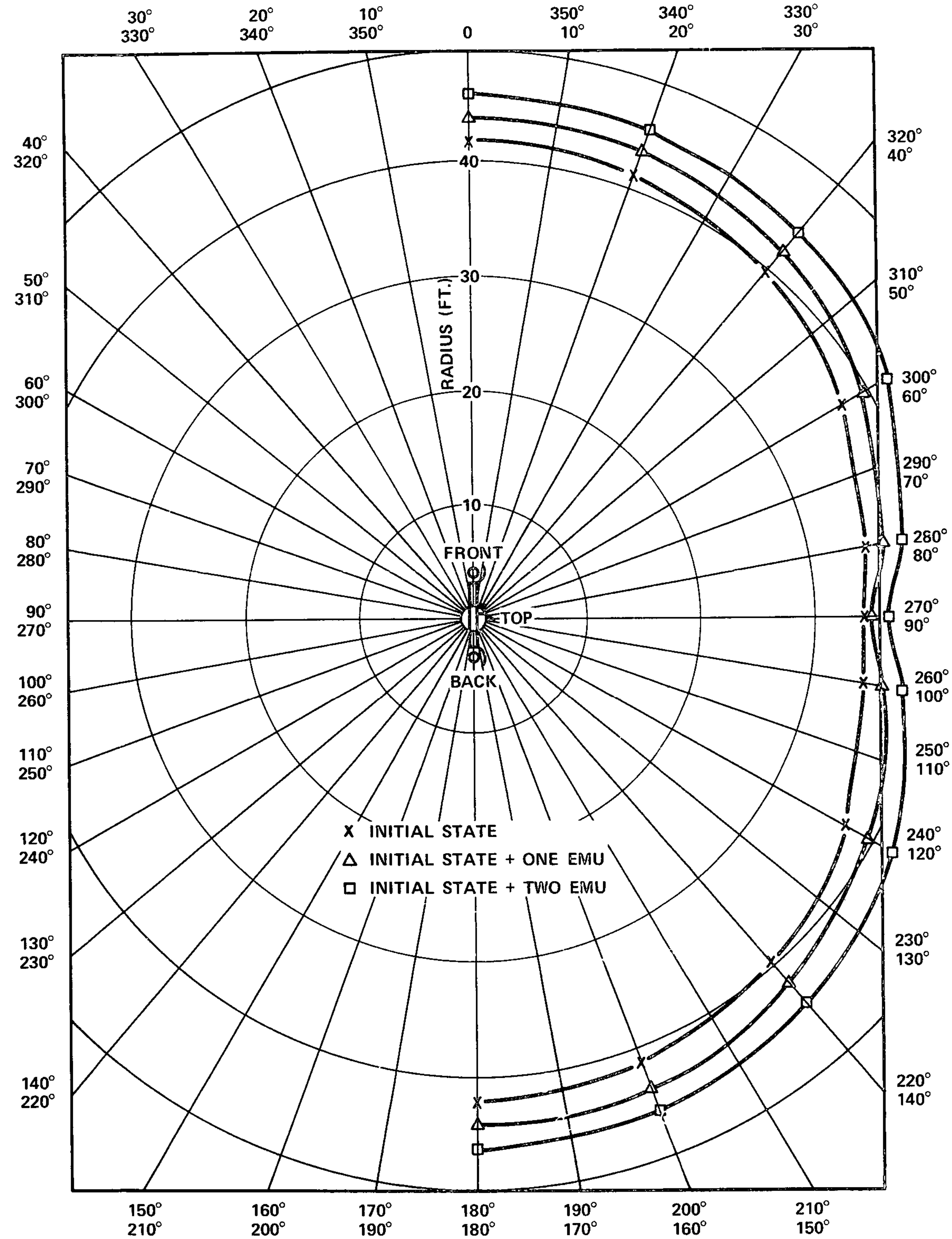


Figure D-2. LRV Vertical 0.5 Nanotesla (Gamma) Contour – Initial State

