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Development of the ARIES Parachute System

by

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Theme

The design and testing of a two-stage parachute system to recover a space telescope weighing up to 2000 pounds is described. The system consists of a 15-ft diameter ribbon parachute reefed to 50 percent for 10 seconds and a 73-ft diameter paraform or cross second stage reefed to 10 percent for 10 seconds; it will be described in detail in the full paper. The results of eight drop tests and one operational rocket launched flight and recovery are presented.

A successful operational recovery of a 1600-lb NASA space telescope was conducted at White Sands Missile Range, NM, in September 1980. The payload was launched by a second

stage Minuteman rocket to an altitude of about 300 miles above sea level. An operational recovery of a 2000-lb NASA space telescope is scheduled for April 4, 1981, at WSMR.

ABSTRACT

Contents

ARIES is a NASA program to develop and qualify an orbital space telescope for use with the space shuttle in the mid-eighties. In order to qualify the telescope system, the second stage Minuteman rocket is used to place a 44-in diameter by 20-ft long 1600-lb payload above the atmosphere for 8 minutes by a ballistic launch at White Sands Missile Range, New Mexico. A parachute system is used to recover the million-dollar payload after it reenters the atmosphere at Mach 7 and slows down by side-on spin. To develop the parachute recovery system[1,2,3] an economical drop body shown in Figure 1 was used. This 2000-lb vehicle could be loaded under the wing of a Navy A7 aircraft at the Naval Weapons Evaluation Facility at Kirtland AFB, New Mexico, and dropped a half-hour later from 20,000 ft mean sea level at the Stallion Test Site, White Sands Missile Range, New Mexico, which is at 4,700 ft m.s.l.

Recovery System

The initial recovery system defined by NASA and used on the first eight drop tests and the first operational recovery consisted of a 12.6-ft diameter ribbon parachute

reefed to 50-percent for 10 seconds and a 73-ft diameter paraform (cross) type second stage parachute deployed 21 seconds after first stage deployment. This parachute was reefed to 10-percent for 10 seconds.

The final recovery system design was the same as above except the first stage was increased to a 15-ft diameter ribbon parachute. A more detailed description of the recovery system and test results will be presented in the final paper.

Results

Results from the 9 drop tests and operational rocket flight are listed in Table I. No parachute deployment occurred on the first test due to battery failure from low temperatures at altitude. A battery warmer was incorporated by Bristol Aerospace Limited, Winnipeg, Canada, who was supplying the electronic system to fire off the heat shield. On the second drop, the 12.6-ft diameter ribbon parachute failed at the overtest dynamic pressure of 360 lb/ft^2. The second stage parachute also failed, due to lack of first stage deceleration. The third drop was completely successful with a 1250-lb payload. The next test was an overtest at q = 250 with a 2139-lb payload. A rigging error resulted in half inflation of the 73-ft cross: an interpanel line was over the canopy. The fifth test resulted in severe friction burning and tearing of

the 73-ft cross. The cause was proven to be the canopy locking spider in the main bag, which was not unlocking completely. Two-loop locking flaps were used for all future tests. Test numbers six and seven proved successful with 1814-lb and 2000-lb payloads. This qualified the 1600-lb operation flight which was successful on September 20, 1980.

Parachute loads obtained from point-mass theoretical trajectories are shown in Figure 3. First stage suspension line peak loads of about 7500-lb are well below the design allowable values of 12,000-lb. The weak link in the system is the 2 ply 1.1 oz/yd^2 nylon cloth in the crown of the 73' cross. This material is subject to friction burning at the high bag strip velocities of 274 ft/sec as shown in Figure 4 for test No. 9. It is believed this test failed the canopy due to the 56 lb/ft^2 dynamic pressure at reefed fill.

By increasing the first stage ribbon parachute diameter from 12.6-ft to 15-ft, the dynamic pressure at first stage filling of the 73-ft cross is reduced from the catastrophic value of 56 to a safe 42 lb/ft^2. The results of testing this new system (No. 9, Table I) will be reported in the final paper.

