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M-66-8
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TITAN III BOOSTERS FOR LANGLEY'S MANNED LIFTING BODY ENTRY PROGRAM (U)

February 1966

Prepared By: R. H. Lea
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Project Manager

Approved By: H. F. Keyser
H. F. Keyser
Manager
Launch Vehicle Applications

CLASSIFICATION CHANGE

TO - [redacted]

Downgraded at [redacted] Year Intervals;
Declassified After 12 Years
DOD Directive 5200.10

GDS EO 11652 dtd 6/30/72
Changed by L. Thorne Date 8/12/77

MARTIN COMPANY
Denver, Colorado
Aerospace Division of Martin-Marietta Corporation

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43598

FOREWORD

This document is an informal report submitted to Langley Research Center, the NASA, in compliance with request to provide launch vehicle data on the Titan family of boosters. The data is purposely prepared for use in defining compatible manned lifting body entry vehicles to be studied for space use potential.

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I. INTRODUCTION

The Titan III family of launch vehicles offers a wide range of payload weight capability to the near earth orbits for minimum cost. This report summarizes the performance and certain system design features for those configurations which the Martin Company believes would be of greatest benefit to the lifting body research and development study being conducted under the direction of NASA's Langley Research Center.

In preparing this document, we have not limited our analysis to the Titan III hardware as it now exists for the R & D flight test program. Rather, we have used configurations that are being assembled from Titan III building blocks and which will be available for the time period contemplated for the lifting body program. These configurations have all of the capabilities and reliabilities necessary to carry out the flight test program.

The standard interface has been made as simple as possible to minimize payload integration cost. Fundamentally, the interface concept is based on maximum isolation of booster and spacecraft functions. Primarily, the interface reduces to one of mechanical mating, however, each specific payload may also have other unique interface requirements.

II. CONFIGURATIONS

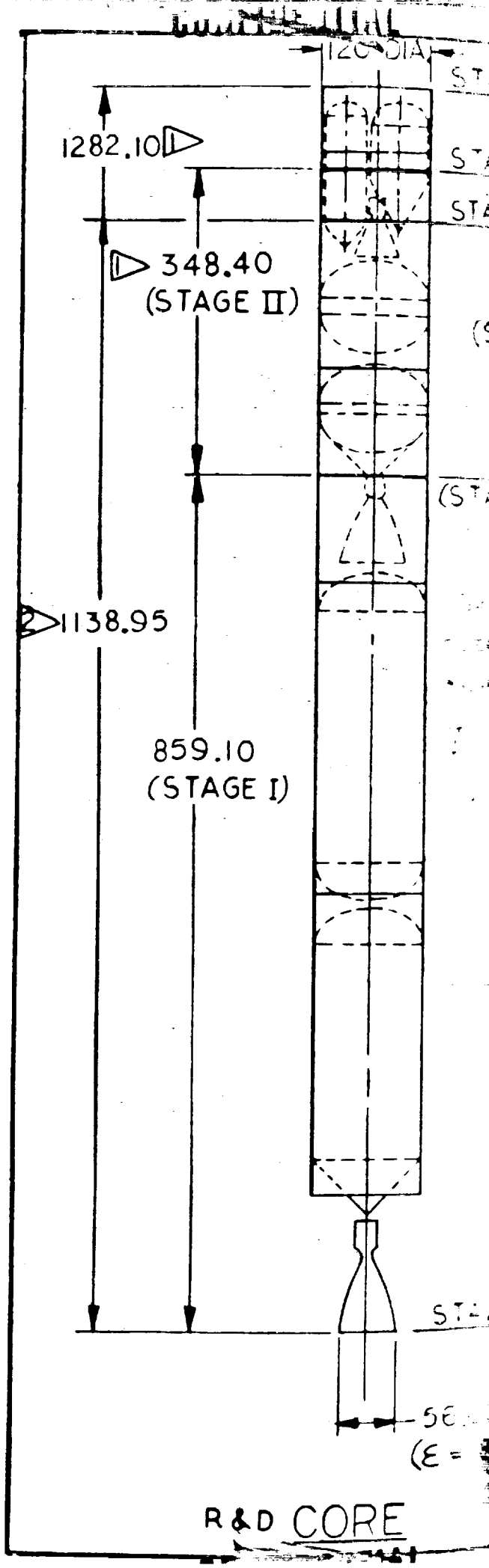
Data for eight configurations of launch vehicles evaluated within the Titan III family are presented in this report. Their body profile, general arrangement, and principal dimensions are shown in Figure 1.

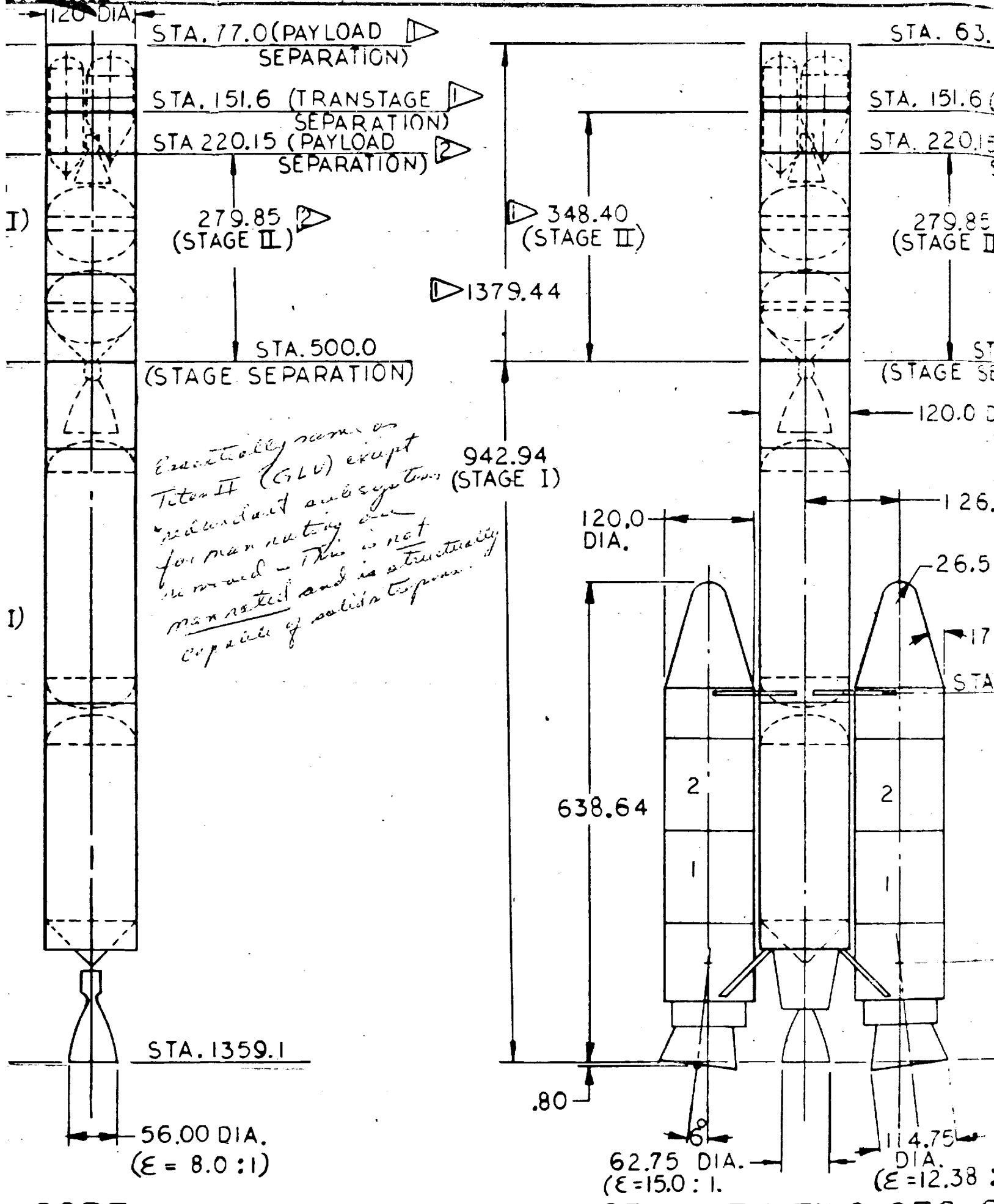
The eight configurations are identified with either of two groups -- those that are with transtage, Group I (thus providing restart capability for the Hohmann transfer), and those that are without transtage, Group II. The vehicles without transtage are limited to establishing orbit by direct injection. The Group II vehicles are externally identical to their counterpart in Group I in all other respects except the interface is lowered by approximately 12 feet to compensate for the omission of the transtage. Items of guidance, control, and telemetry equipment that are located in transtage for the Group I vehicle missions, are located in the forward compartment of the second stage just below the payload interface.

The configurations within each group are different as to their use of and the number of solid segments comprising each solid strap-on motor (SRM). The minimum configuration of each group consists of a basic Titan III R & D core vehicle, without solids and with or without transtage. The R & D core has been flown numerous times in the course of the Titan III R & D program. The remaining configurations within each group vary as to the use of a pair of 2, 5, or 7 segment SRM's strapped to an uprated core vehicle.

The uprating of the core vehicle consists of an increase in the Stage I main engine expansion ratio and an increase in Step I tankage volume and propellant load. These performance improvements are currently under development. The transtage vehicle is standard for all Group I vehicles.

Each config. may be used with or without transition.





CORE

UP-RATED CORE WITH TWO SEG. S

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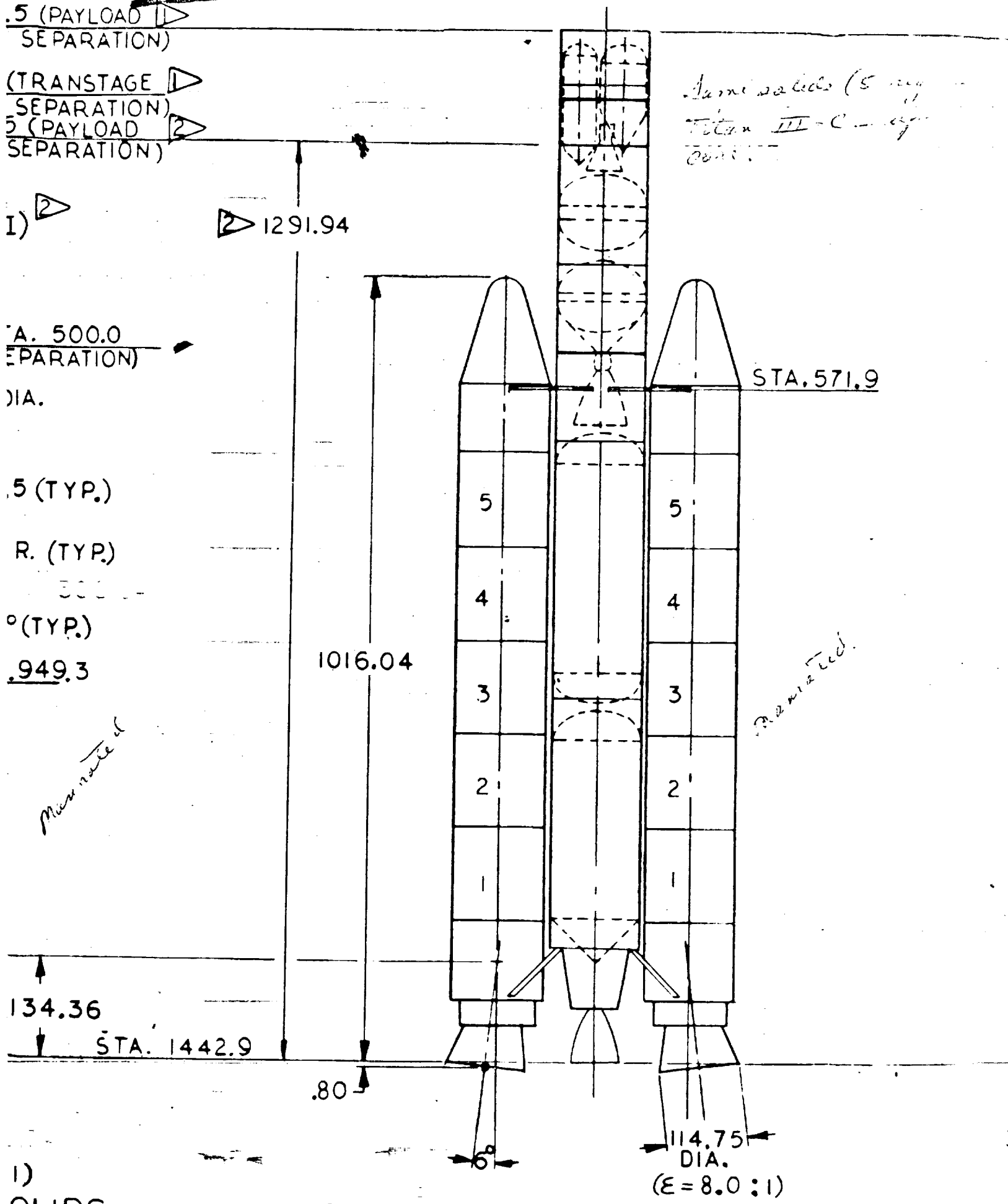

