

REPORT DOCUMENTATION PAGE

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13. ABSTRACT (Maximum 200 words) The primary emphasis of this study was to develop less expensive alternative grenade attachment concepts, which offer better fabrication and performance reliability than the current rope and band assembly. To this end, this study comprised four inter-related tasks: alternative attachment concept development, computer modeling dynamic structural analysis, prototype fabrication and testing, and manufacturing process development and cost analysis. Early in the project, after detailed review of the entire TDP, we began to suspect that the grenade attachment scheme may be only one of several significant system cost drivers. For this reason, the system cost analysis was expanded early to include a detailed assessment of other component and subassembly costs. This approach permitted the alternative grenade attachment concepts developed in this study to be evaluated with respect to other significant cost reducing and reliability enhancing modifications.					
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8 July 1997

Contract Summary

MANUFACTURING TECHNOLOGY FOR THE APOBS SYSTEM

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PROGRAM OBJECTIVES

- ▲ Utilize existing models to determine viability of baseline APOBS configuration.
- ▲ Develop alternatives, paying particular attention to attachment techniques.
- ▲ Perform dynamic structural analyses
- ▲ Prototype and test potential alternative attachments
- ▲ Perform manufacturing and cost analyses.

TASK STRUCTURE SUMMARY

- Task 1 - Develop alternative attachment schemes that will support improved performance and reliability, yet result in reduced assembly time and reduced cost.
- Task 2 - Perform a dynamic structural analysis of the APOBS system in order to better understand design loads and related safety factors.
- Task 3 - Prototype and test a family of alternative configurations in order to demonstrate their viability and to validate the modeling that has been performed.
- Task 4 - Perform a manufacturing and cost analysis in order identify the cost drivers and to demonstrate the economy and efficiency of the design.

HOW DID WE DO THIS?

- ▶ We utilized our in-house line throwing simulation (FLYOUT) to determine the stresses on the grenades as the APOBS is launched and flies out.
- ▶ We compared the simulation results with actual experience in the prior APOBS tests.
- ▶ We performed static tests to determine the effects of the calculated stresses on the attachments.
- ▶ We identified the critical attachment parameters and methodically corrected perceived deficiencies.
- ▶ We constructed dummy line charge segments and made a series of launches using our internal gun test facility.

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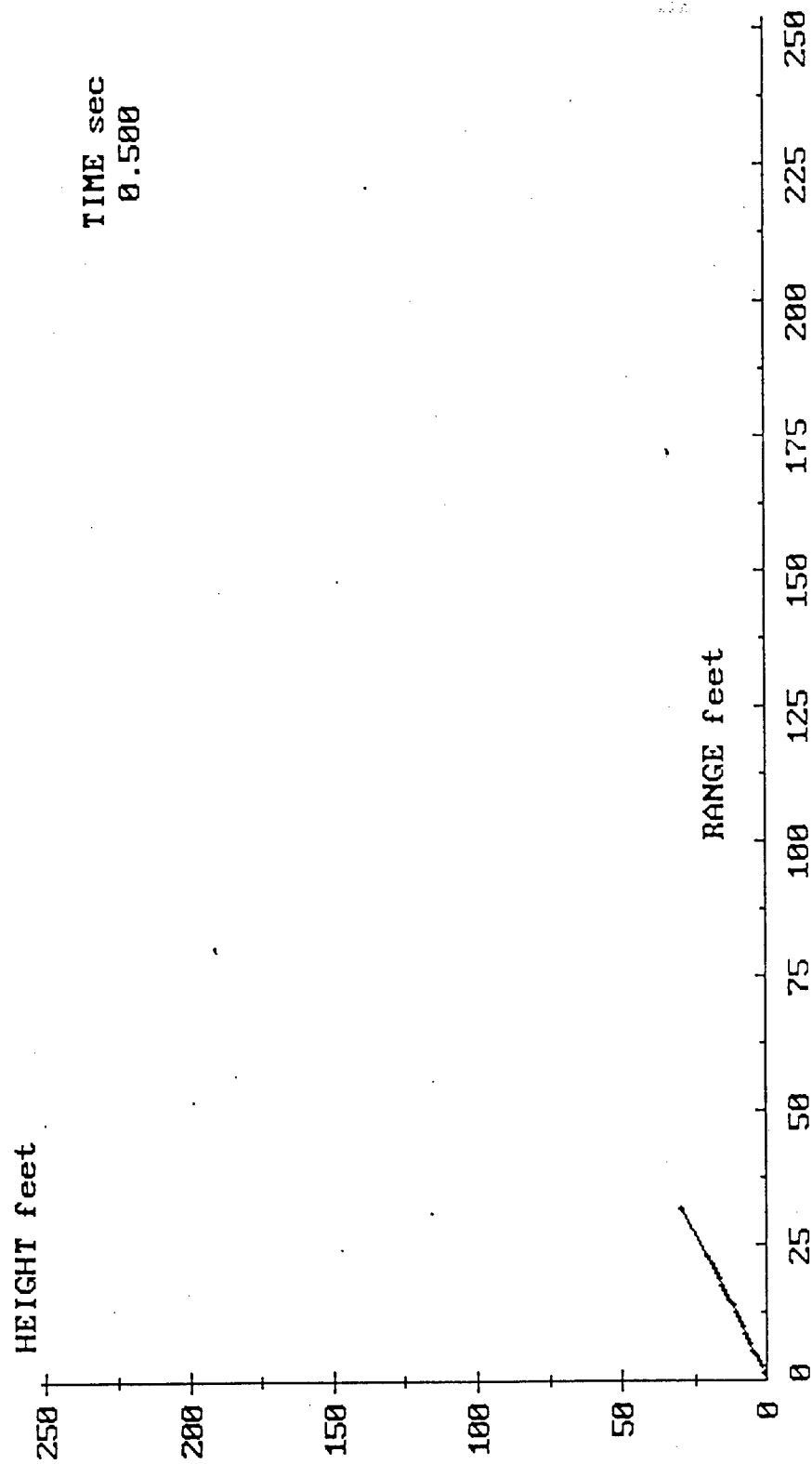


Figure 2 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 0.500 SECONDS.