Conclusions

A series of nine drop tests was conducted to develop a four-stage parachute recovery system for ARIES. The final system consists of a 15-ft diameter ribbon parachute

reefed to 50 percent for 10 seconds and a 73-ft diameter cross or paraform reefed to 10 percent for 10 seconds. The following conclusions were reached:

1. The recovery system will be qualified for a 2200-lb payload.

2. A successful operational flight with recovery of a 1600-lb payload was conducted at WSMR.

References

1. Steeves, R. G. "73 Foot Paraform Drop Test Report No. 1290-TR-10," Space Vector Corp. Aug. 31, 1979.

2. Morrison, Robert S. "Evaluation of the 73-foot Diameter Paraform Recovery Parachute System," AFFTC-TR-79-30, Dec. 1979.

3. Steeves, R. G., "Design Study of a Parachute System for ARIES Payloads," Report No. 1290-TR-7, May 30, 1979.

Table I

ARIES TESTS

A - Drop Tests

Drop No.	Test Date	q_o (lb/ft^2)	Test Site		Results	Wt. (lb)
1	Aug , 79		TTR	all lost	frozen battery, went free-fall	--
2	Dec 4, 79	360	Stallion	all lost	12.6' failed 360 q	--
3	Jun 3, 80	170	Stallion	all rec.	successful	1250
4	Jun 10, 80	250	Stallion	all rec.	drogue O.K., some tears, rigging error	2139
5	Jul 11, 80	250	Stallion	badly damaged	main destroyed afterbody and fins reusable	2139
6	Aug 22, 80	170	Stallion	all rec.	100% successful	1814
7	Aug 26, 80	170	Stallion	all rec.	100% successful	2000
8	Dec 16, 80	170	Stallion	badly damaged	main destroyed afterbody and fins reusable	2392
9	Feb 24, 81	200	Stallion		New 15' ribbon first stage	2200