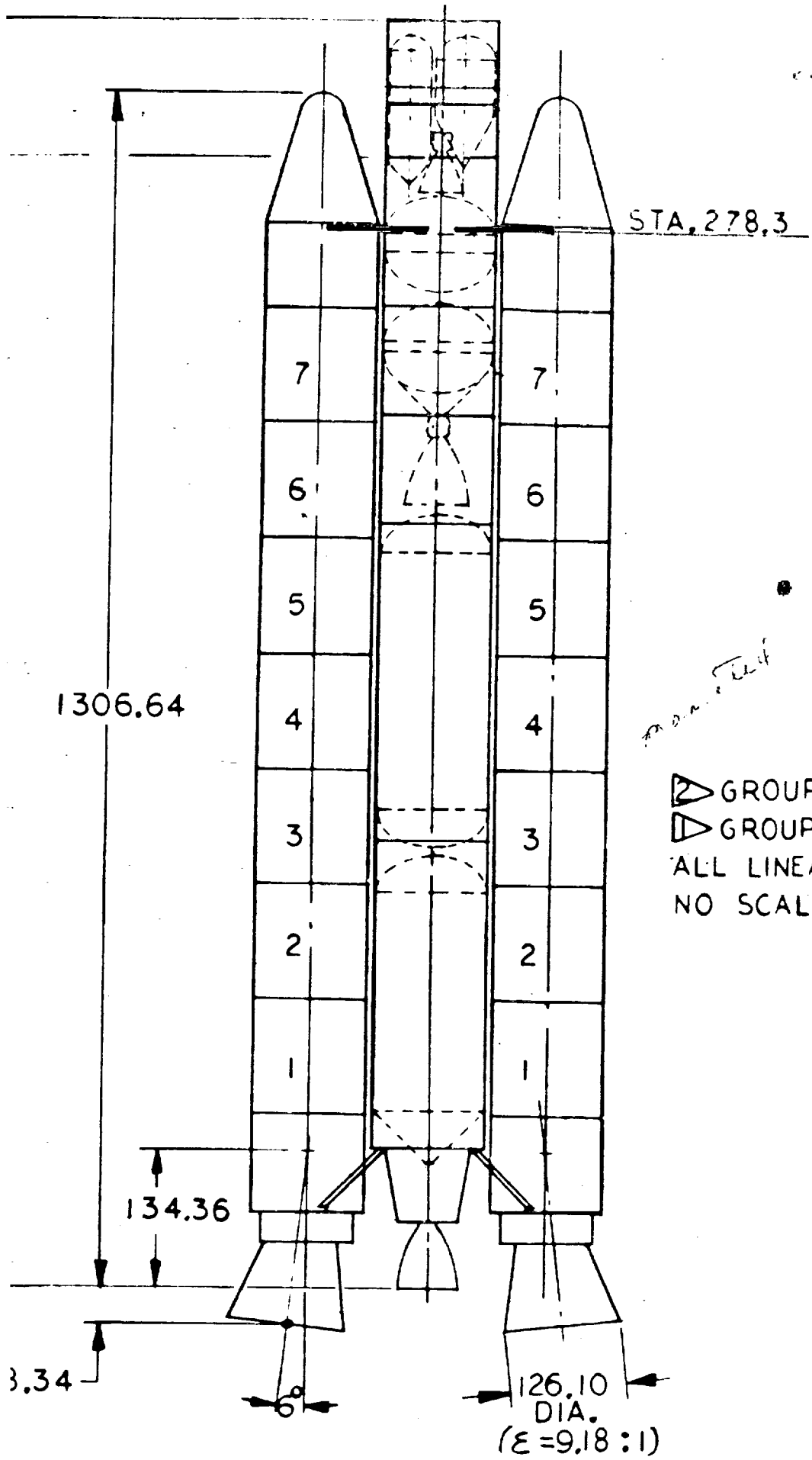

GROUP II ONLY (W/O TRANSTAGE)
GROUP I ONLY (WITH TRANSTAGE)
ALL LINEAR DIMENSIONS IN INCHES
NO SCALE

FIGURE -I-
GROUP I & II
CONFIGURATIONS

ED CORE WITH SEVEN SEG. SOLIDS

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M-66-8

TITAN III BOOSTERS FOR LANGLEY'S MANNED LIFTING BODY ENTRY PROGRAM (U)

Revision 2

28 April 1966

DOWNGRADED AT 3 YEAR INTERVALS
DECLASSIFIED AFTER 12 YEARS
DOD DIRECTIVE 5200.10

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SUPPLEMENTAL DATA

Consideration is being given to a Titan III version that uses three-segment solid rocket motors. This supplement includes this data by replacing page 12, and by adding pages 12A and B (performance) and page 15A (weights and thrust).

The second paragraph of page 4 indicates that minimum performance is approximately 8% less than nominal. This ratio varies considerably depending on the launch vehicle and orbit. In all cases, the difference is based on a margin of $2\frac{1}{2}\%$ V* (ideal velocity).

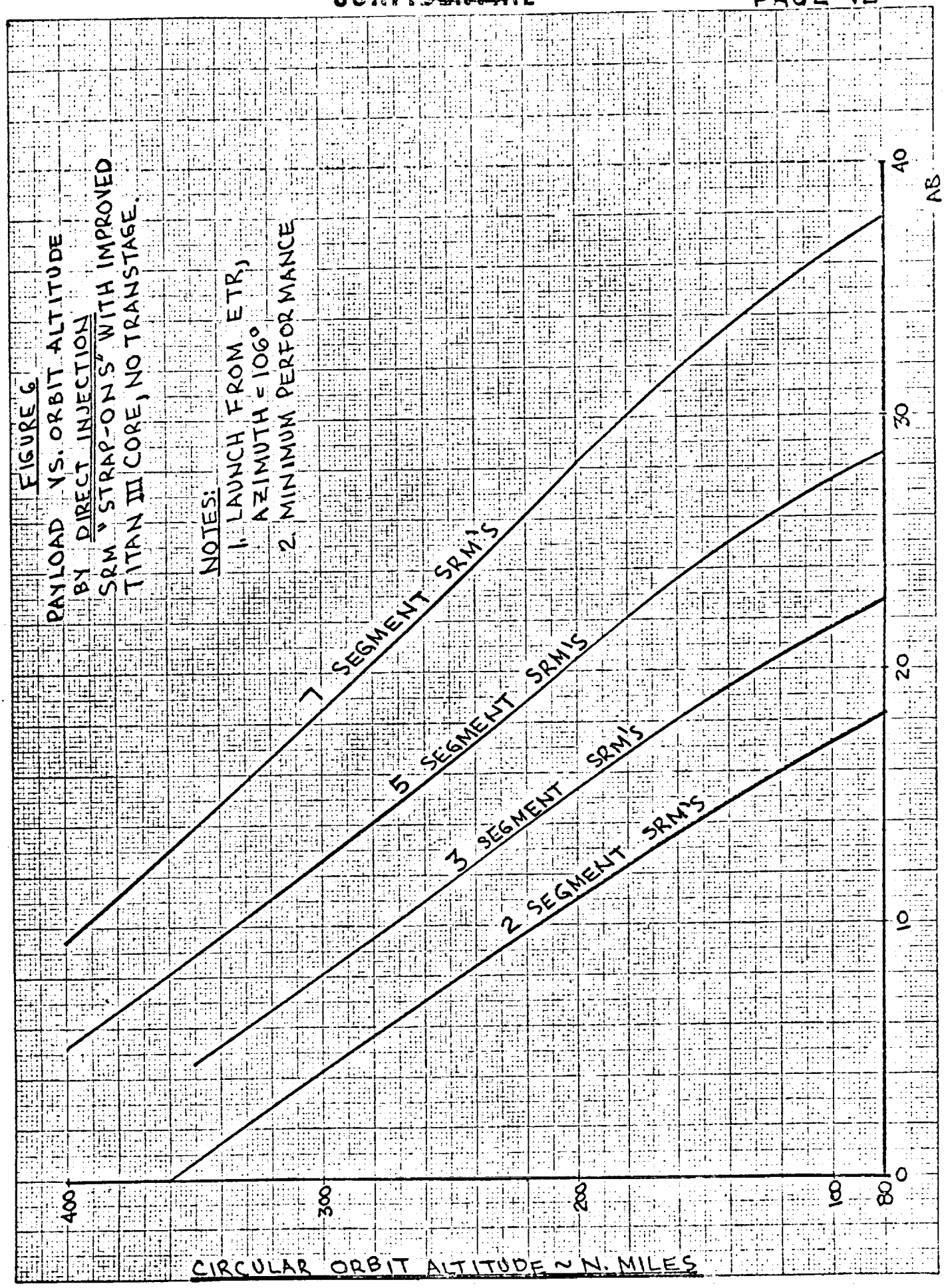
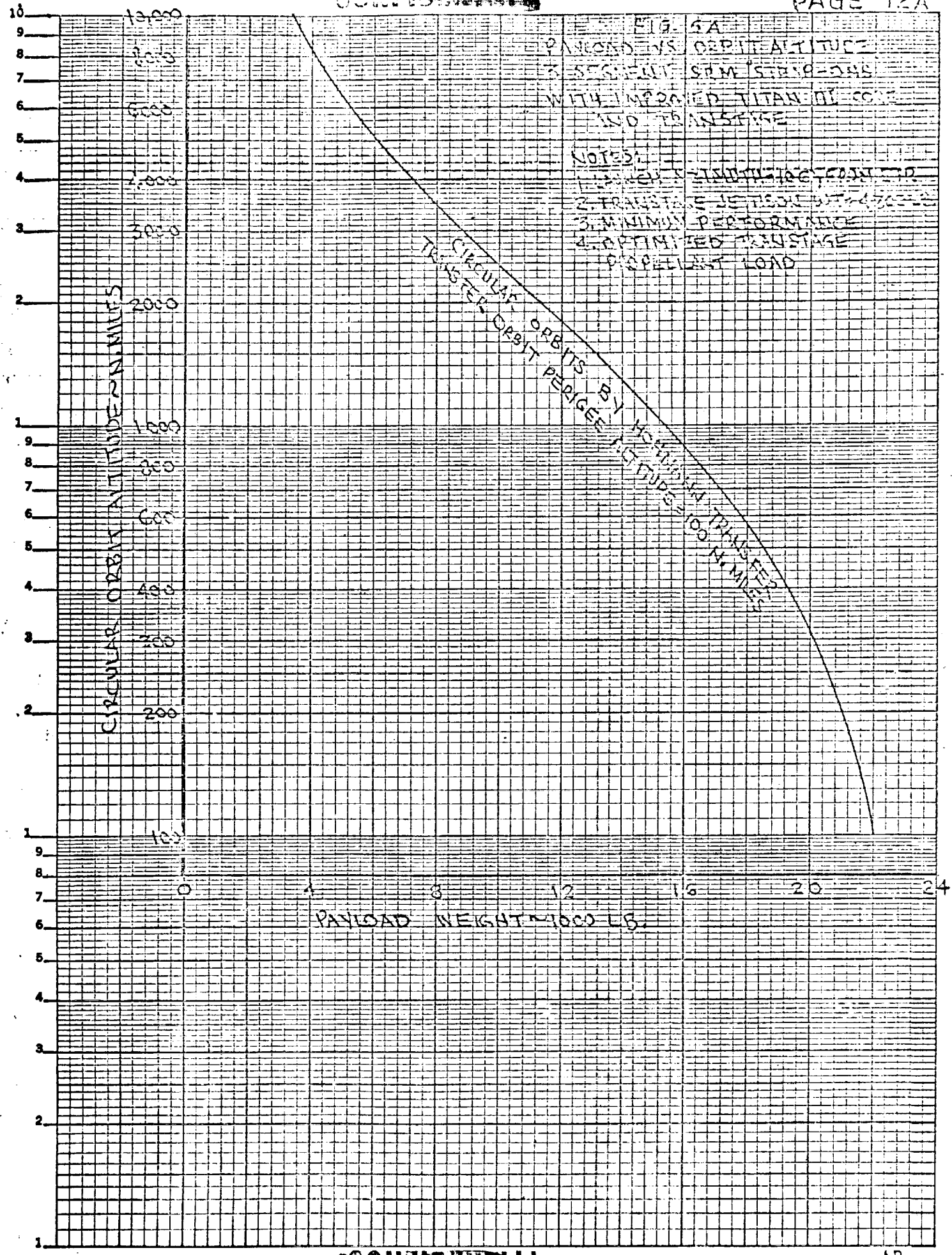


FIGURE 6
PAYLOAD VS. ORBIT ALTITUDE
BY DIRECT INJECTION
SRM "STRAP-ONS" WITH IMPROVED
TITAN III CORE, NO TRANSTAGE.
NOTES:
1. LAUNCH FROM ETR,
AZIMUTH = 106°
2. MINIMUM PERFORMANCE
7 SEGMENT SRM'S
5 SEGMENT SRM'S
3 SEGMENT SRM'S
2 SEGMENT SRM'S
AB
4-28-66
PAYLOAD WEIGHT ~ 1000 LB.
0
10
20
30
40
400
300
200
100
80
CIRCULAR ORBIT ALTITUDE ~ N. MILES