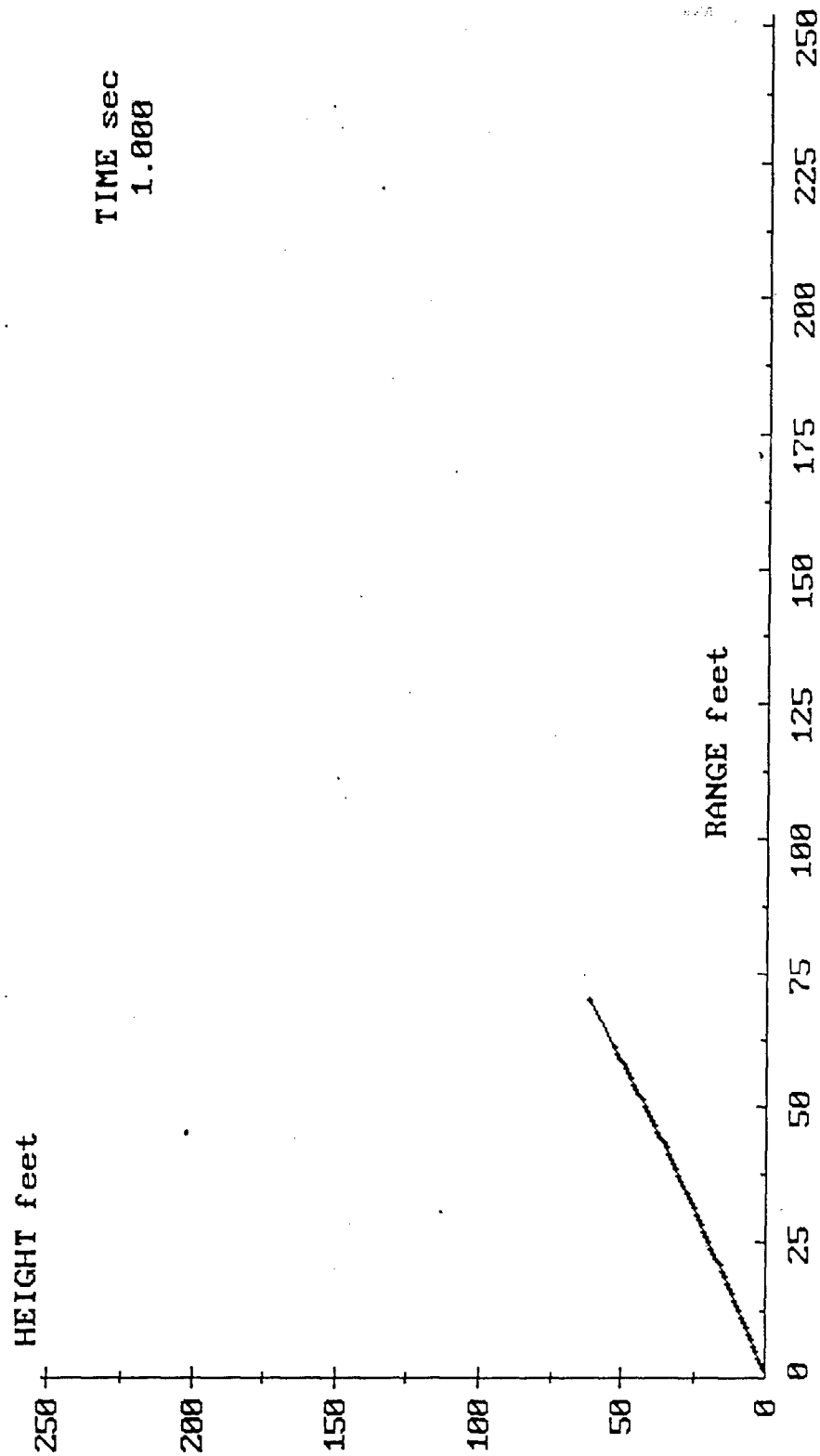


Figure 3 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 1.000 SECONDS.

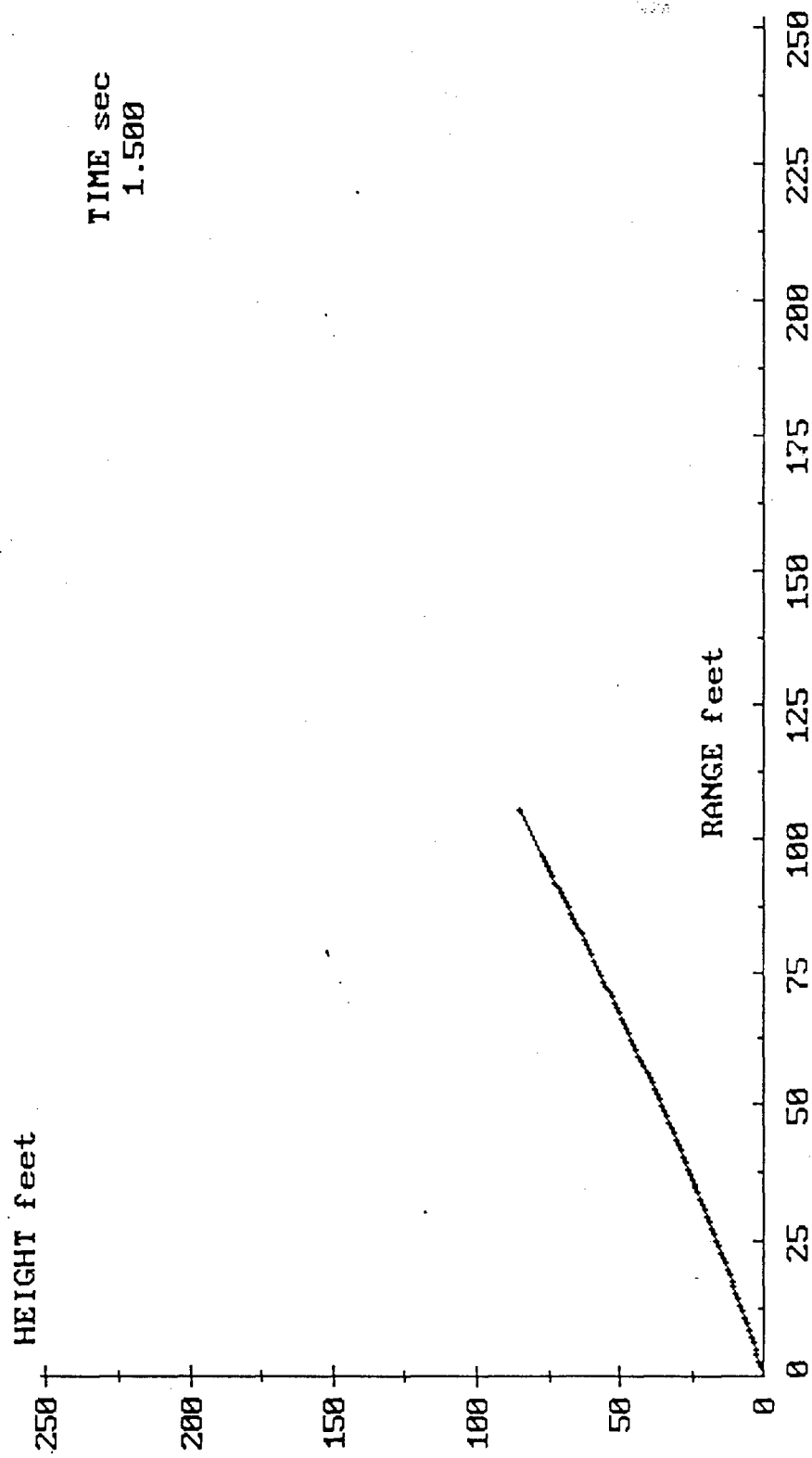


Figure 4 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 1.500 SECONDS.