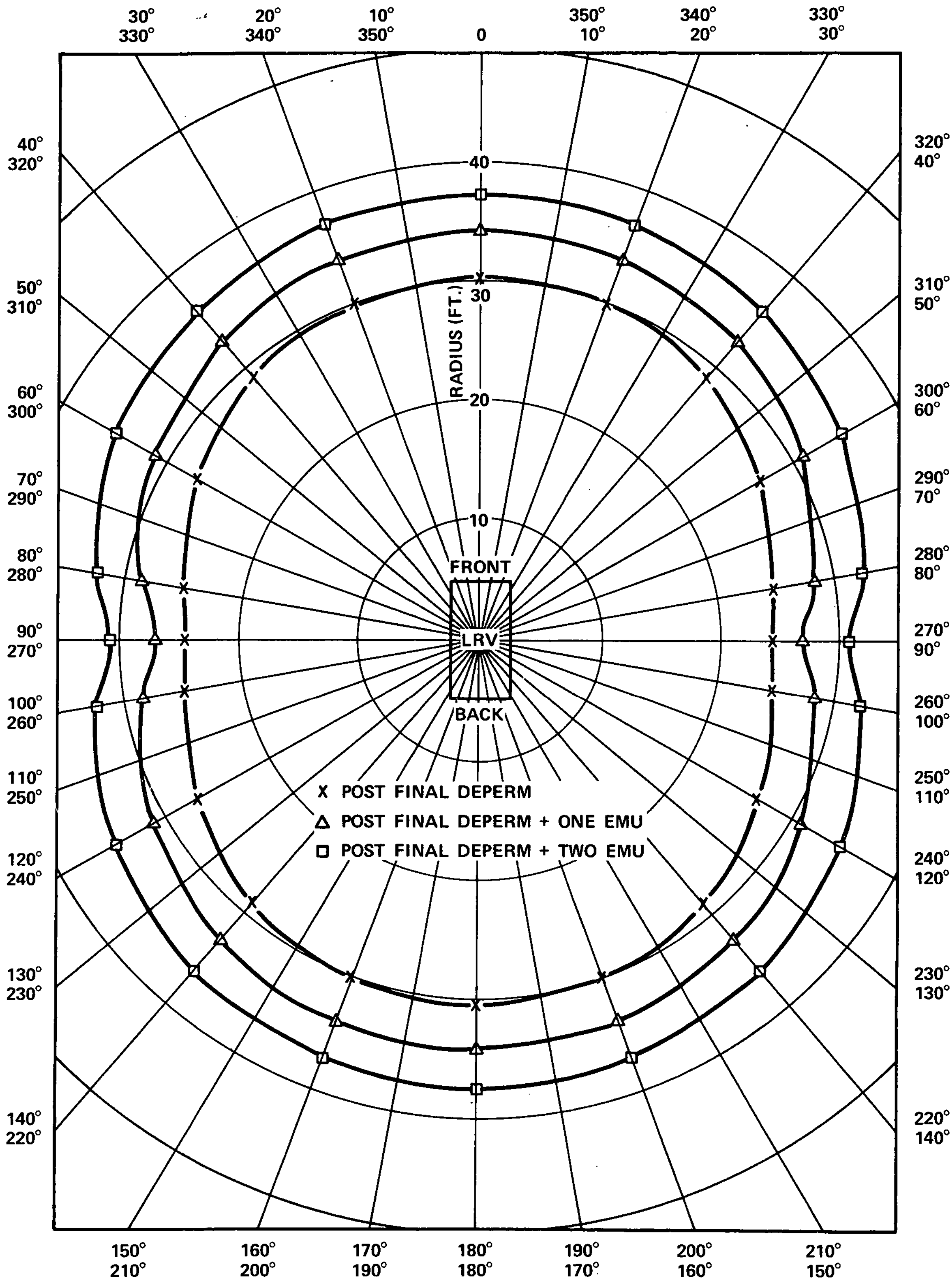


Figure D-3. LRV Horizontal Plane 0.5 Nanotesla (Gamma) Contour – Post Final Deperm