K+E SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS

AB
3-28-66

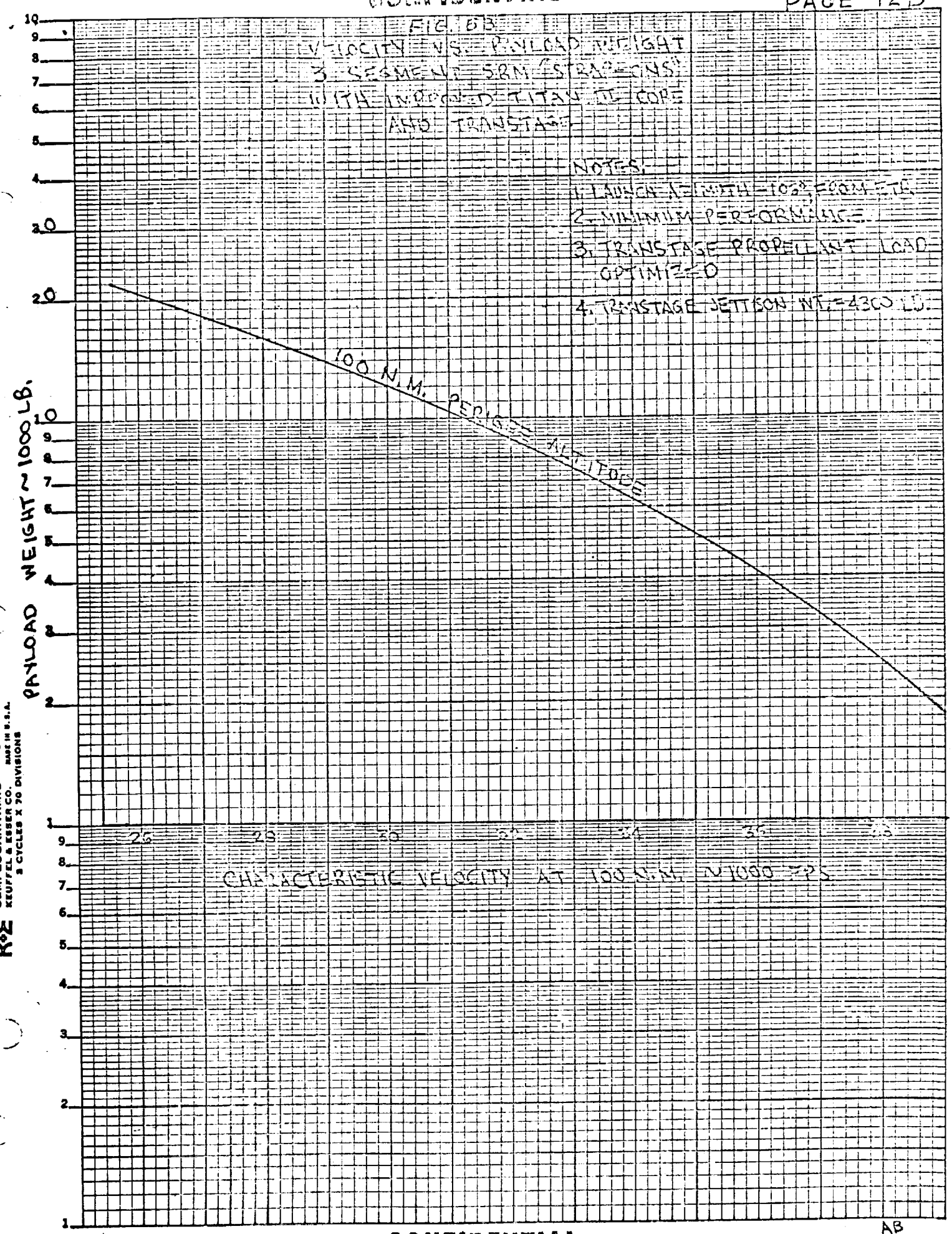


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TABLE II (Addendum)

Up-Rated Core + Solids

3-Segment With Transtage

Description	Step C	Step I	Step II	Step III	Stg 0	Stg I	Stg II	Stg III
Dry Weight	--	16,635	6,361	4,146	---	27,142	10,507	4,146
Burnout Weight	119,758	17,991	6,948	4,273	529,955	121,165	34,386	4,273
Loaded Weight	687,603	307,023	75,736	27,438	1,097,800	410,197	103,174	27,438

3-Segment Without Transtage

Dry Weight	--	16,635	7,369		---	24,004	7,369	
Burnout Weight	119,758	17,991	7,956		503,525	94,735	7,956	
Loaded Weight	687,603	307,023	76,744		1,071,370	383,767	76,744	

TABLE III (Addendum)

3-Segment - 0 Stage Thrust Near Tail-Off = 1.26×10^6 lbs

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R. W. Kasing

OFFICIAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

[redacted]

UNITED STATES GOVERNMENT

Memorandum

Langley Research Center

TO : Distribution List

DATE: May 4, 1966

FROM : MORL Studies Office

SUBJECT: Transmittal of [redacted] Martin document No. M-66-8, "Titan III Boosters for Langley's Manned Lifting Body Entry Program (U)" of April 28, 1966

1. The Titan III booster that uses three-segment solid motors is currently under development evaluation by the Air Force. Therefore, the attached subject document, which gives performance and weights for this booster, is forwarded for your information and retention. Page 12 of the attached document replaces page 12 of M-66-8 of February 1966 (forwarded to you on March 16, 1966); also, pages 12A, 12B, and 15A should be added to M-66-8 of February 1966.

Kermit A. Edwards

Kermit A. Edwards

Attachment
M-66-8

[redacted]

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III. PERFORMANCE

A. Payload and Velocity Data

The orbital performance capabilities for the Titan III family of launch vehicles are presented here, Figures 2 through 6, consistent with the configurations depicted in the preceding chapter and the system weights given in the following section of this chapter. The data presented are based on nominal propulsion parameters and system weights characteristic of each vehicle configuration.

All performance values are guaranteed minimums to circular orbits, both by direct injection and the Hohmann transfer. All are based on a 106° launch azimuth from ETR at an inclination of 32°. The minimum values reflect a reduction of approximately 8% from nominal at 100 n.m.

Only direct inject values are given for the Group II vehicles, without transtage, since they do not have restart capability.

Figure 2 shows the payload capability as a function of orbital altitude for the minimum configuration of both Groups I and II (with and without transtage). The minimum configurations do not use solids and employ the use of the Titan III R & D core vehicle. No velocity data is given for these configurations.

Figures 3, 4, and 5 show payload weight as a function of orbital altitude for the configurations using 2, 5, and 7 segment solids, respectively, with transtage (group I) and an uprated core. Direct inject capability is given for all altitudes ranging between 80 and 400 n.m. Payloads for Hohmann transfer are given for 100, 200, 300, and 400 n.m. origins. Figures 3A, 4A, and 5A show characteristic velocities versus payload weight

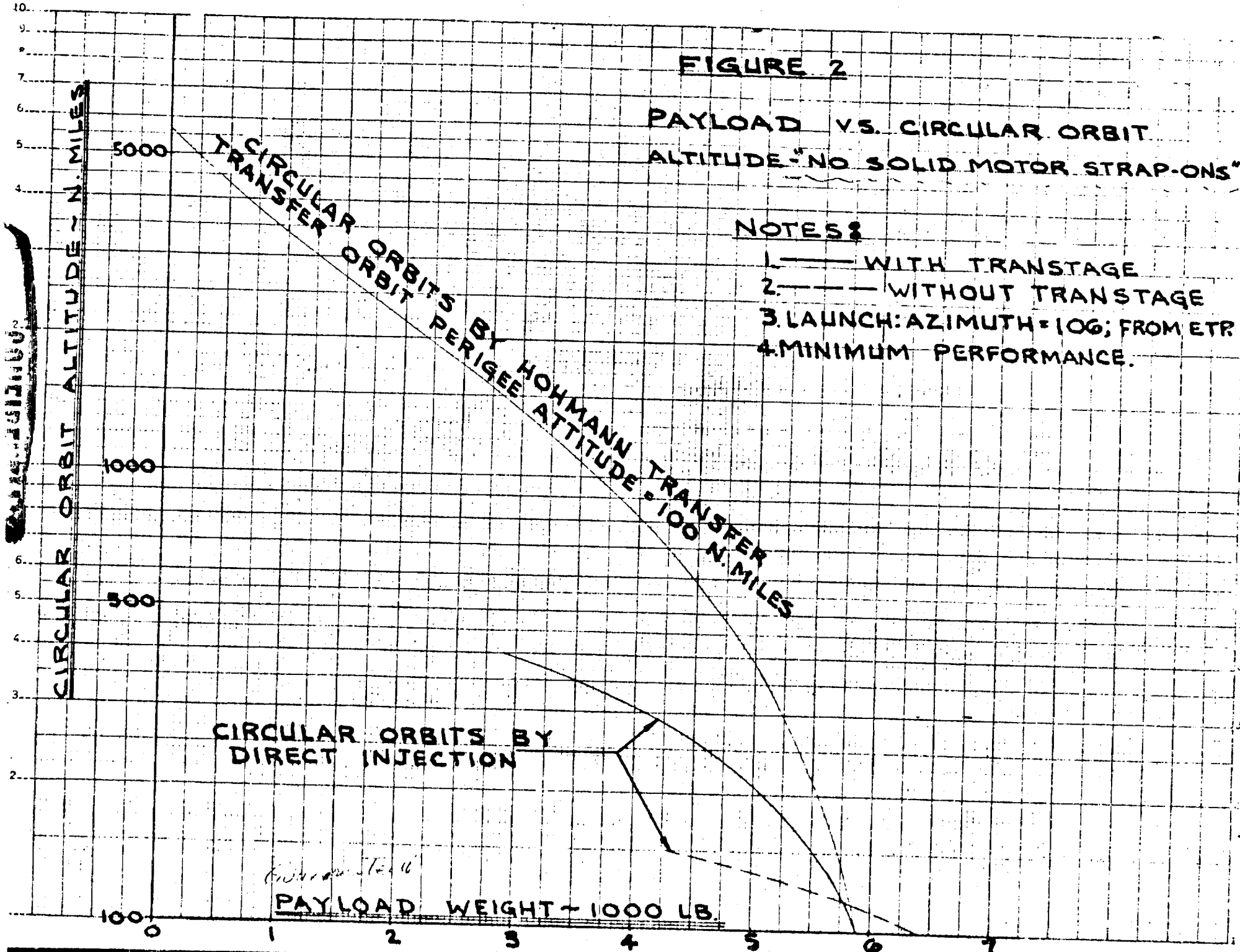


FIGURE 2

PAYLOAD V.S. CIRCULAR ORBIT ALTITUDE - "NO SOLID MOTOR STRAP-ONS"

NOTES:

1. ——— WITH TRANSTAGE
2. - - - - WITHOUT TRANSTAGE
3. LAUNCH: AZIMUTH = 106; FROM ETR
4. MINIMUM PERFORMANCE.

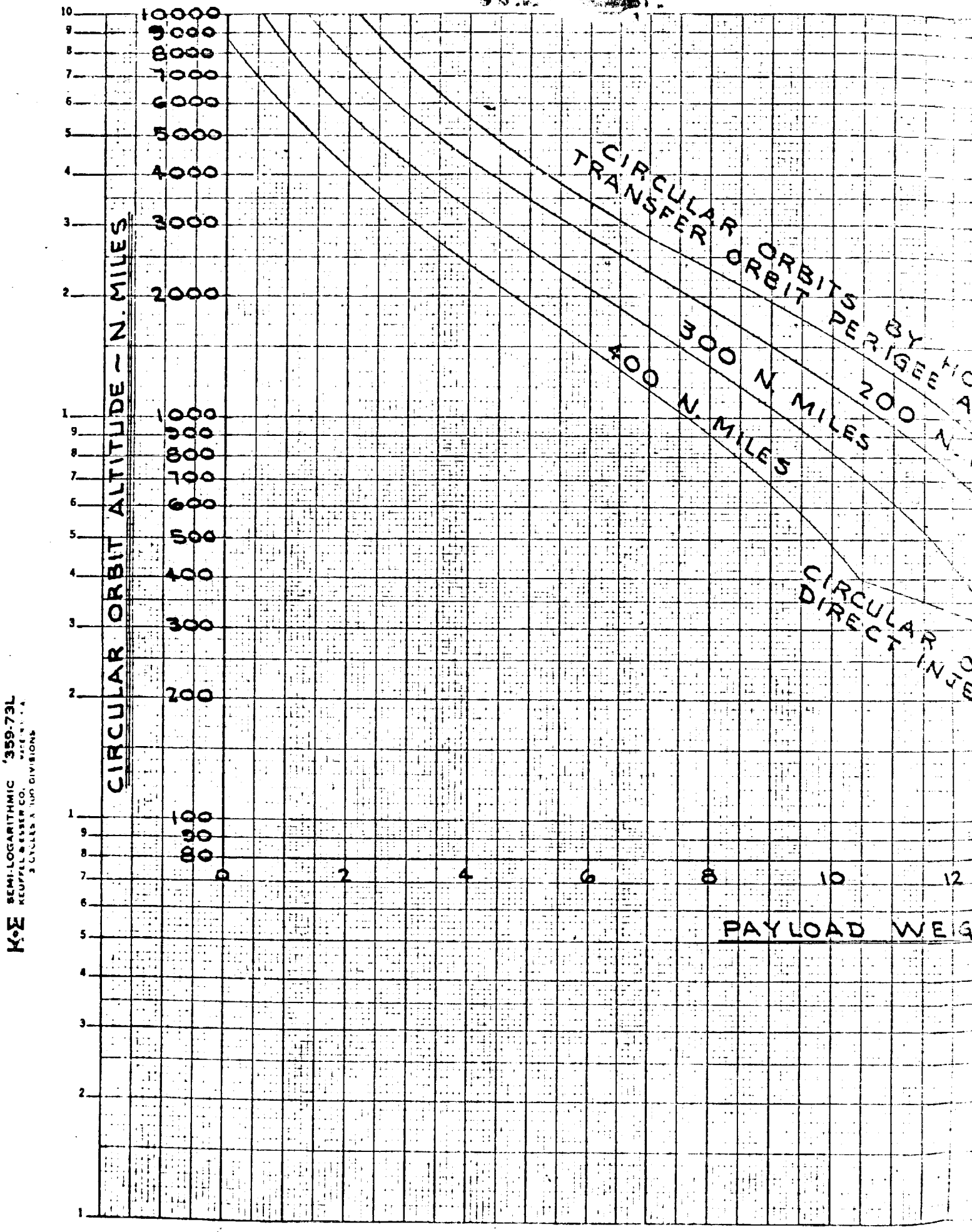
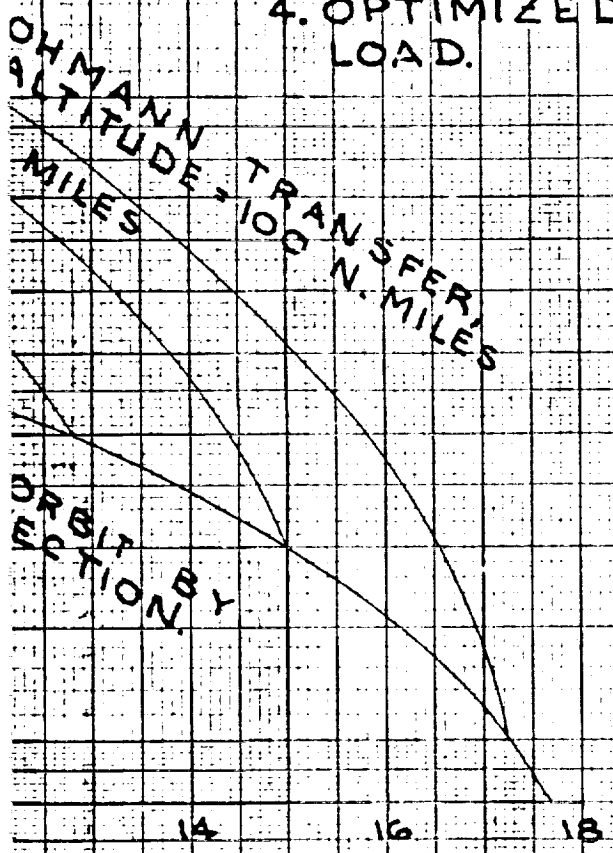

CIRCULAR ORBIT ALTITUDE ~ N. MILES
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
0
2
4
6
8
10
12
CIRCULAR ORBITS BY HO
TRANSFER ORBIT PERIGEE A
200 N.
300 N. MILES
400 N. MILES
CIRCULAR O
DIRECT INJE
PAYLOAD WEIG
K+E SEMI-LOGARITHMIC 359-73L
KEUFFEL & ESSER CO.