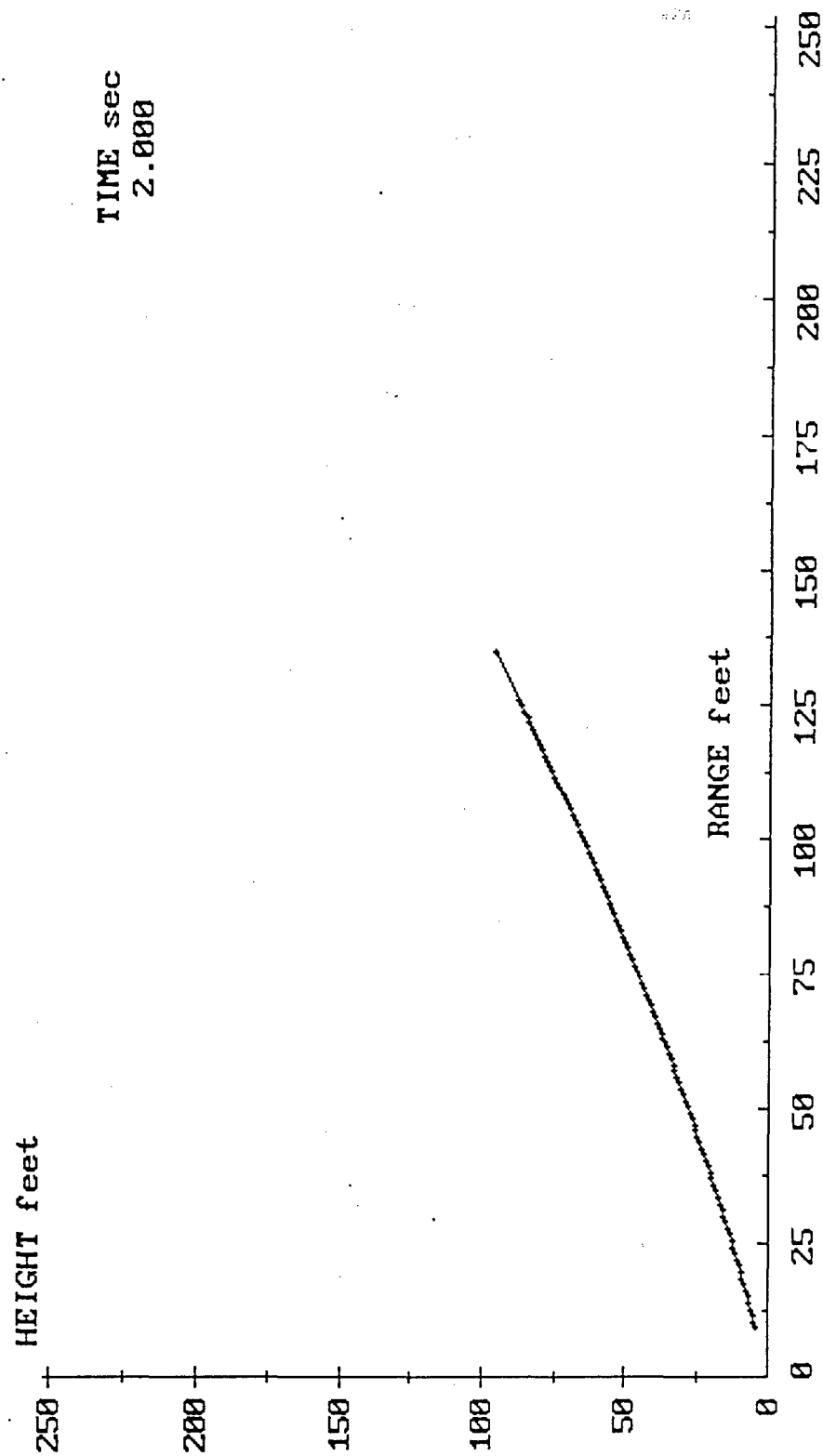


Figure 5 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 2.000 SECONDS.

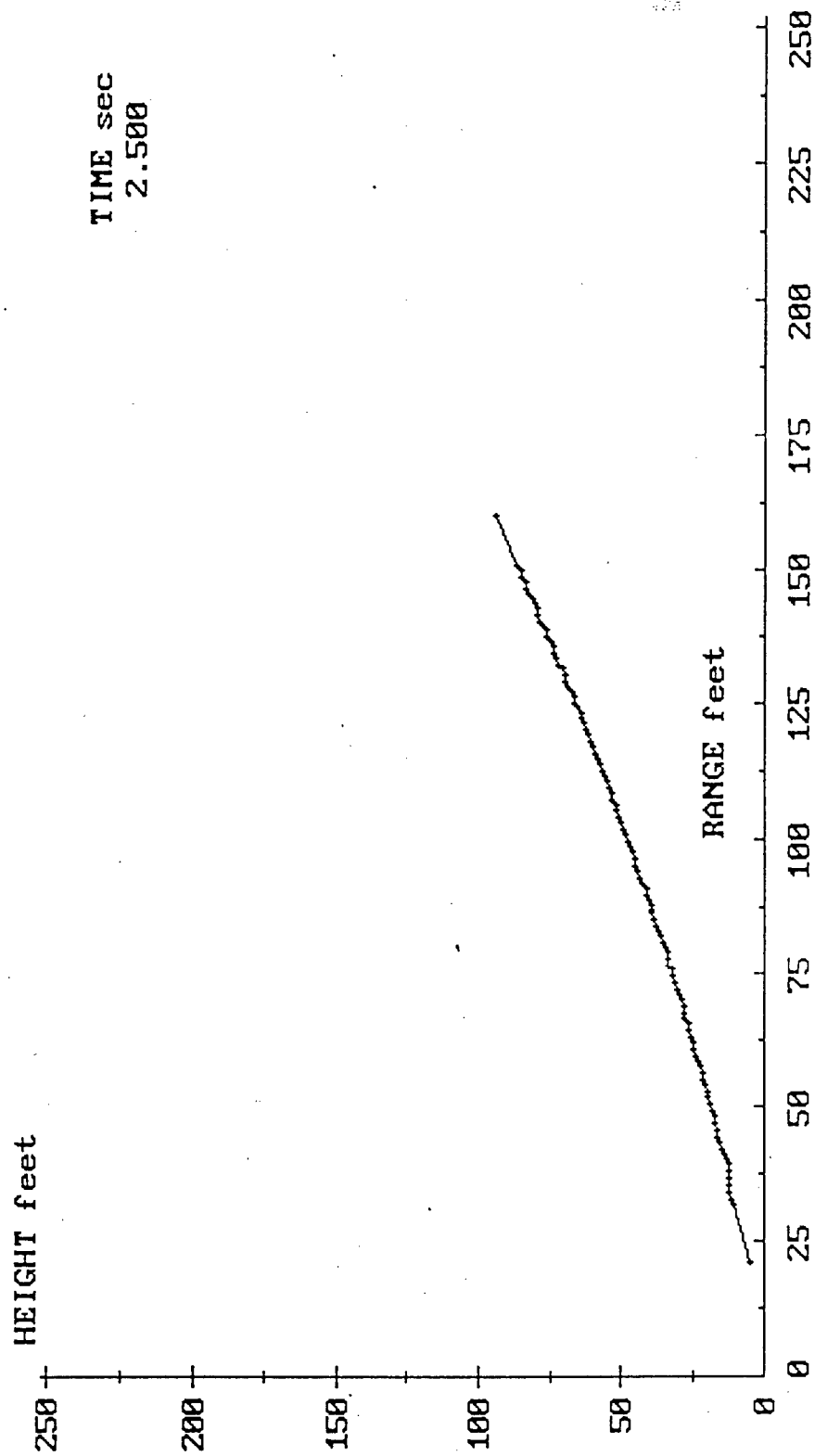


Figure 6 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 2.500 SECONDS.