B - Operational Recoveries

1	Sep 20 , 80	~100	WSMR	no damage	100% successful	~1600
(Scheduled)						
2	Apr 1, 80		WSMR			2000

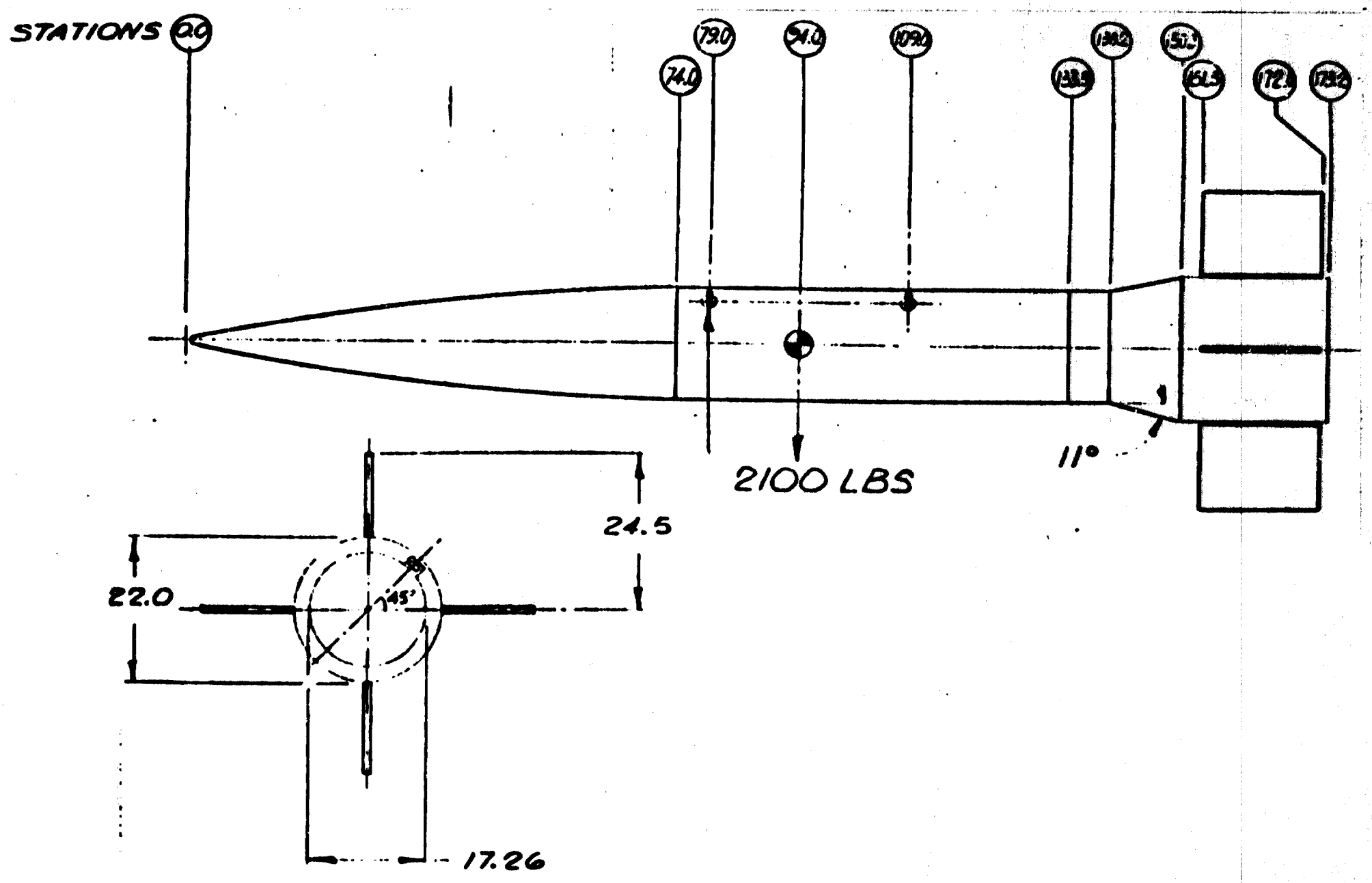