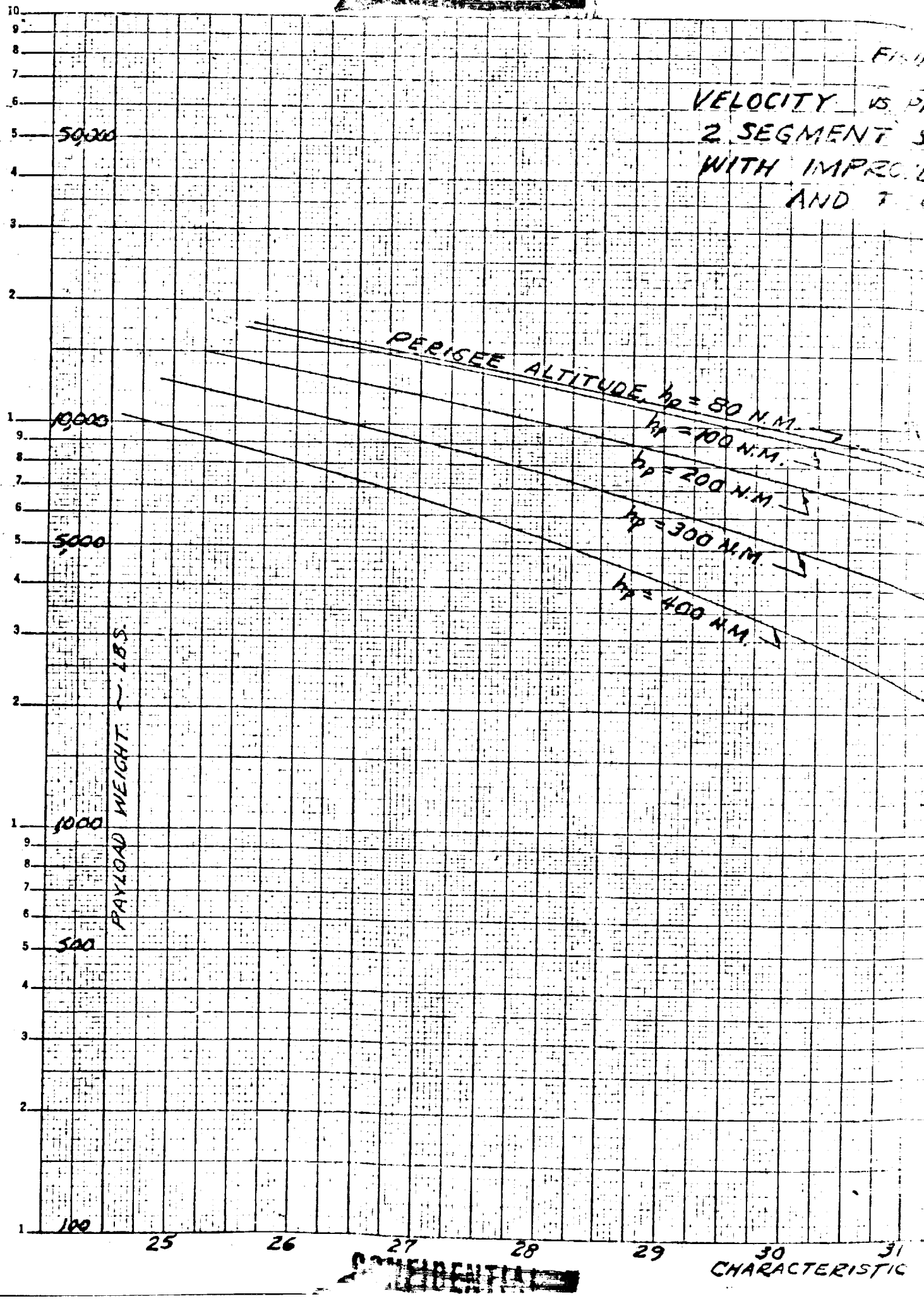
FIGURE 3
PAYLOAD vs. ORBIT ALTITUDE
2 SEGMENT SRM "STRAP-ONS"
WITH IMPROVED TITAN III CORE
AND TRANSTAGE.

NOTES:

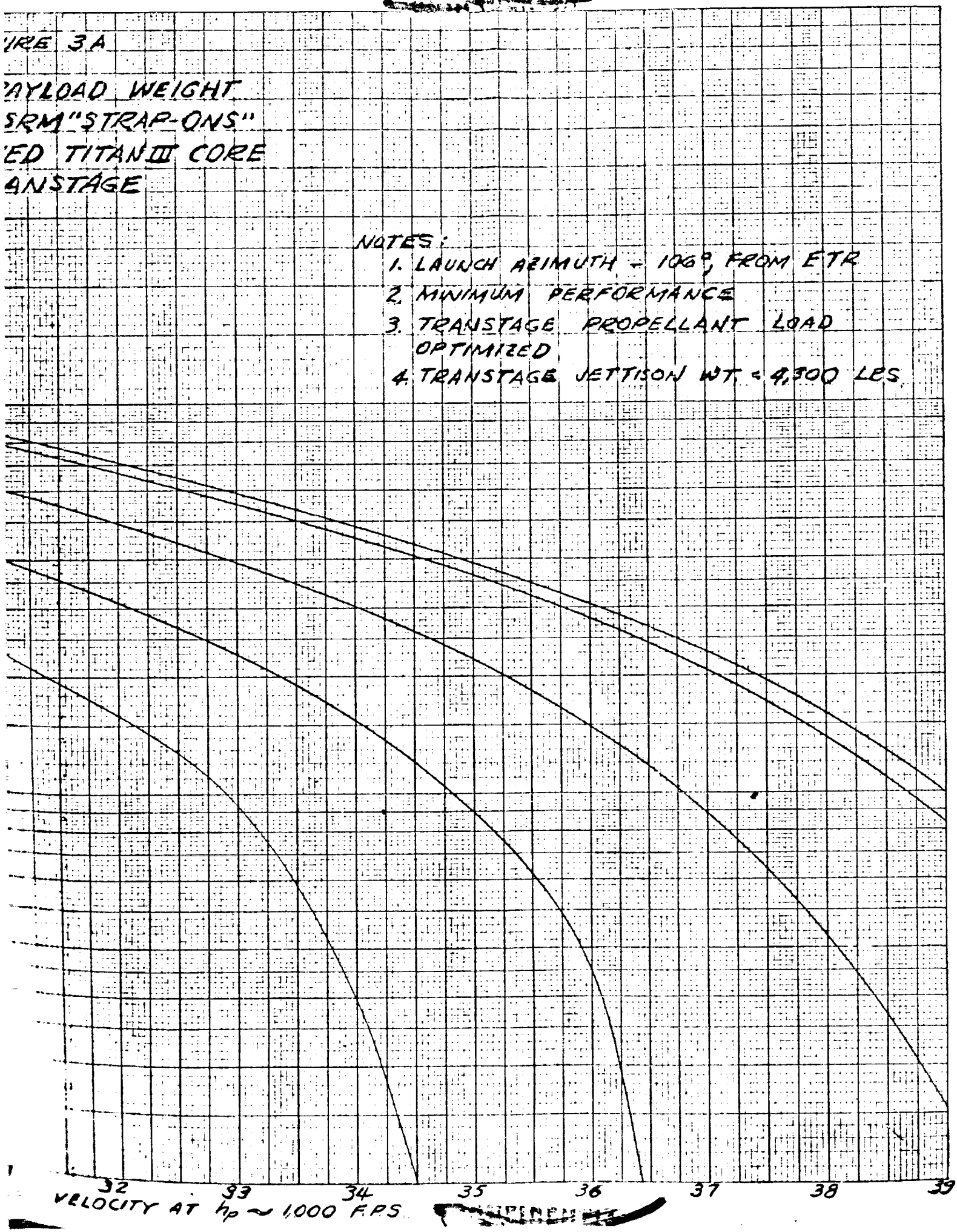
1. LAUNCH: AZIMUTH = 106°; FROM ETR
2. TRANSTAGE JETTISON WT. = 4300 LB.
3. MINIMUM PERFORMANCE
4. OPTIMIZED TRANSTAGE PROPELLANT LOAD.



GHT ~ 1000 LB.


VELOCITY VS P
2 SEGMENT S
WITH IMPROV
AND T
PERIGEE ALTITUDE, h_p = 80 N.M.
h_p = 100 N.M.
h_p = 200 N.M.
h_p = 300 N.M.
h_p = 400 N.M.
PAYLOAD WEIGHT ~ LBS.
50,000
10,000
5000
1000
500
100
25
26
27
28
29
30
31
CHARACTERISTIC
K+E SEMI-LOGARITHMIC 359-73L
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 200 DIVISIONS

[redacted]



[redacted]