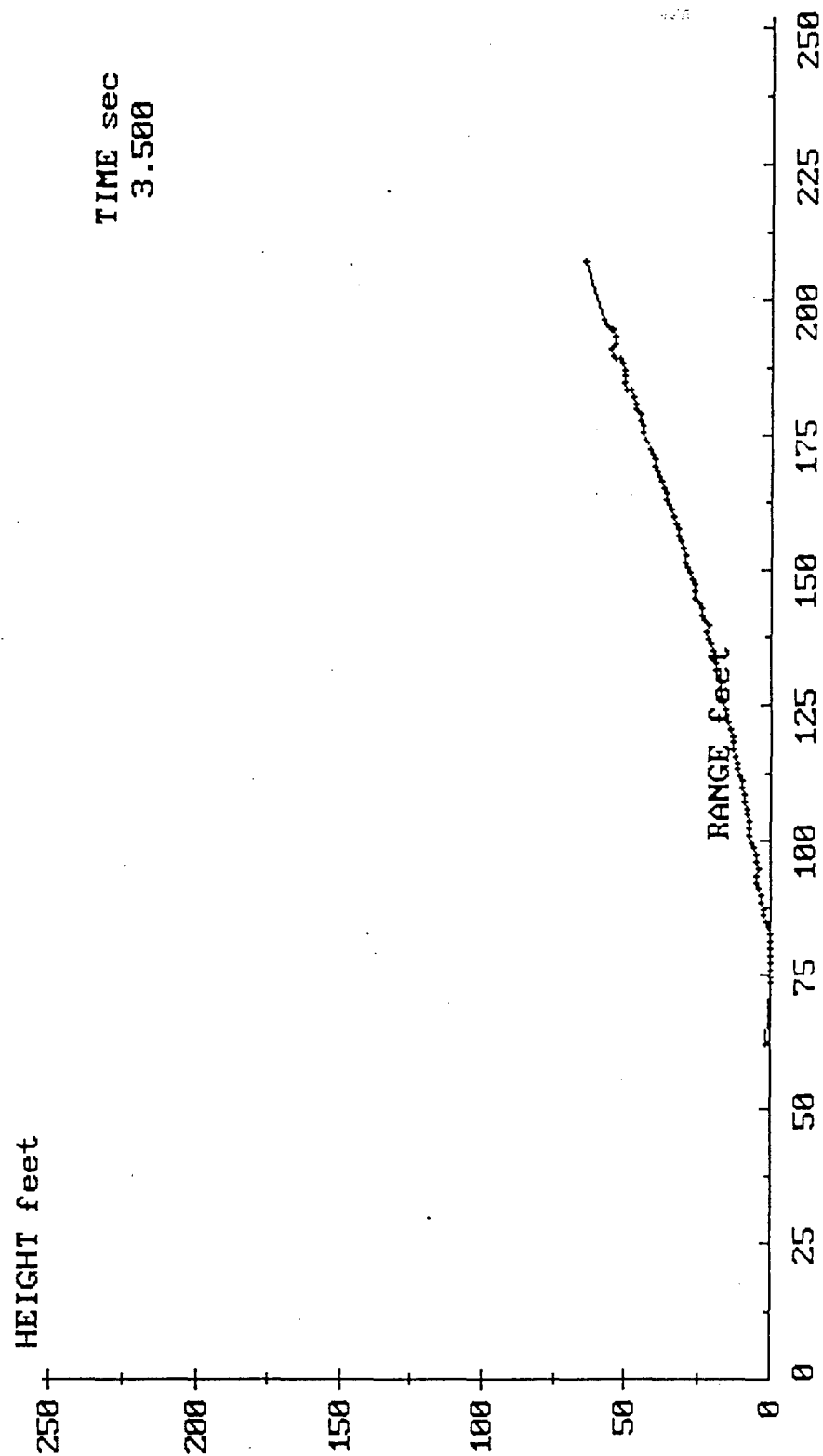


Figure 7 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 3.500 SECONDS.

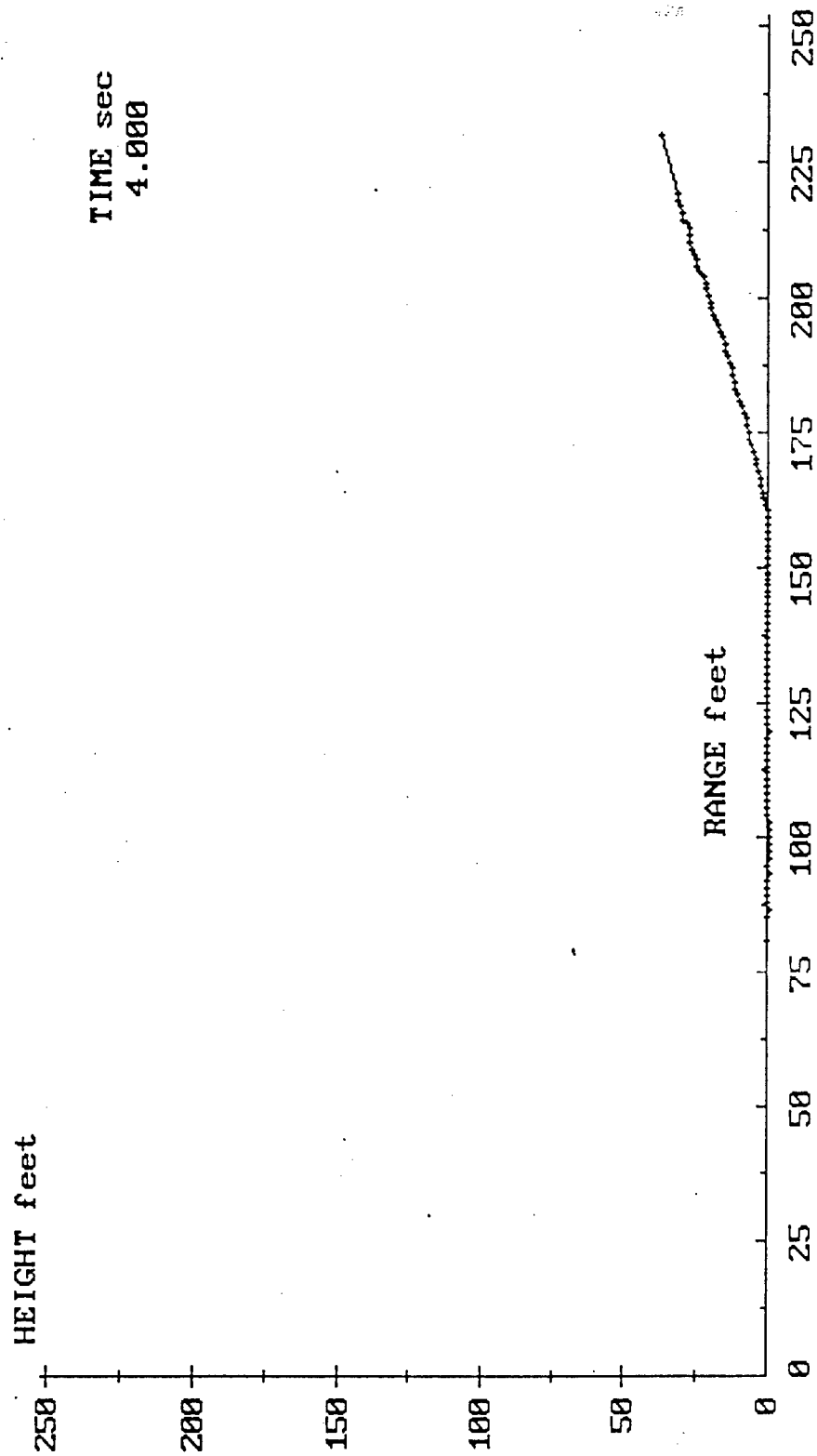


Figure 8 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 4.000 SECONDS.