Figure 1. ARIES Parachute Test Vehicle

ARIES RECOVERY SYSTEM

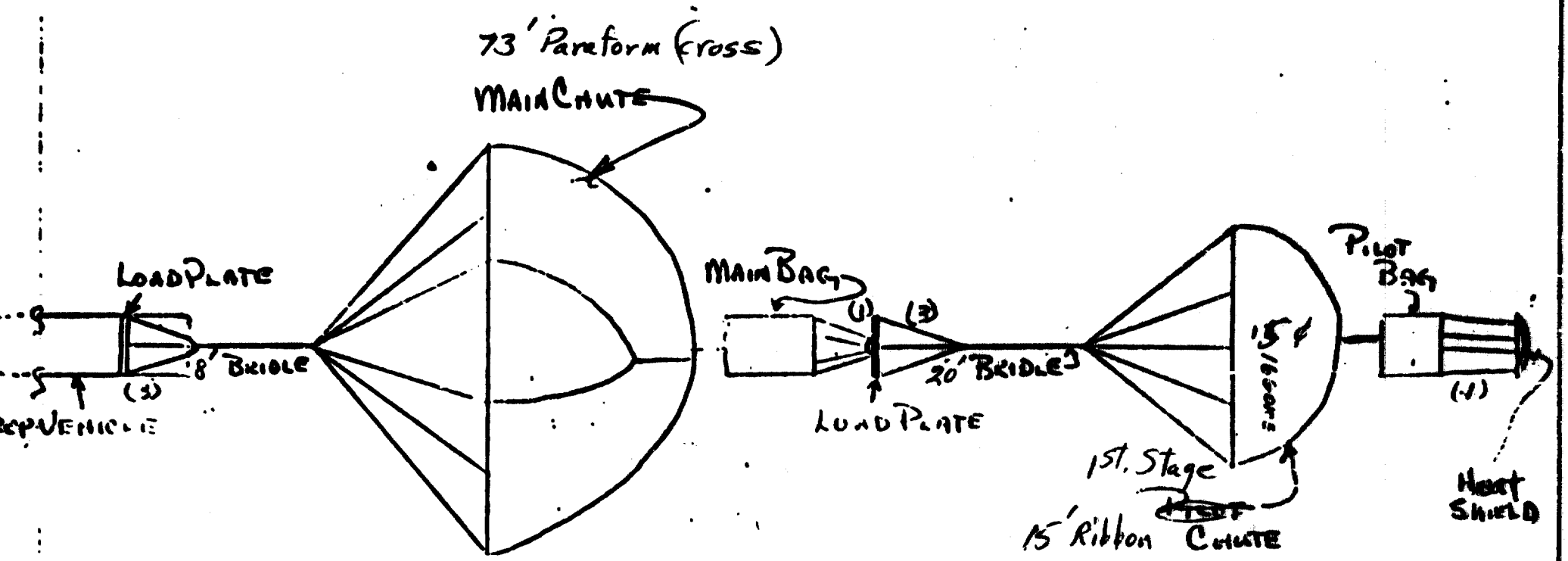


Figure 2. Sketch of ARIES Recovery System

Figure 3. ARIES Loads

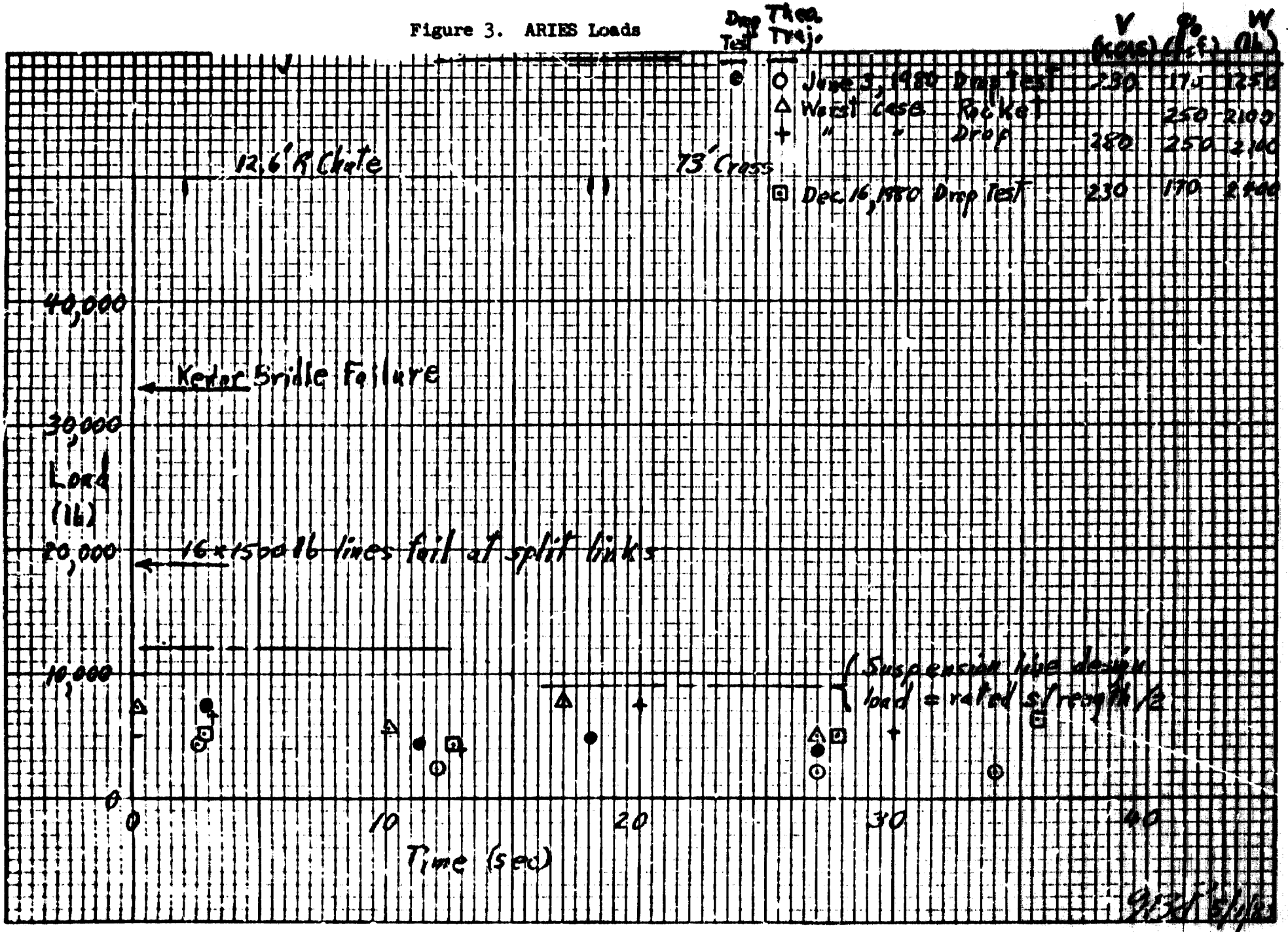