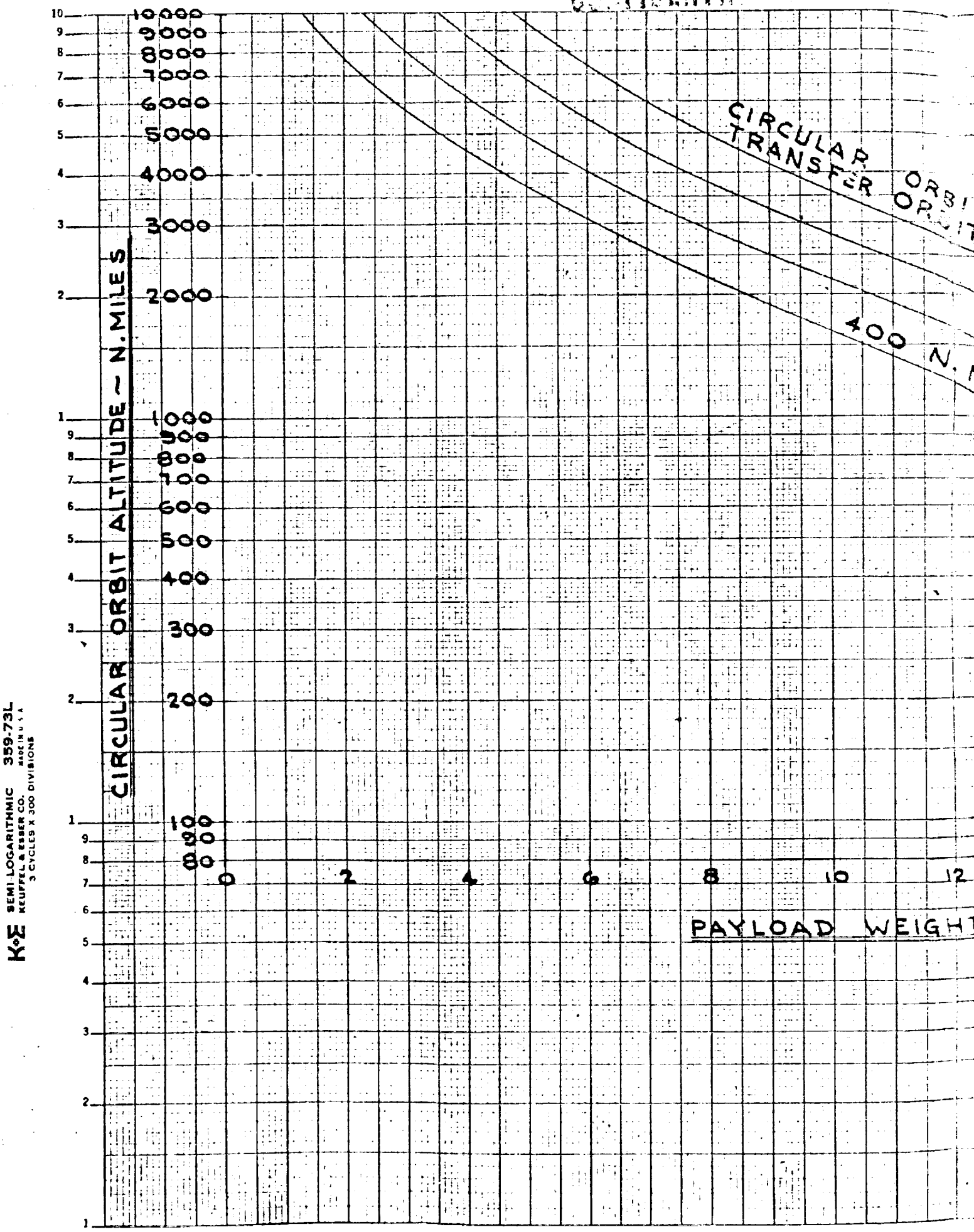
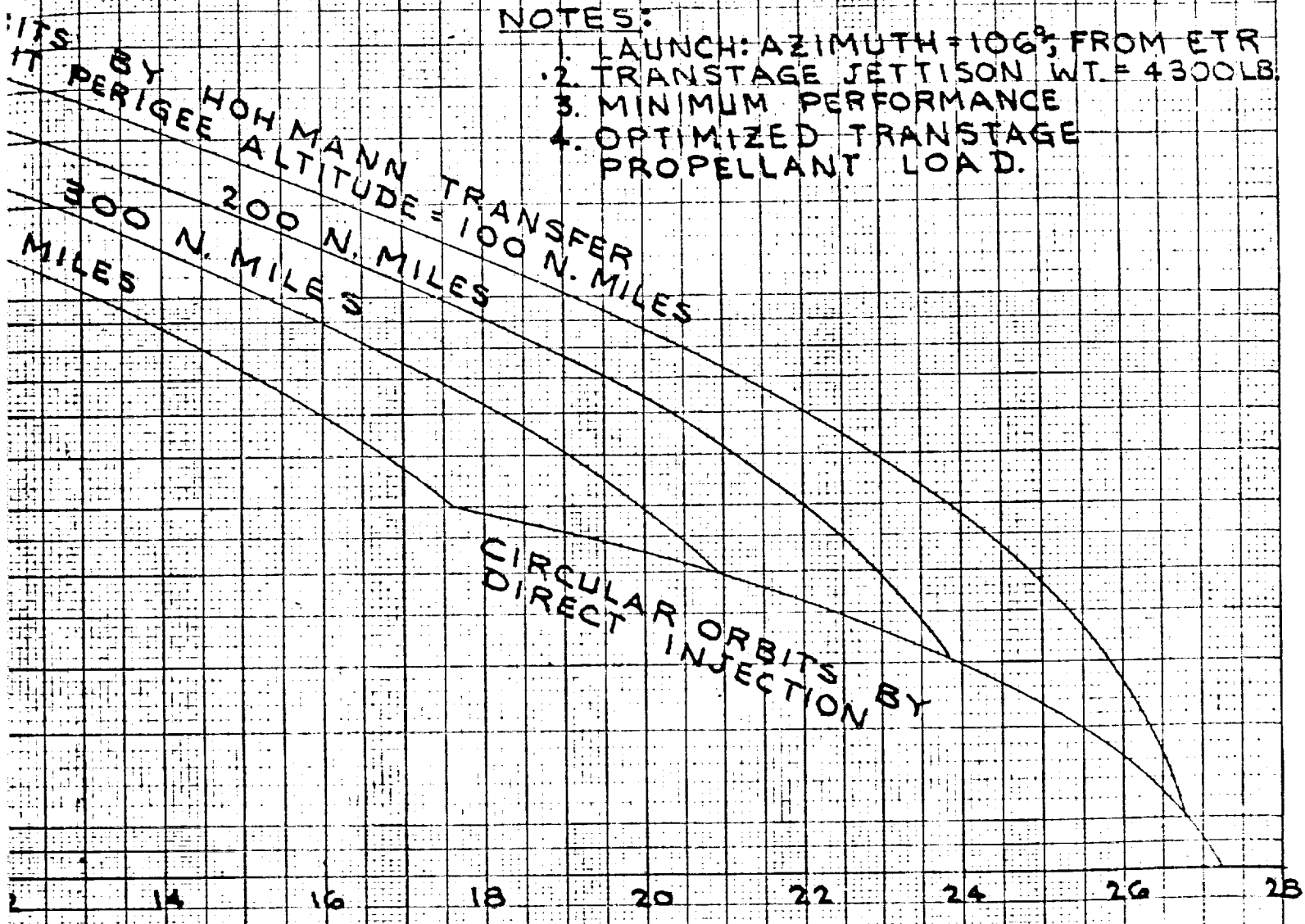
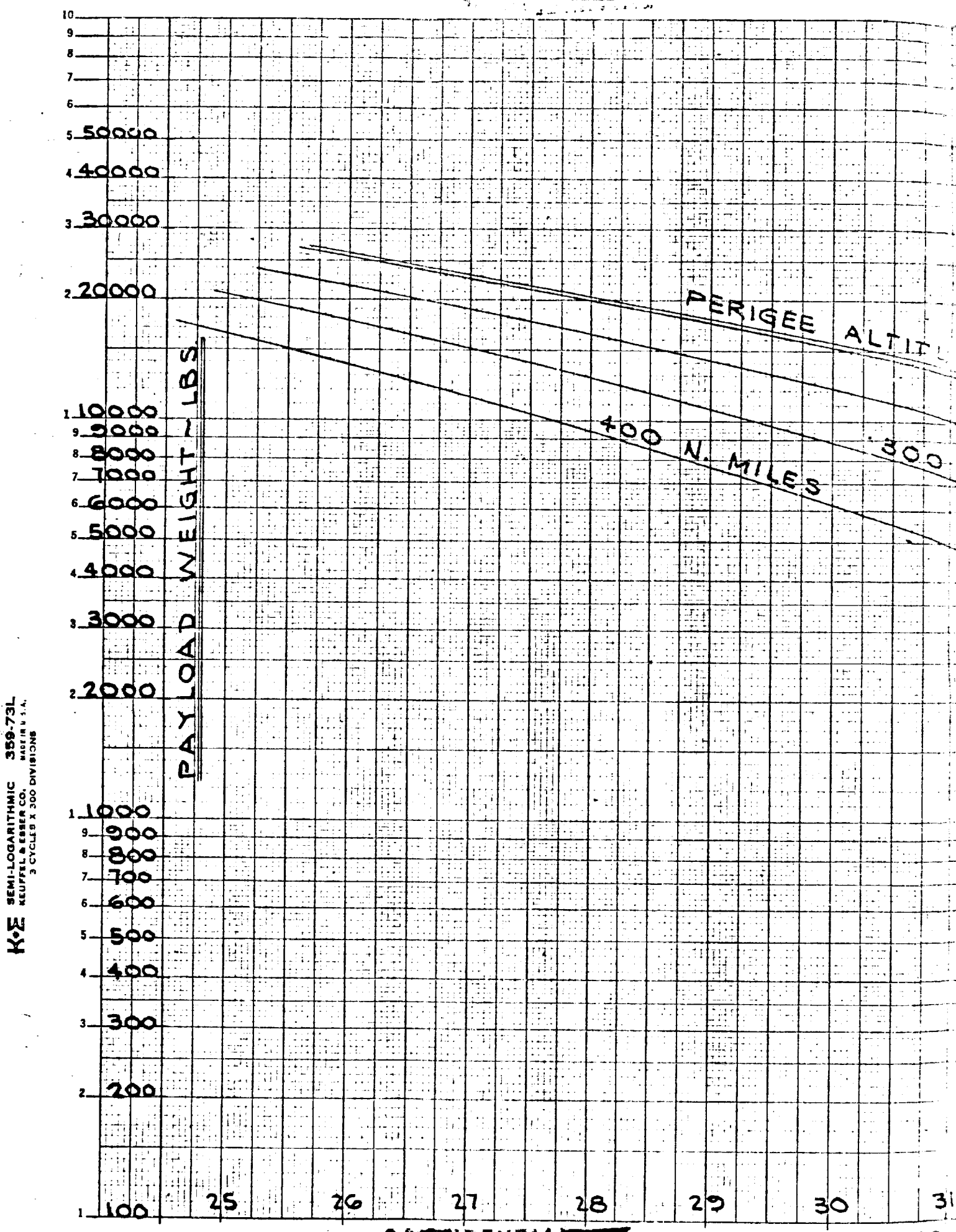

CIRCULAR ORBIT ALTITUDE ~ N. MILES
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
CIRCULAR ORBIT
TRANSFER ORBIT
400 N.
0
2
4
6
8
10
12
PAYLOAD WEIGHT
K+E SEMI LOGARITHMIC 359-73L
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 300 DIVISIONS

FIGURE 4
PAYLOAD VS. ORBIT ALTITUDE
5 SEGMENT SRM "STRAP-ONS"
WITH IMPROVED TITAN III CORE
AND TRANSTAGE.

NOTES:
1. LAUNCH: AZIMUTH = 106°; FROM ETR
2. TRANSTAGE JETTISON WT. = 4300 LB.
3. MINIMUM PERFORMANCE
4. OPTIMIZED TRANSTAGE PROPELLANT LOAD.



IT ~ 1000 LB.

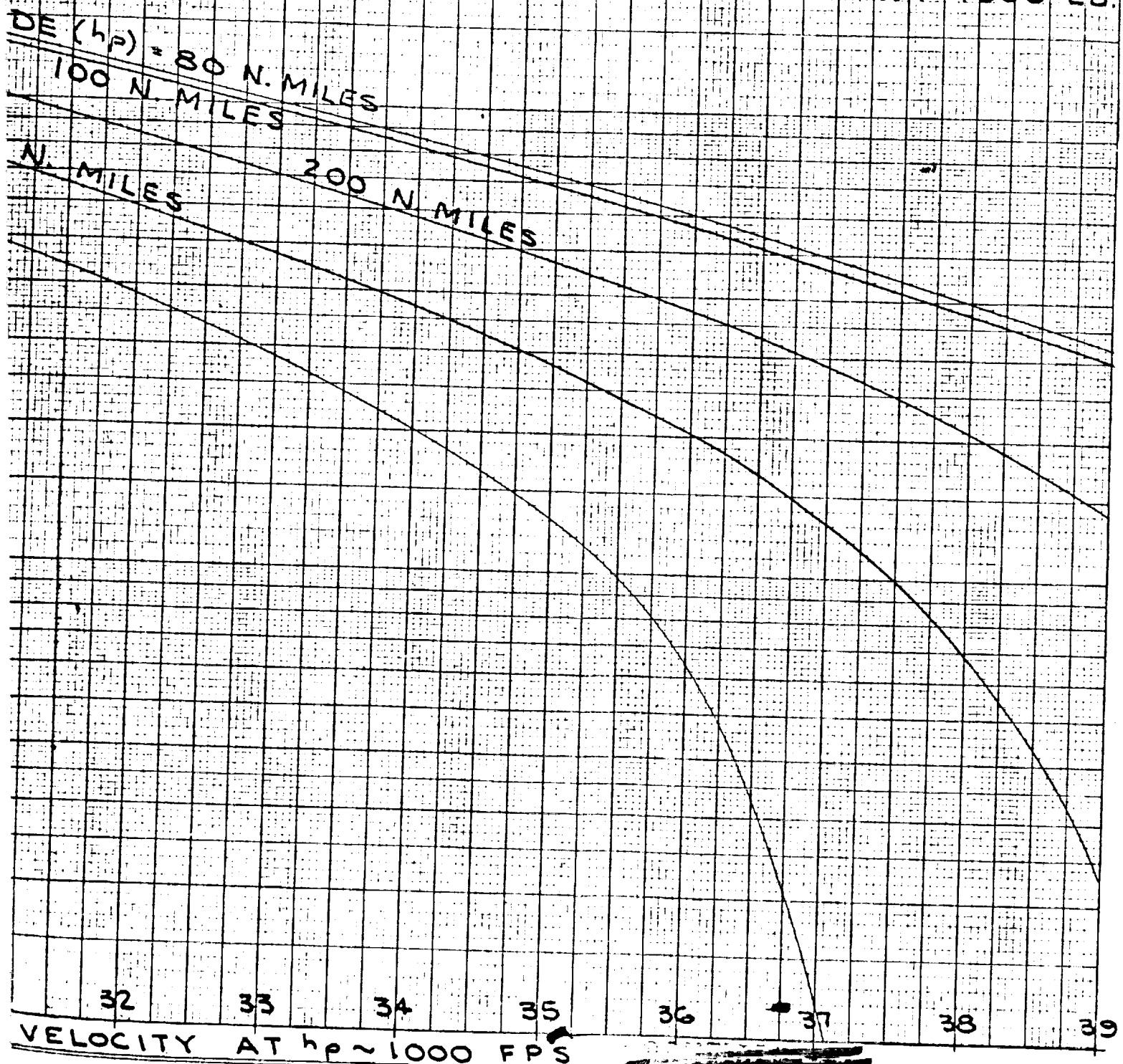


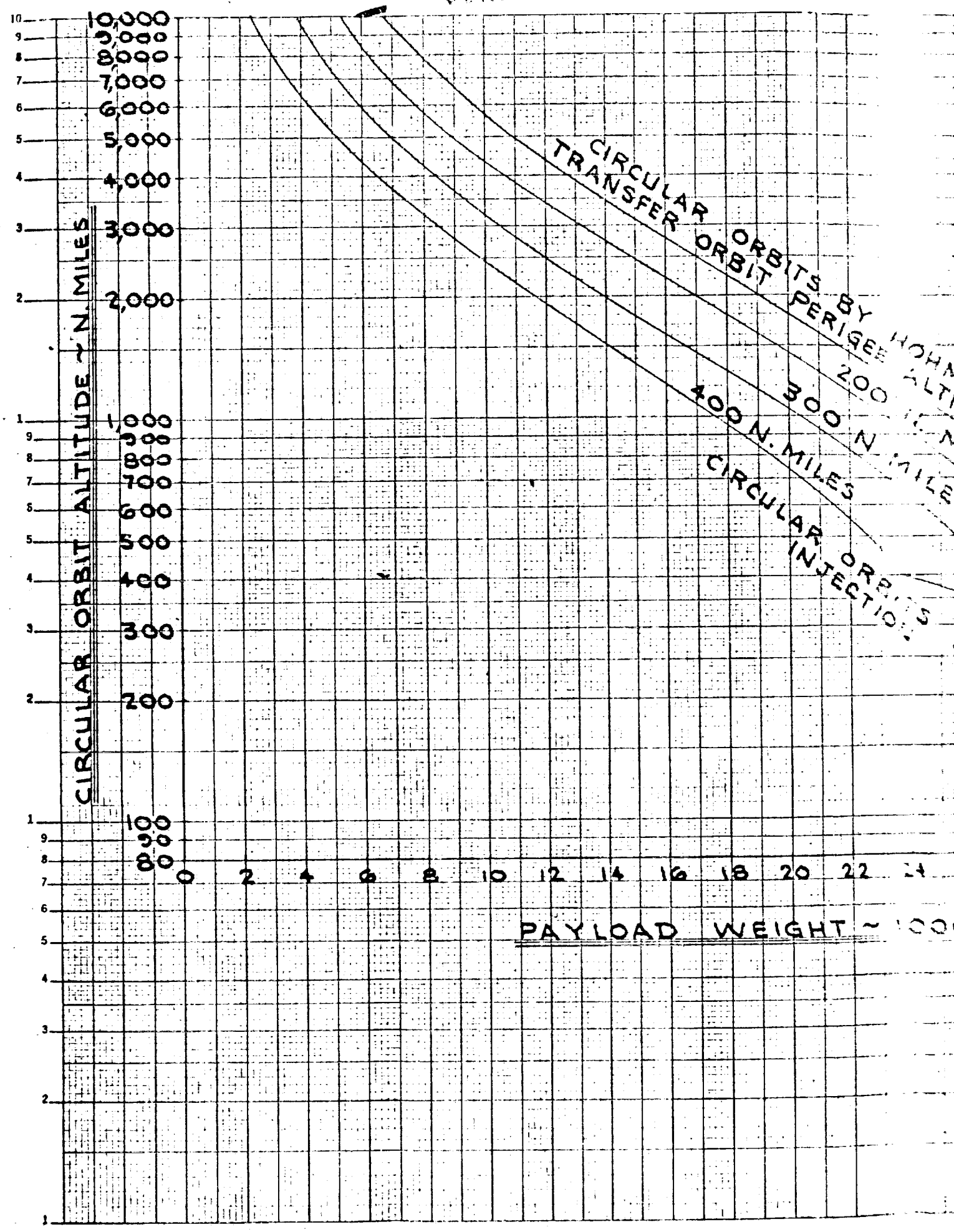
[redacted]

CHARACTERISTIC

FIGURE 4A
VELOCITY VS. PAYLOAD WEIGHT
5 SEGMENT SRM "STRAP-ONS"
WITH IMPROVED TITAN III CORE

NOTES:
1. LAUNCH: AZIMUTH = 106° FROM ETR
2. MINIMUM PERFORMANCE.
3. OPTIMIZED TRANSTAGE PROPELLANT LOAD.
4. TRANSTAGE JETTISON WT. = 4300 LB.