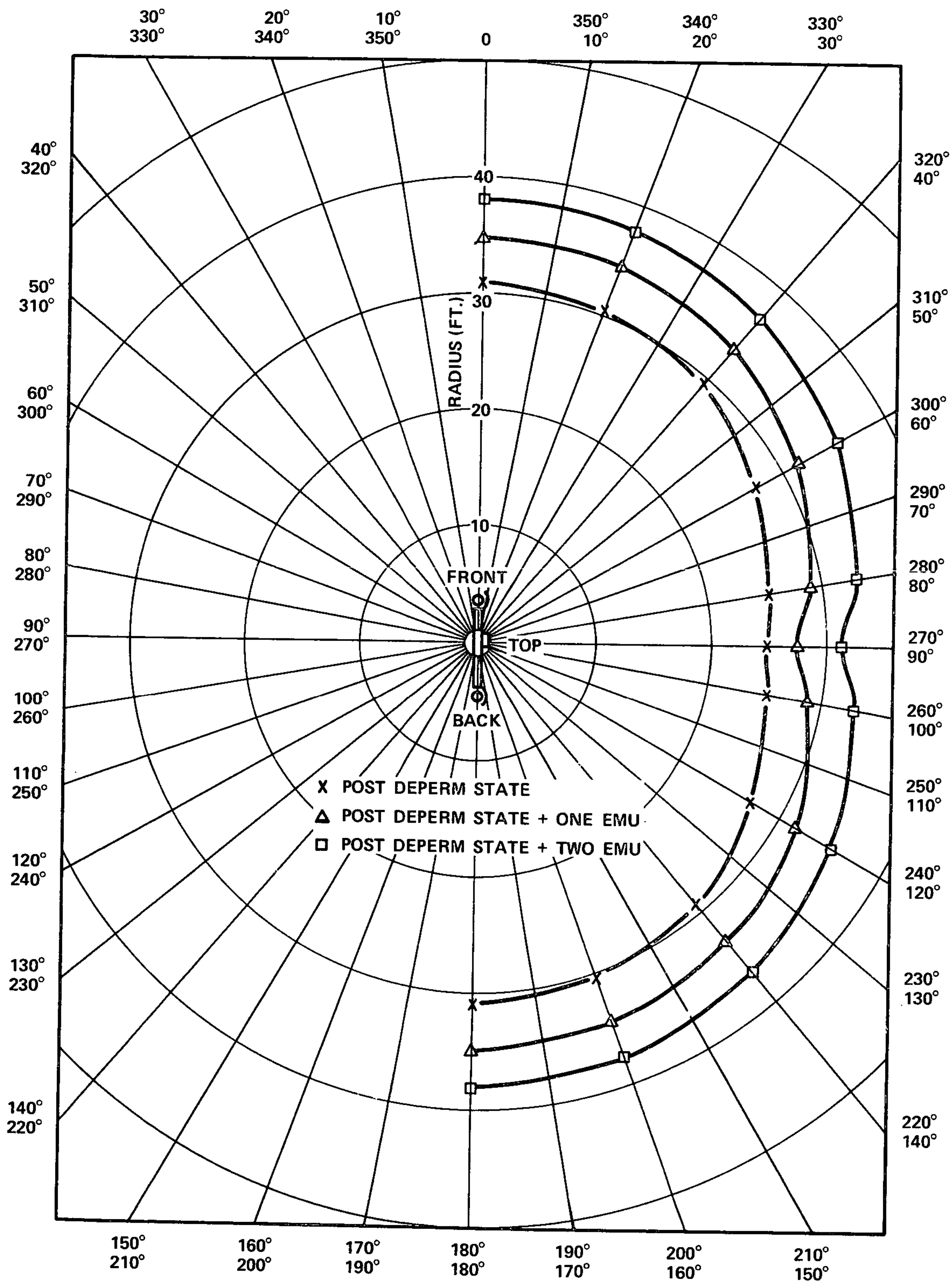


Figure D-4. LRV Vertical 0.5 Nanotesla (Gamma) Contour – Post Final Deperm