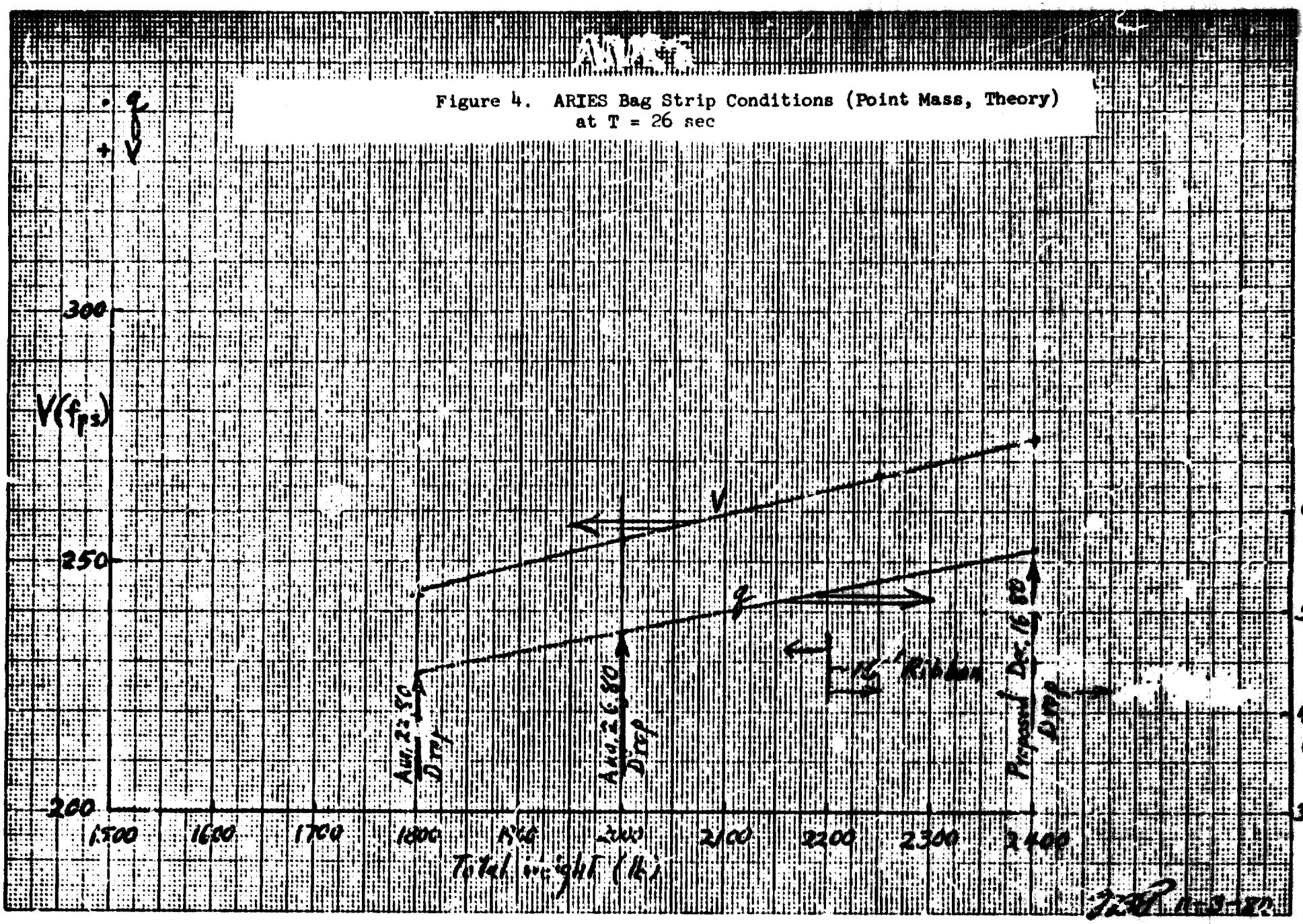


Figure 4. ARIES Bag Strip Conditions (Point Mass, Theory)
at T = 26 sec



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