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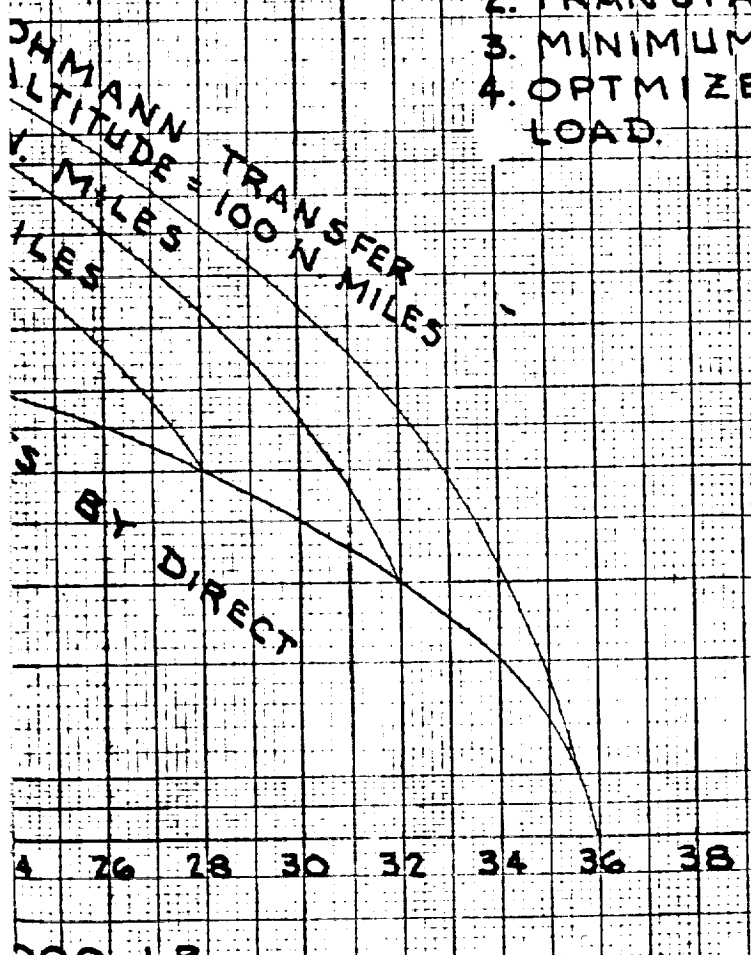
3 CYCLES X 300 DIVISIONS

FIGURE 5
PAYLOAD VS. ORBIT ALTITUDE
7 SEGMENT SRM "STRAP-ONS"
WITH IMPROVED TITAN III CORE
AND TRANSTAGE.

NOTES:
1. LAUNCH: AZIMUTH = 106; FROM ETR
2. TRANSTAGE JETTISON WT. = 4300 LB.
3. MINIMUM PERFORMANCE.
4. OPTMIZED TRANSTAGE PROPELLANT LOAD.



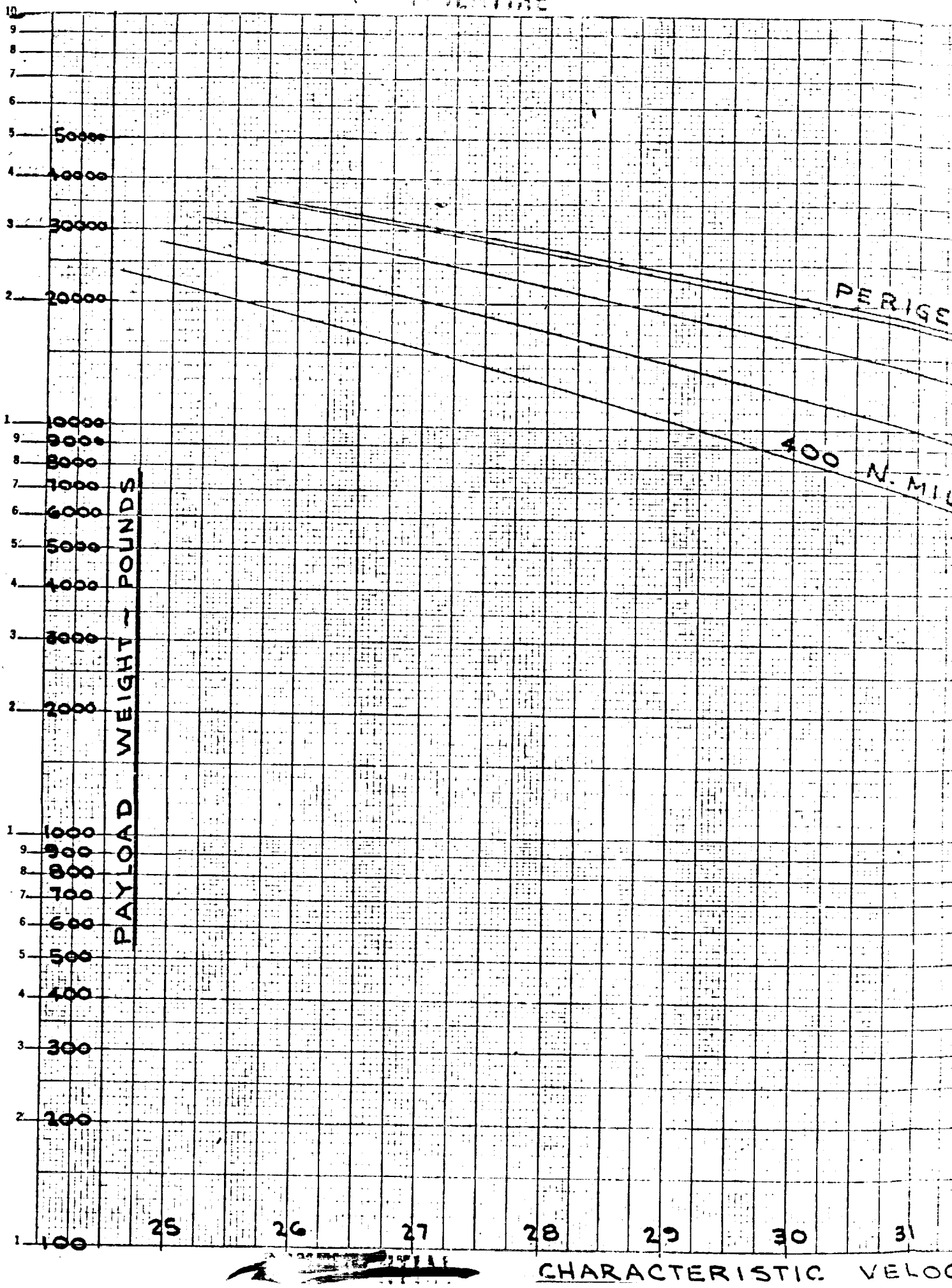

PERIGE
400 N. MI
PAYLOAD WEIGHT ~ POUNDS
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
25
26
27
28
29
30
31
CHARACTERISTIC VELOC
K+E SEMI-LOGARITHMIC 359-73L
KEUFFEL & ESSER CO.
MADE IN U.S.A.
3 CYCLES X 300 DIVISIONS

FIGURE 5A
VELOCITY vs. PAYLOAD WEIGHT
7 SEGMENT SRM "STRAP-ONS"
WITH IMPROVED TITAN III CORE
AND TRANSTAGE

NOTES:
1. LAUNCH AZIMUTH = 106°; FROM ETR
2. MINIMUM PERFORMANCE
3. OPTIMIZED TRANSTAGE PROPELLANT LOAD
4. TRANSTAGE JETTISON WT. = 4300 LB.