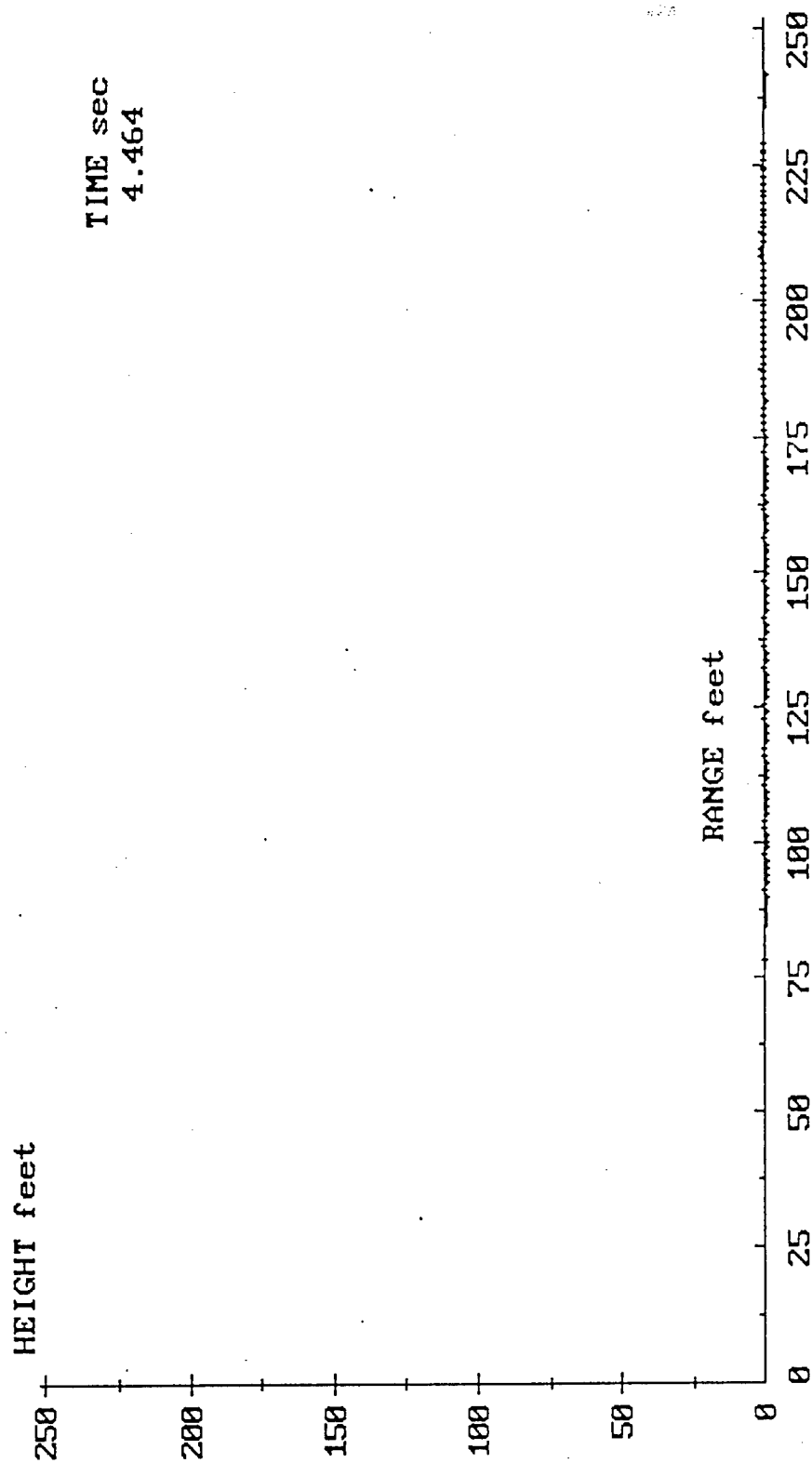
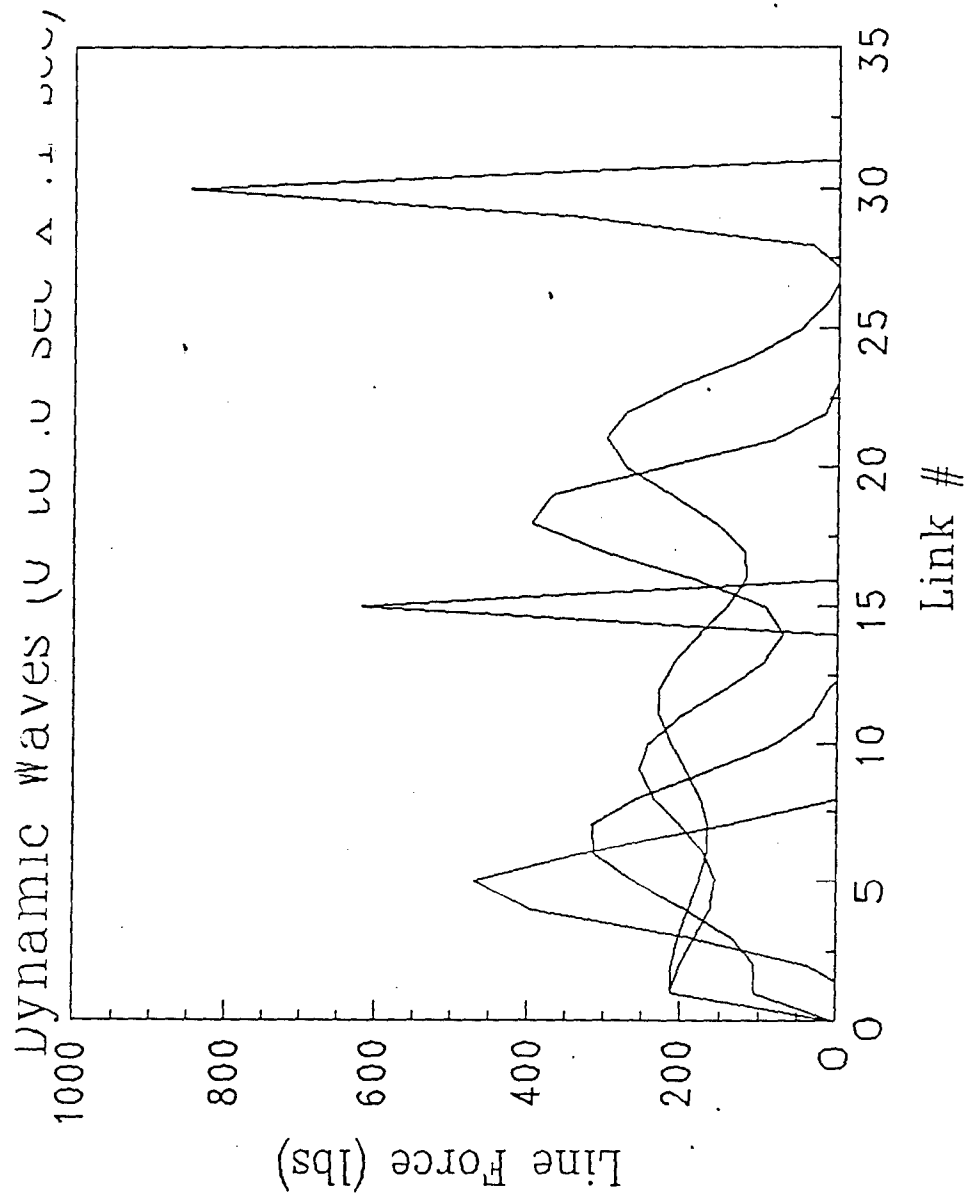


Figure 9 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 4.464 SECONDS.



DESIGN PERFORMANCE

LINK #	DESCRIPTION	F_{MAX} (lb)	F_{DESIGN} (lb)
1	MOTOR BRIDLE	473	900 (SPEC)
2	FUZE TO FIRST GRENADE	1141	1187 (SPRING)
3 - 61	ALL OTHERS - FRONT ASSEMBLY	735 TO 897	3200 (1/4" rope)
62	60th GRENADE TO CONNECTOR	960	3200 (1/4" ROPE)
63	CONNECTOR TO 61st GRENADE	1026	1187 (SPRING)
64 - 111	ALL OTHERS REAR ASSEMBLY	421 - 818	3200 (1/4" rope)
112	PARACHUTE BRIDLE	306	600 (SPEC)

SOME INTERESTING OBSERVATIONS

- ▶ All of the connections experience greater tensile forces than the rocket motor thrust of 200 pounds.
- ▶ The flyout is not a static process.
- ▶ The rocket motor accelerates and reaches a high velocity before the slack is taken up.
- ▶ Elastic tensile waves are developed, and they travel up and down the line, making a quantitative understanding of the flyout dynamics impossible without a validated simulation tool.
- ▶ The superposition of these waves, which travel faster than the line charge, causes brief duration, extremely high stresses in some of the links.
- ▶ The magnitude of these forces is sufficient to risk a failure.
- ▶ The waves are damped by the energy absorption, primarily elastic deformation, of the rope as it stretches.
- ▶ The knowledge of elastic characteristics of the rope and the connections are critical.