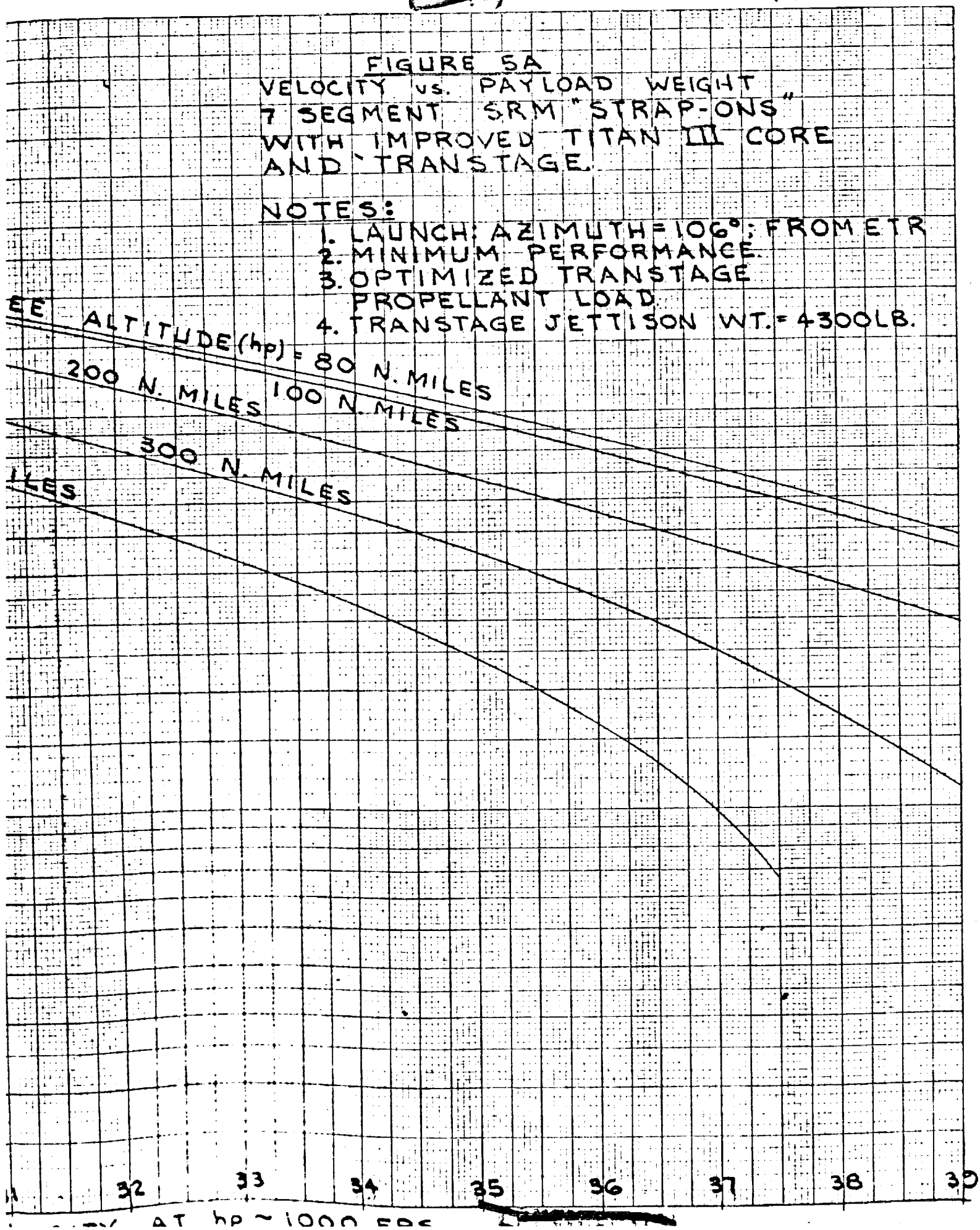


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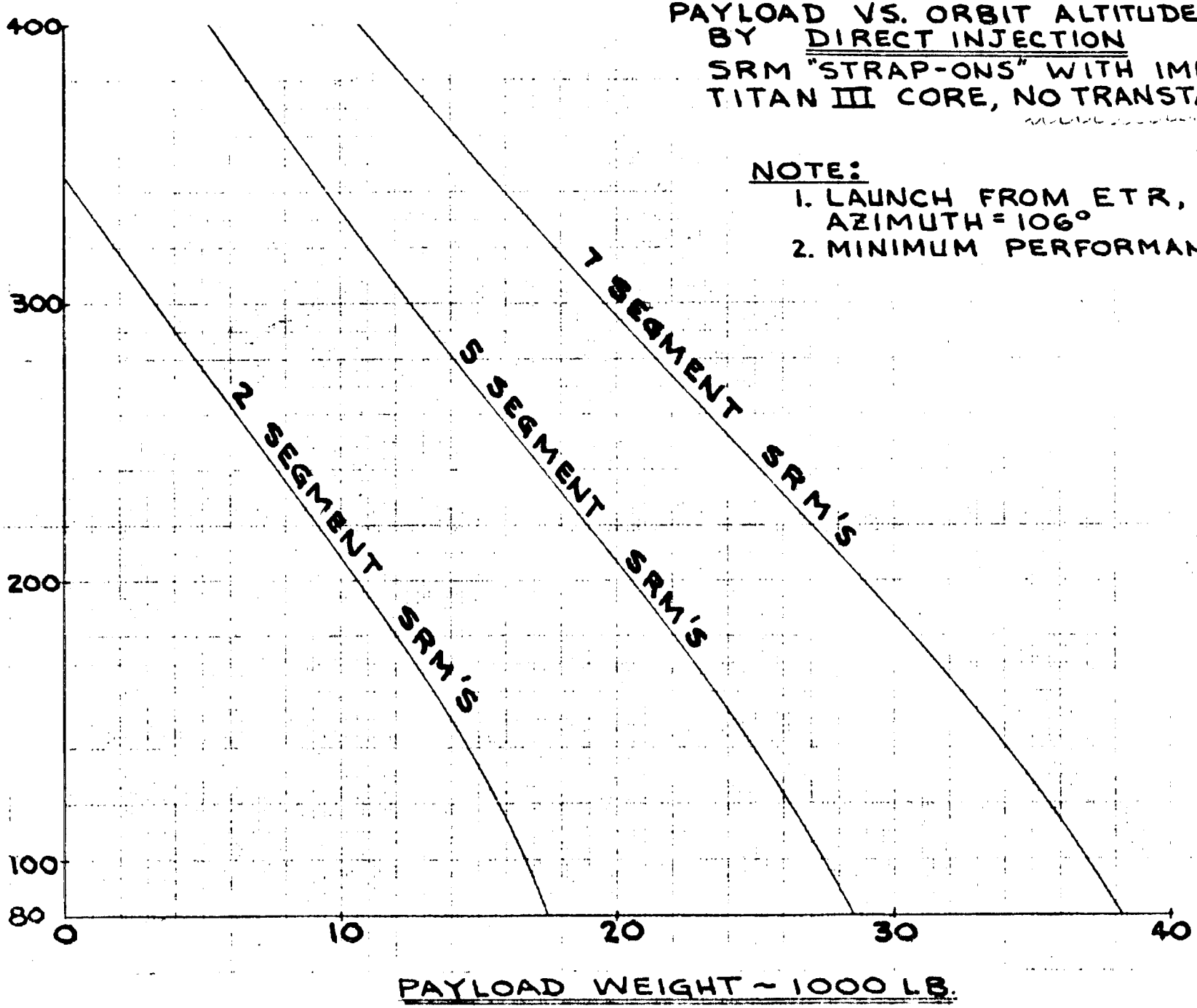
FIGURE 6
PAYLOAD VS. ORBIT ALTITUDE
BY DIRECT INJECTION
SRM "STRAP-ONS" WITH IMPROVED
TITAN III CORE, NO TRANSTAGE.

NOTE:
1. LAUNCH FROM ETR, AZIMUTH = 106°
2. MINIMUM PERFORMANCE



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A. Payload and Velocity Data (Continued)

for the corresponding Group I configurations, for perigee at altitudes of 80, 100, 200, 300, and 400 n.m. Transtage propellant loads have been optimized throughout.

Figure 6 shows the payload weight capability versus orbital altitude for the Group II configurations, without transtage but with uprated core, using 2, 5, or 7 segment solids flying direct inject missions.

B. Weights

Table I gives the weight summary for the configurations with transtage. These weights are based on a transtage system which is approximately 800 pounds lighter than the system we are using for the R & D program. This reduction is based on expected savings in the instrumentation and guidance areas.

Table II gives the weights for the configurations that do not use the transtage. To make this possible, approximately 1000 pounds of equipment has been transferred to Step II.

Table III gives the thrust values for the various stages at burnout or at time of maximum acceleration.

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TABLE I

TITAN III FAMILY OF BOOSTERS - WITH TRANSTAGE

Predicted Nominal Weight Summary for 0, 2, 5, & 7 Segment Solids

IIIA, R&D, Core

Description	Step I	Step II	Step III	Stg I	Stg II	Stg III
Dry Weight	13,183	6,176	4,146	23,505	10,322	4,146
Burnout Weight	14,598	6,740	4,273	115,332	34,178	4,273
Loaded Weight	266,425	73,294	27,438	367,157	100,742	27,438

Up-Rated Core + Solids

2-Segment

Description	Step 0	Step I	Step II	Step III	Stg 0	Stg I	Stg II	Stg III
Dry Weight	--	16,635	6,361	4,146	--	27,142	10,507	4,146
Burnout Weight	106,709	17,991	6,948	4,273	516,906	121,165	34,386	4,273
Loaded Weight	544,854	307,023	75,736	27,438	955,051	410,197	103,174	27,438

5-Segment

Dry Weight	--	16,635	6,361	4,146	--	27,142	10,507	4,146
Burnout Weight	158,952	17,991	6,948	4,273	569,149	121,165	34,386	4,273
Loaded Weight	1,036,764	307,023	75,736	27,438	1,446,961	410,197	103,174	27,438

7-Segment

Dry Weight	--	16,635	6,361	4,146	--	27,142	10,507	4,146
Burnout Weight	191,750	17,991	6,948	4,273	601,947	121,165	34,386	4,273
Loaded Weight	1,405,122	307,023	75,736	27,438	1,815,319	410,197	103,174	27,438

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TABLE II

TITAN III FAMILY OF BOOSTERS - WITH NO TRANSTAGE

Predicted Nominal Weight Summary
For 2, 5, & 7 Segment Solids

IIIA, R&D, Core

Description	Step I	Step II	Stg. I	Stg. II
Dry Weight	13,183	7,184	20,367	7,184
Burnout Weight	14,590	7,771	88,892	7,771
Loaded Weight	266,425	74,302	340,722	74,302

Up-Rated Core + Solids

2-Segment

Description	Step 0	Step I	Step II	Stg. 0	Stg. I	Stg. II
Dry Weight	--	16,635	7,369	--	24,004	7,369
Burnout Weight	106,709	17,991	7,956	490,476	94,735	7,956
Loaded Weight	544,854	307,023	76,744	928,621	383,767	76,744

5-Segment

Dry Weight	--	16,635	7,369	--	24,004	7,369
Burnout Weight	158,952	17,991	7,956	542,719	94,735	7,956
Loaded Weight	1,036,764	307,023	76,744	1,420,531	383,767	76,744

7-Segment

Dry Weight	--	16,635	7,369	--	24,004	7,369
Burnout Weight	191,750	17,991	7,956	575,517	94,735	7,956
Loaded Weight	1,405,122	307,023	76,744	1,788,889	383,767	76,744

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TABLE III

TITAN III ENGINE THRUSTS - 10^6 LBS.

At Burnout or Tail-Off (SRMS)

Number Of Solid Segments	Stage			
	0	1	2	3
0	0	.430	.100	.016
2	.700	.525	.100	.016
5	1.70	.525	.100	.016
7	2.42	.525	.100	.016

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IV. SYSTEM DATA

The information in this chapter may be useful in identifying constraints that may exist in interfacing the lifting body system with the Titan III.

A. Mechanical Interface and Structural Strength

Figure 7 shows the interface drawing for joining the payload to the Titan. The interface requires twenty-four 5/16" shear pins and eight tension bolts. The interface is the same for all configurations except that the bolts are 1" in diameter when mating is made directly to Step II, while they are only 7/8" in diameter when mating is with the transtage.

The structural strength at the payload interface is given in terms of an "Ultimate Equivalent Axial Load".

$$P_{equiv} = P_{axial} + \frac{2 \times \text{moment}}{R}$$

P_{equiv} = Total axial equivalent load (compression)

P_{axial} = Direct axial load due to thrust

Moment = Due to unsymmetrical winds, buffeting and gusts

R = Radius of the airframe (60 inches)

Titan III (with Transtage; interface at Station 77.0 or Station 63.5)

$P_{equiv} = .84 \times 10^6$ lbs. (ultimate)

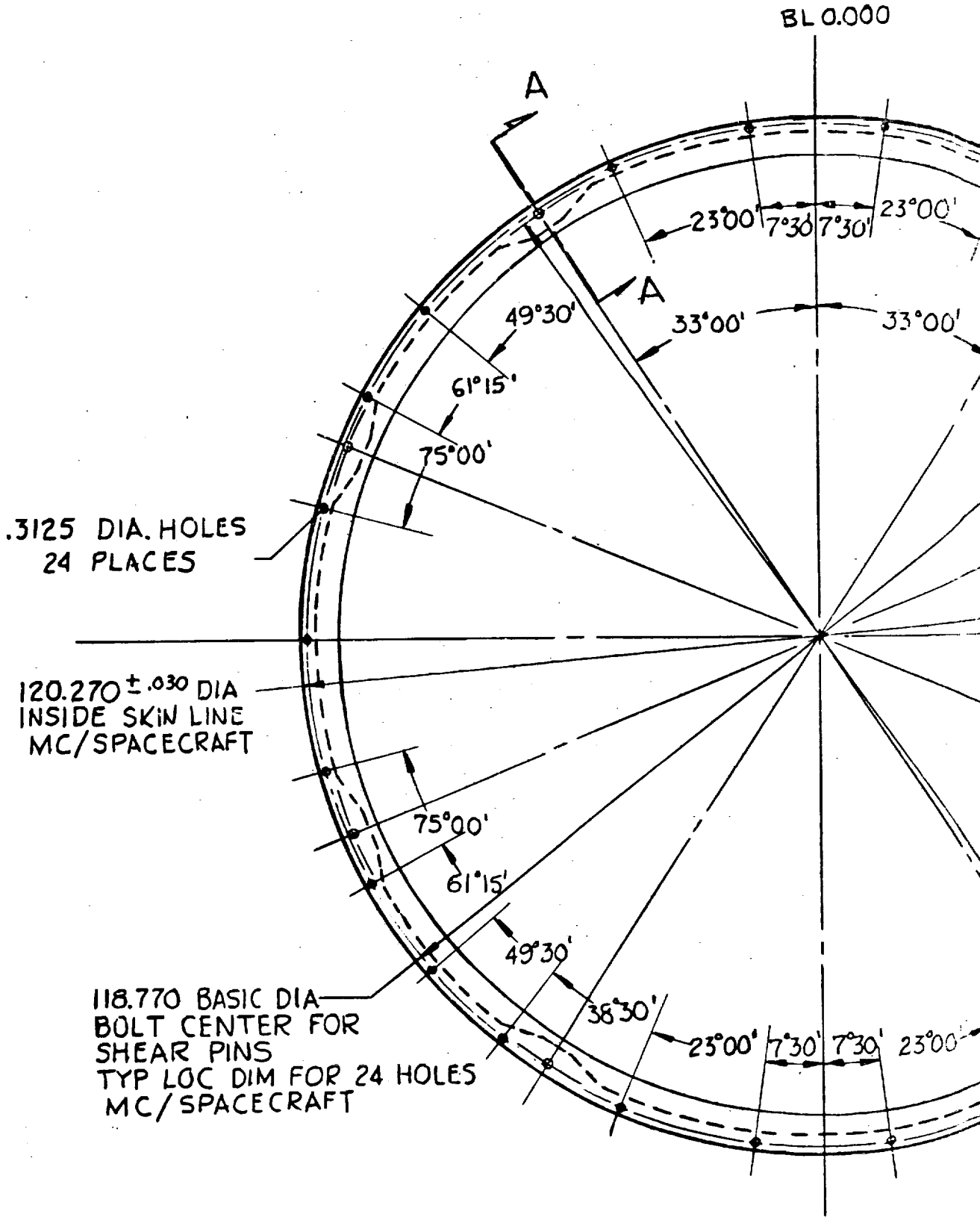
Capability of One Longeron (total of 8 longerons and bolts)

Ultimate Compression is 105,000 lbs. (per longeron)

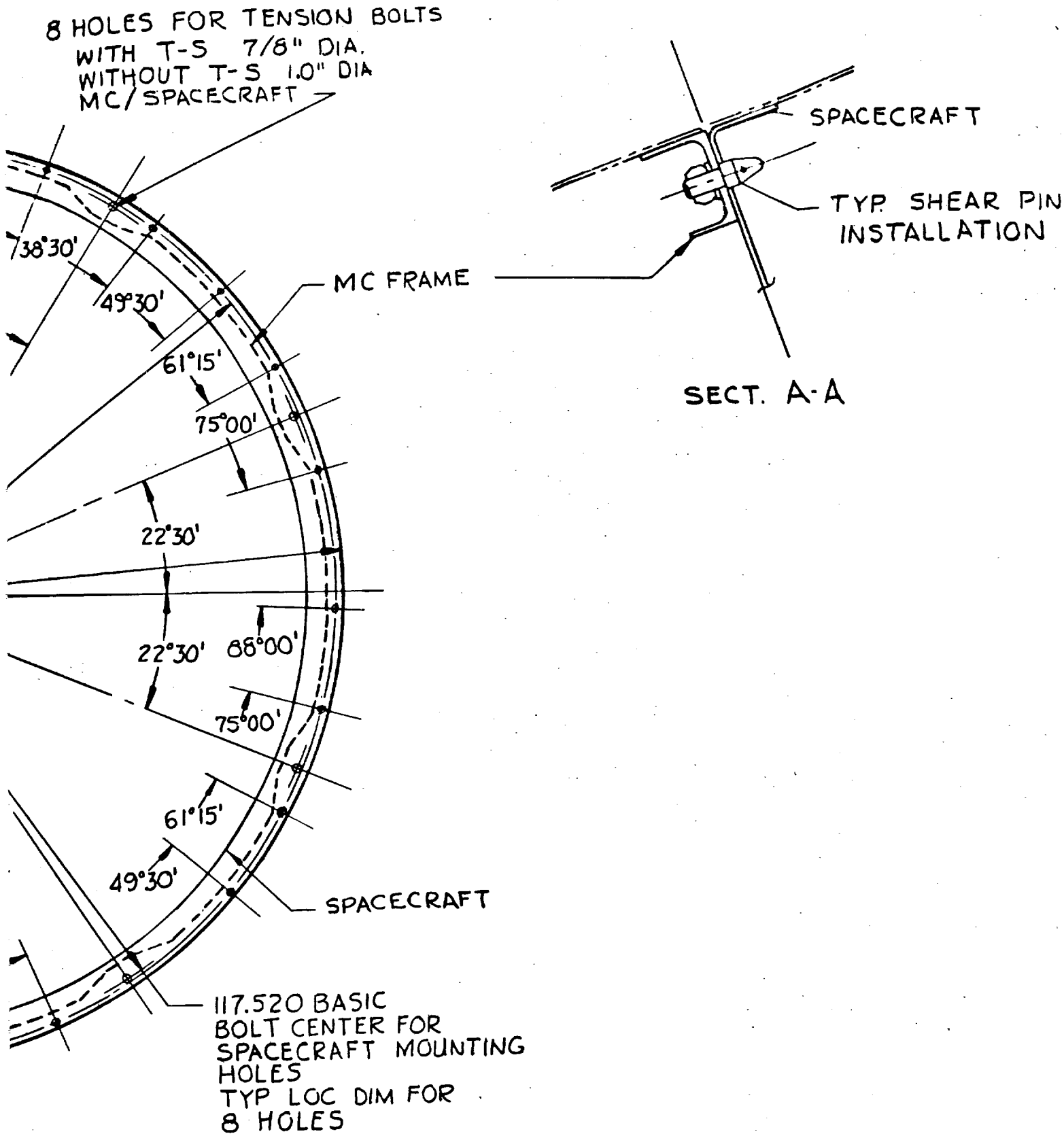
Ultimate Tension is 86,300 lbs. (per bolt)

Titan III (without Transtage; interface at Station 220.0)

$P_{equiv} = 1.08 \times 10^6$ lbs. (ultimate)



X-SECTION VIEW AT PA
INTERFACE- TYP W &



AYLOAD
W/O T-S

FIG. 7 INTERFACE DIMENS.

Capability of One Longeron (total of 8 longerons and bolts)

Ultimate Compression is 135,000 lbs. (per longeron)

Ultimate Tension is 125,000 lbs. (per bolt)

B. Electrical Interface Data

The electrical interface can be somewhat flexible since it is a function of spacecraft power and signal requirements. At the present time, the interface between the payload and Titan is through a 16 pin connector. Interface between payload and the planned uprated Titan is made through a 60 pin connector.

C. G & C System Capability and Limitations

1. Basic Core Configuration - No control stability problem exists that would constrain the payload within stricter limitations than those inherent in the payload weight limit and lifting body vehicle size consistent with its weight.

2. Core With Transtage - The flight control system for the core with transtage has the following limitations imposed pertinent to the payload:

a. Payload weight will be greater than 500 lbs.

b. The payload (including support truss) will have inertia characteristics about its own c.g. equal to or greater than pitch and yaw = 500 slug-ft^2; roll = 100 slug-ft^2.

c. The lateral c.g. position during transtage operation will not exceed a conical envelope emanating from the equivalent engine gimbal point of three degrees half angle (Figure 8). A

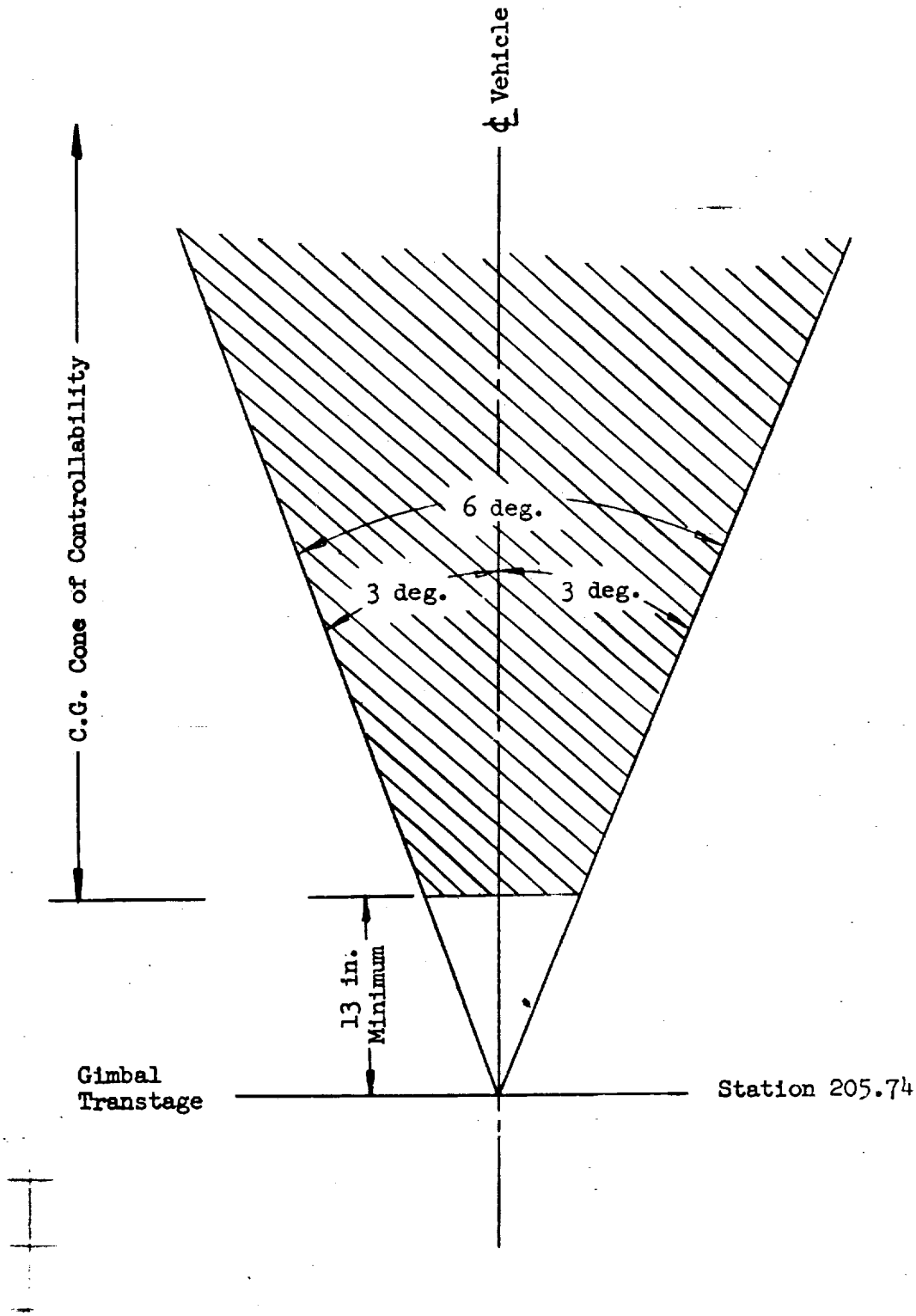
reduced c.g. envelope may be required to control some of the large heavy vehicles.

3. Core With Strapped-On Solids - Operation of the maximum vehicle configuration is feasible with lifting body payloads within the constraints of Figure 9. The limiting envelope beyond which bears the label "Autopilot Constraints" is conservative since some control system improvements have been made and the curve was generated for the Titan III-C. Payloads outside the constraint envelope may also be compatible but will require additional investigation to support any commitments.

Long, large and heavy payloads may accentuate a hydraulic actuator-structural bending mode coupling problem for Stage I or Stage II. Solution of this problem may be possible by actuator improvement or change of structural stiffness. If the core with strapped-on solids has a transtage, the constraints for the transtage as stated in Section B will still apply.

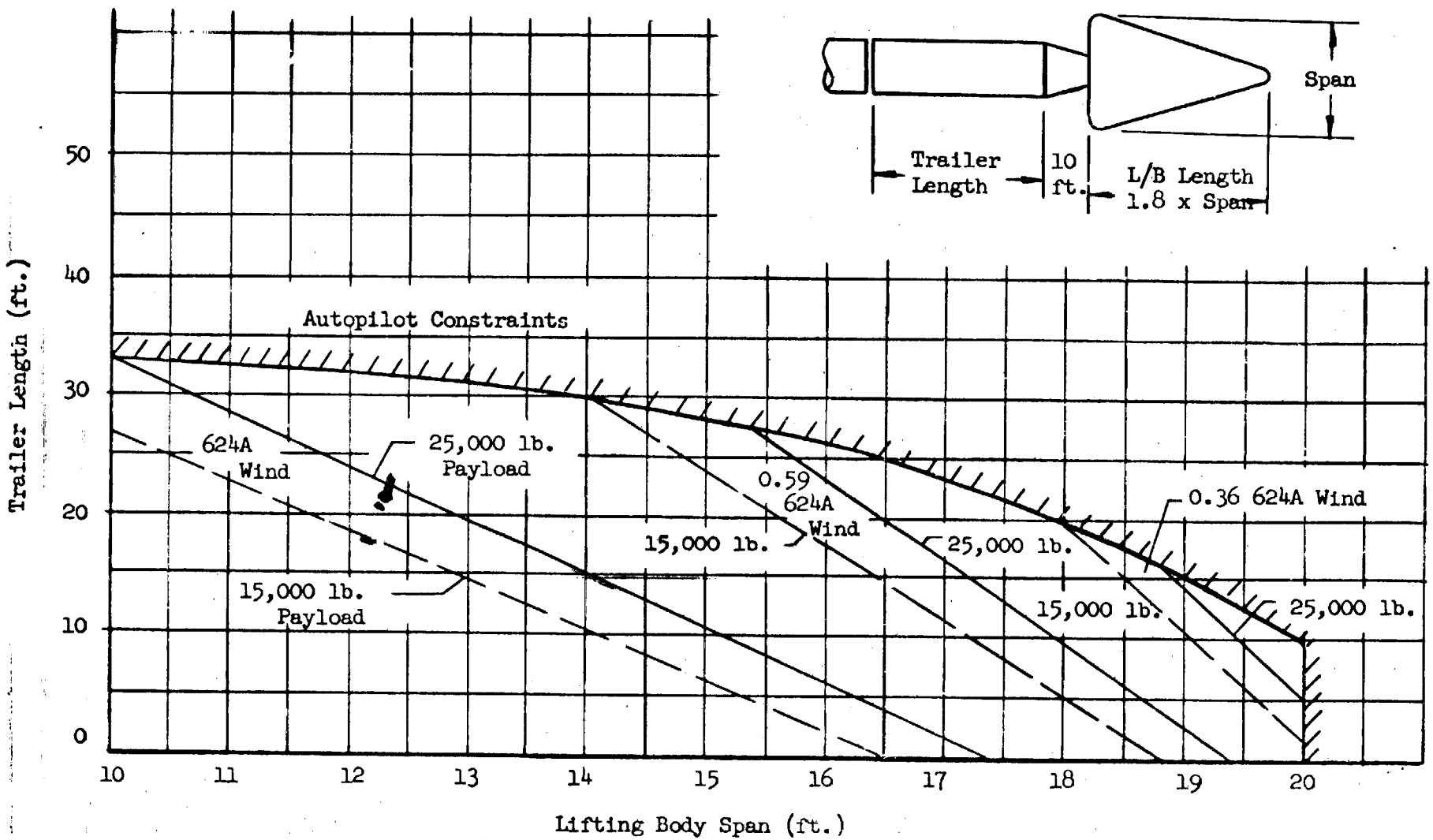
4. Proper orientation of the glider body is very important. The resulting aerodynamic loads and control requirements are very dependent on selection of glider incidence angle.

5. Payload elasticity has an appreciable effect on the payload compatibility envelope. With the possible thinness of a hypersonic re-entry body, cognizance of the pitching inertia properties and air frame stiffness for pitching is emphasized, to contain loads and control requirements within the capability limits. Caution is also mentioned in minimizing the trailer length when considering the large, in volume, and heavy lifting body payloads.



Transtage Lateral Center of Gravity Envelope

FIGURE 8



Envelope of Compatible Lifting Body Payloads - With Strap-Ons

FIGURE 9

D. Design for Manned Missions

1. Design Philosophy - The aspects of crew safety and its achievement with payloads characteristic of manned lifting body vehicles, were given due consideration during the Titan III design and development effort. Since crew safety is highly dependent upon mission success, a high degree of flight reliability has been the design goal throughout the system development program. Provision of crew safety at all times poses a different set of requirements with each unique payload. As a result, differences in types of equipment installed and redundancies provided will prevail. Once a payload is defined, the complete system can be integrated and its crew safety and mission success potential can be ascertained. Inherent capability of each is employed in providing the best integrated system.

2. Design Features - The launch vehicle system design features, both inherent and built-in, pertinent to crew safety and mission success are as follows:

- Thrust termination capability is provided. In the case of the SRM's, thrust is reduced to a very low level by bursting two large frangible disks and venting chamber pressure forward.
- The SRM's provide an inherently mild environment. By the nature of solid propellants, a catastrophic explosion of the propellants and an envelopment of the entire system by a fireball is precluded since combustion will be greatly retarded in the event of a loss of pressure on structural break-up.
- A safety factor of 1.4 was applied to working loads derived from conditions of environment encountered in flight such as aerodynamic and dynamic loads. A safety factor of 1.25 was applied to the well-

defined load forces such as those due to engine thrust. These ultimate loads are combined for design loads for body airframe.

- Desired flight reliability is achieved by providing redundance in critical control systems such as guidance, rate gyro, auto hydraulic system, actuators, and power distribution.
- Provision of real time displays of critical parameters to the flight crew and ground control (via telemetry) for use in ab decisions.
- Provision of a malfunction detection system (MDS) capable of:
  - Monitoring vehicle parameters that would indicate potentia catastrophic vehicle malfunctions.
  - Initiating redundant system switchover or abort signals.
  - Displaying currently controlling system (for redundant system).
  - Requiring a primary and independent confirming indication prior to initiating abort or switchover.
- No single MDS malfunction will result in a false abort, loss of abort sensing capability, loss of crew display or command, or inadvertent switchover or failure to switch.
- Reduction to a minimum of failures with short warning times.
- Provision of an abort system to enable manned payload escape event of a detectable potentially catastrophic malfunction w cannot be corrected.

- In the event emergency escape is not feasible during a critical flight period such as maximum dynamic pressure, compensating redundancies to ensure mission success will be provided.
- It is a goal in the design and development phases to produce Titan III launch vehicles for manned missions with a flight reliability of 0.97.