FLYOUT PERMITTED US TO INVESTIGATE WAYS TO REDUCE THE ELASTIC WAVE EFFECTS

- ▶ We can shorten the motor bridle so that the rocket does not have as much speed when it grabs the fuze.
- ▶ This results in a smaller amplitude stress wave.
- ▶ Rope elasticity can be modified to reduce stress wave peaks.

DESIGN PERFORMANCE WITH SHORTER BRIDLES

DESIGN PERFORMANCE WITH 48 INCH MOTOR BRIDLE

LINK #	DESCRIPTION	F _{MAX} (lb)	144" BRIDLE (lb)
1	MOTOR BRIDLE	291	473
2	FUZE TO FIRST GRENADE	786	1141
3 - 61	ALL OTHERS - FRONT ASSEMBLY	568 - 818	735 - 897
62	60th GRENADE TO CONNECTOR	851	960
63	CONNECTOR TO 61th GRENADE	976	1026
64 - 111	ALL OTHERS - REAR ASSEMBLY	410 - 791	421 - 818
112	PARACHUTE BRIDLE	341	306

DESIGN PERFORMANCE WITH 24 INCH MOTOR BRIDLE

LINK #	DESCRIPTION	F _{MAX} (lb)	144" BRIDLE (lb)
1	MOTOR BRIDLE	222	473
2	FUZE TO FIRST GRENADE	629	1141
3 - 61	ALL OTHERS - FRONT ASSEMBLY	502 - 812	735 - 897
62	60th GRENADE TO CONNECTOR	889	960
63	CONNECTOR TO 61th GRENADE	1022	1026
64 - 111	ALL OTHERS - REAR ASSEMBLY	412 - 777	421 - 818
112	PARACHUTE BRIDLE	213	306

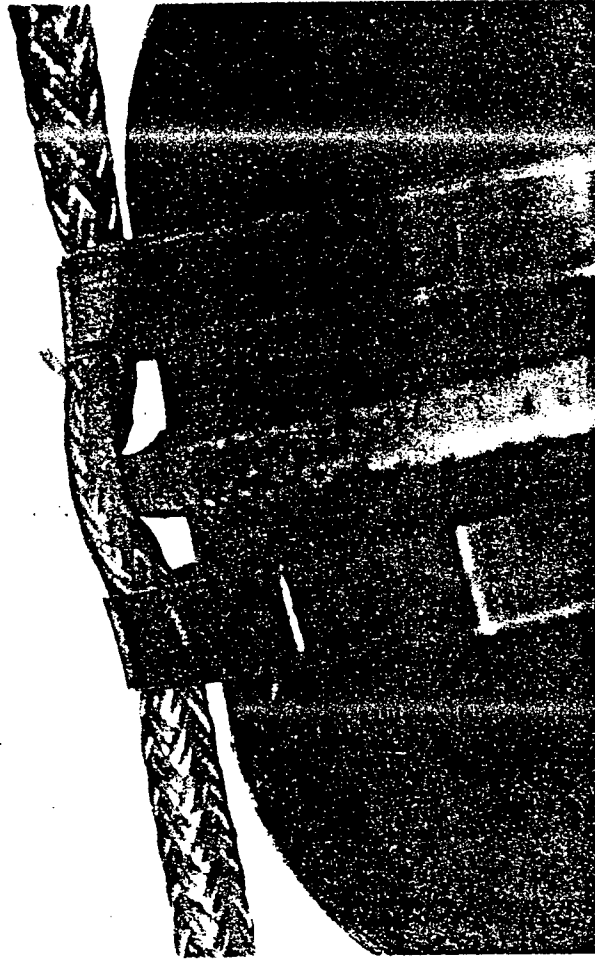
S A A

EFFECTS OF REDUCED STIFFNESS

- ▶ Much can be gained by modifying both bridle length and line charge stiffness.
- ▶ Adequate design safety factors can be achieved with zero weight penalty.

STATIC TEST RESULTS

- ▶ Calibrated pull force of 200 pounds was applied to existing attaching bands.



POTENTIAL ALTERNATIVE ATTACHMENT TECHNIQUES

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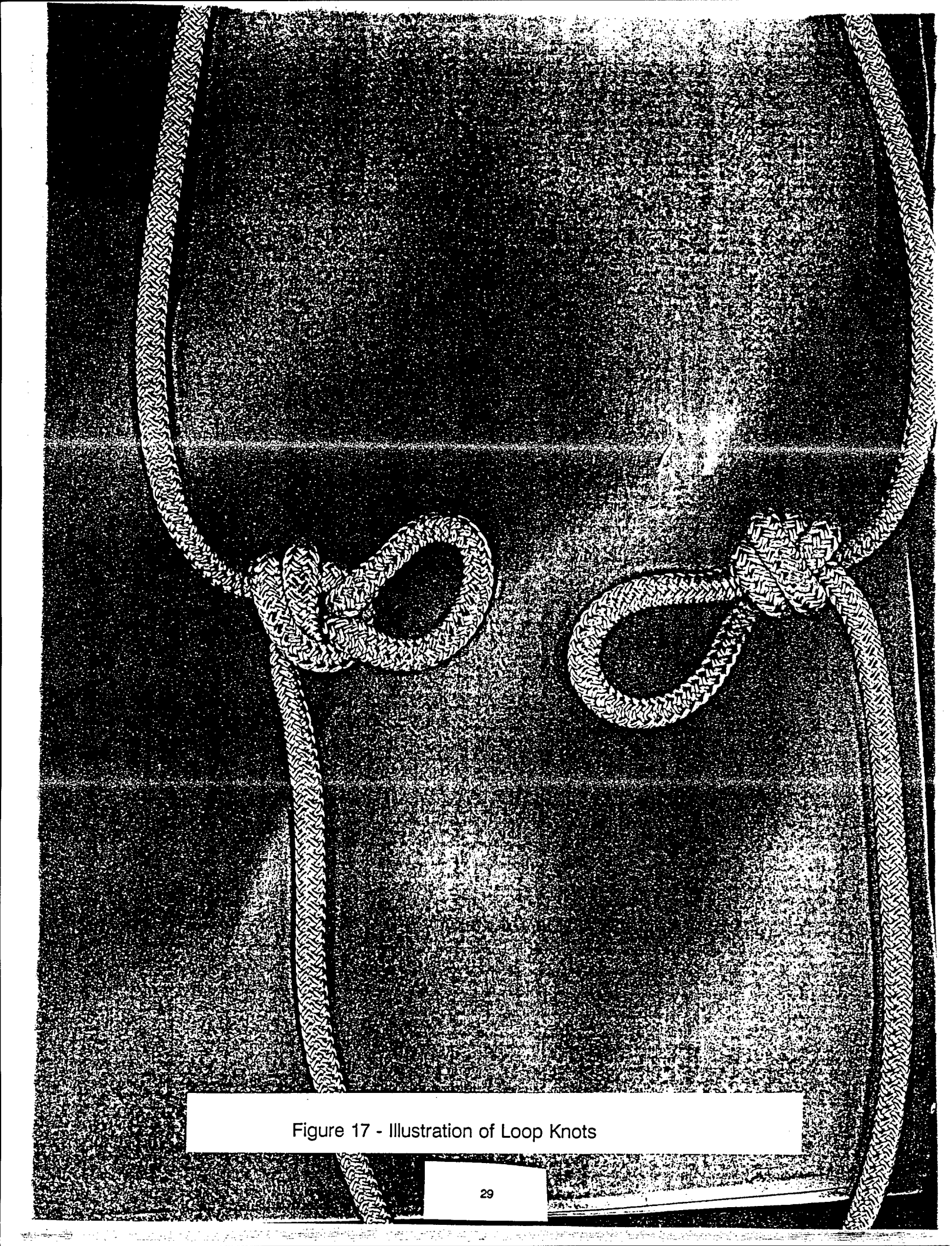
A high-contrast, black and white photograph of a rope with a distinct woven texture. The rope is arranged in a large, roughly rectangular shape, with two loops formed in the lower half. The loops are positioned on the left and right sides, facing each other. The background is dark and grainy, providing a stark contrast to the lighter-colored rope. The overall image has a grainy, high-contrast quality, typical of a photocopy or a low-quality scan.

Figure 17 - Illustration of Loop Knots

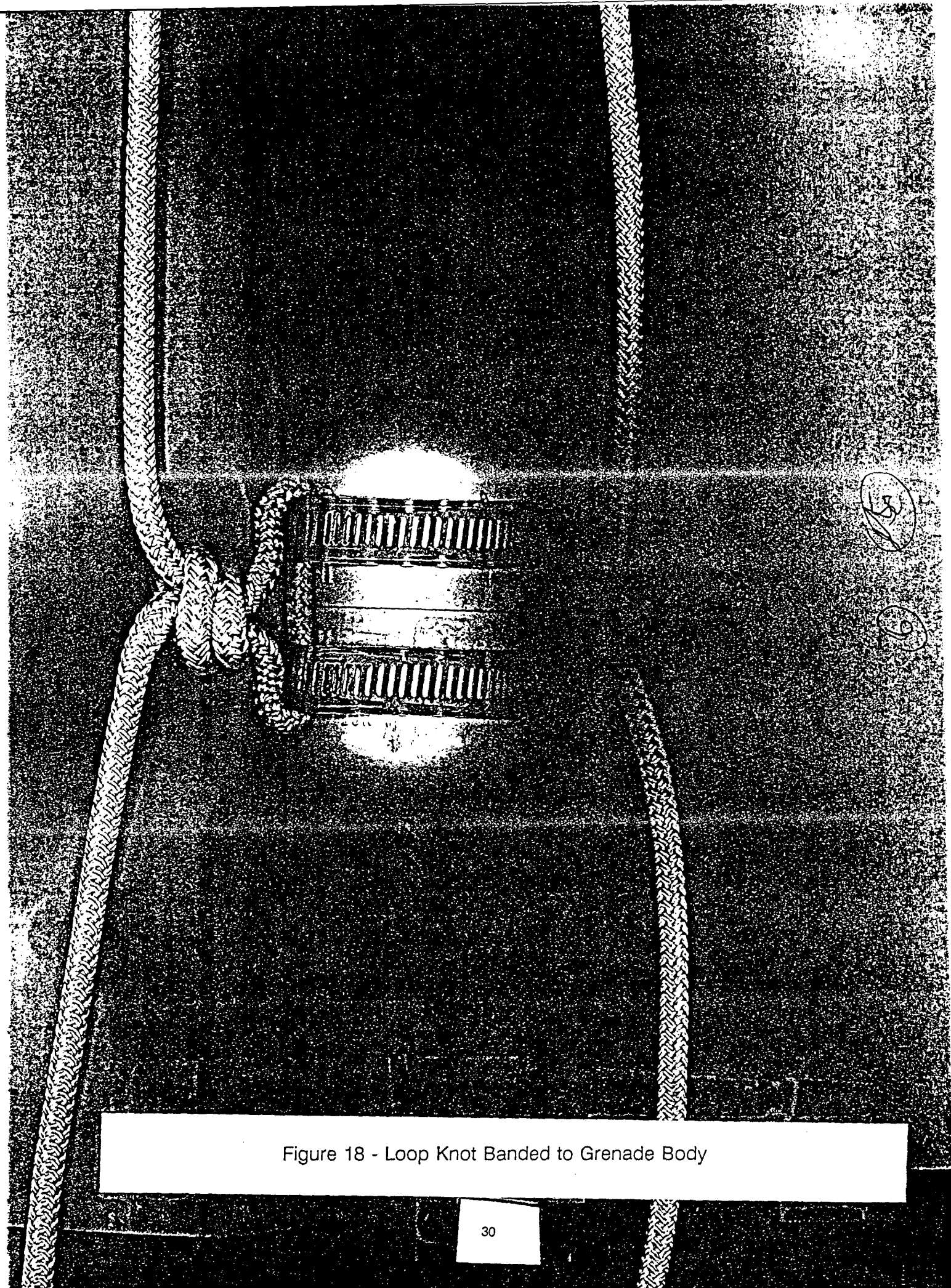


Figure 18 - Loop Knot Banded to Grenade Body

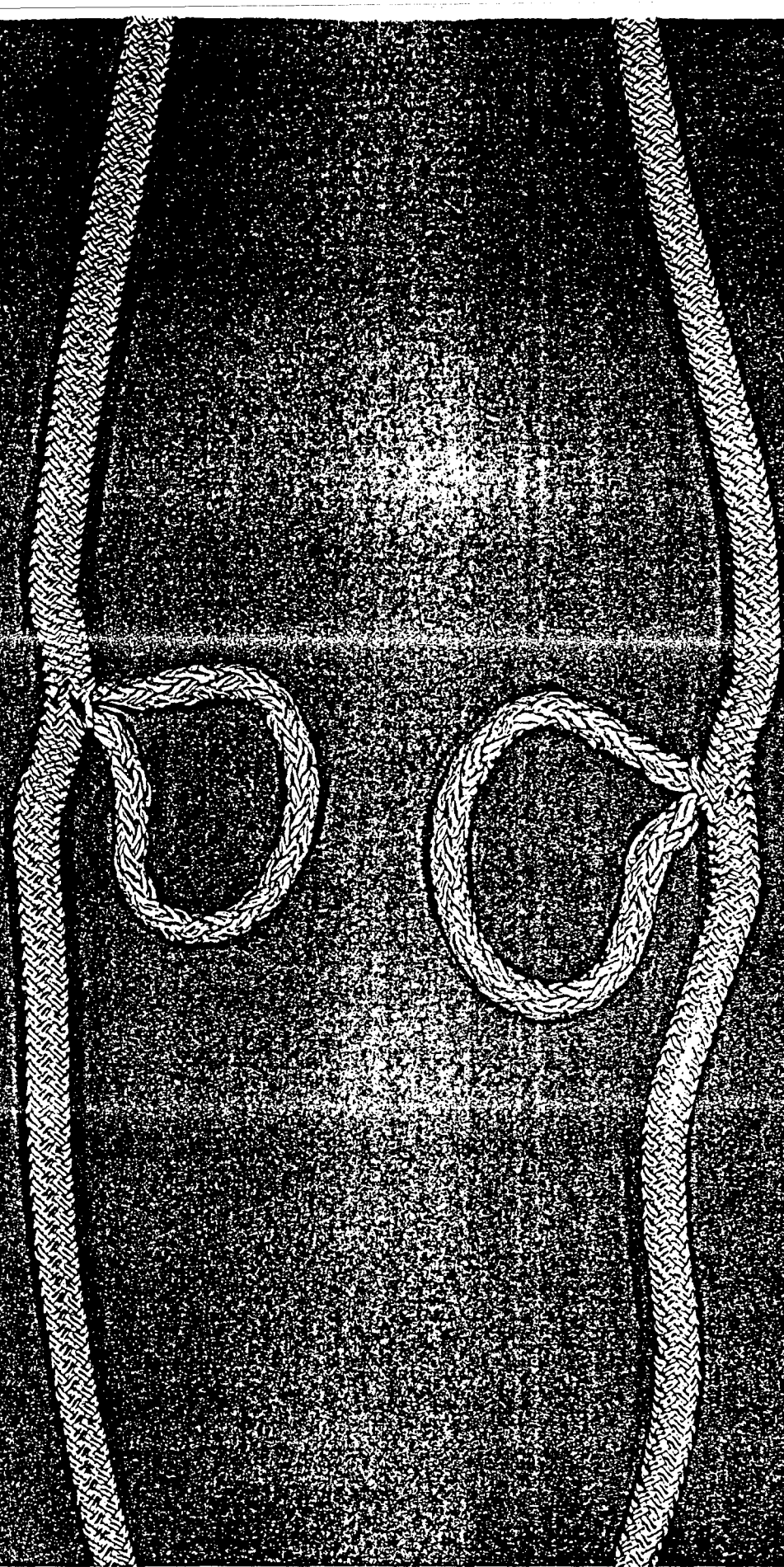


Figure 19 - Modification of Banding Technique Using
Inner Core of Line

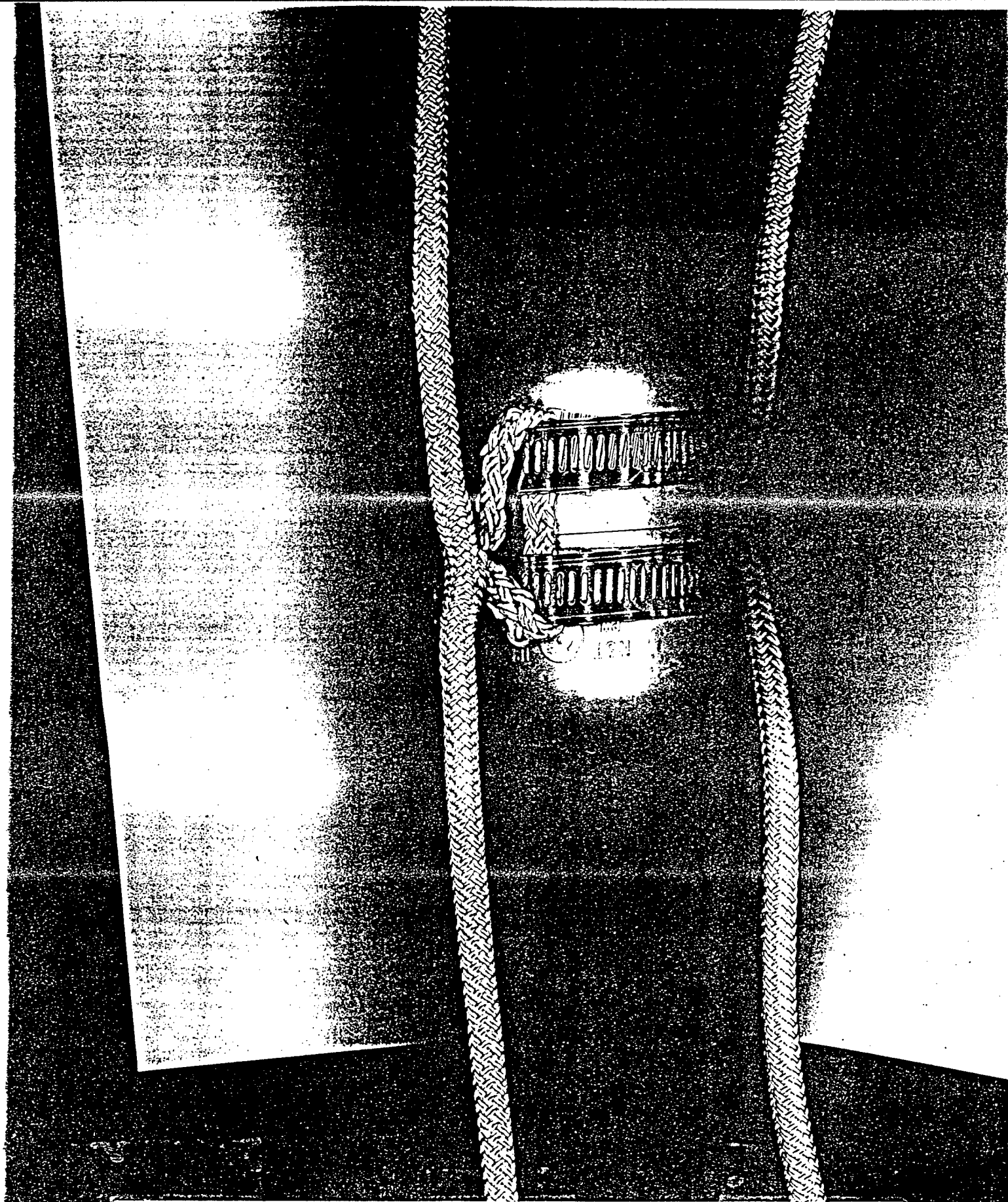
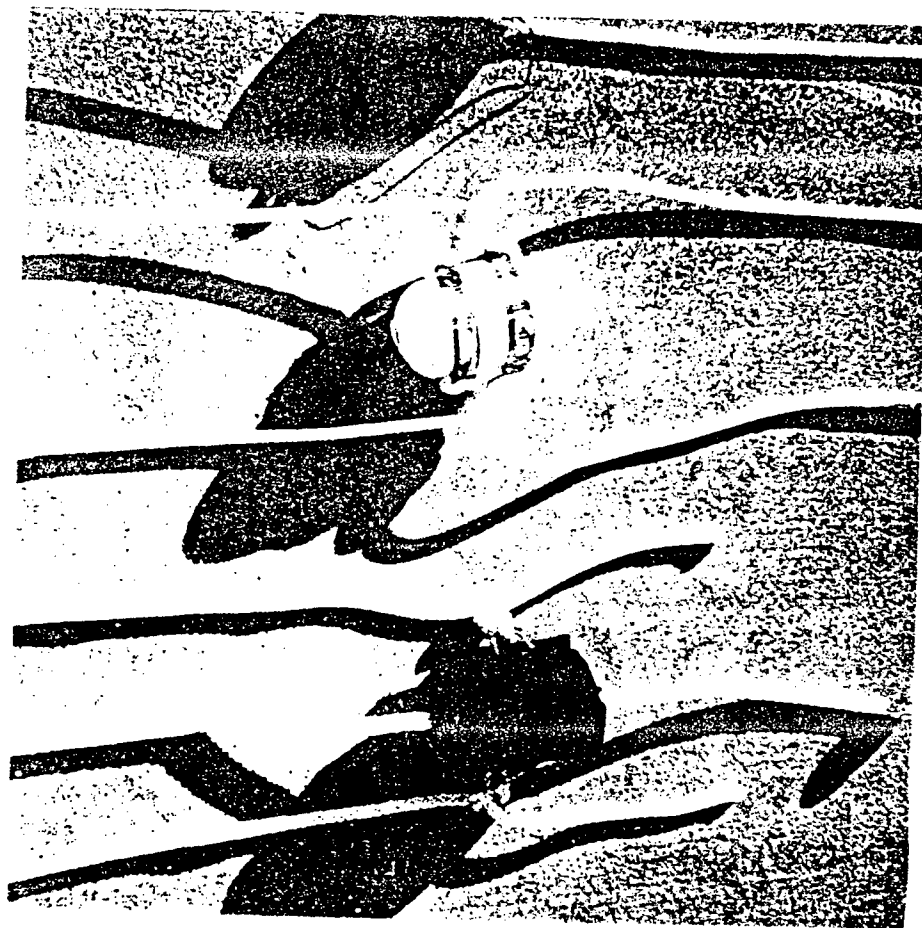
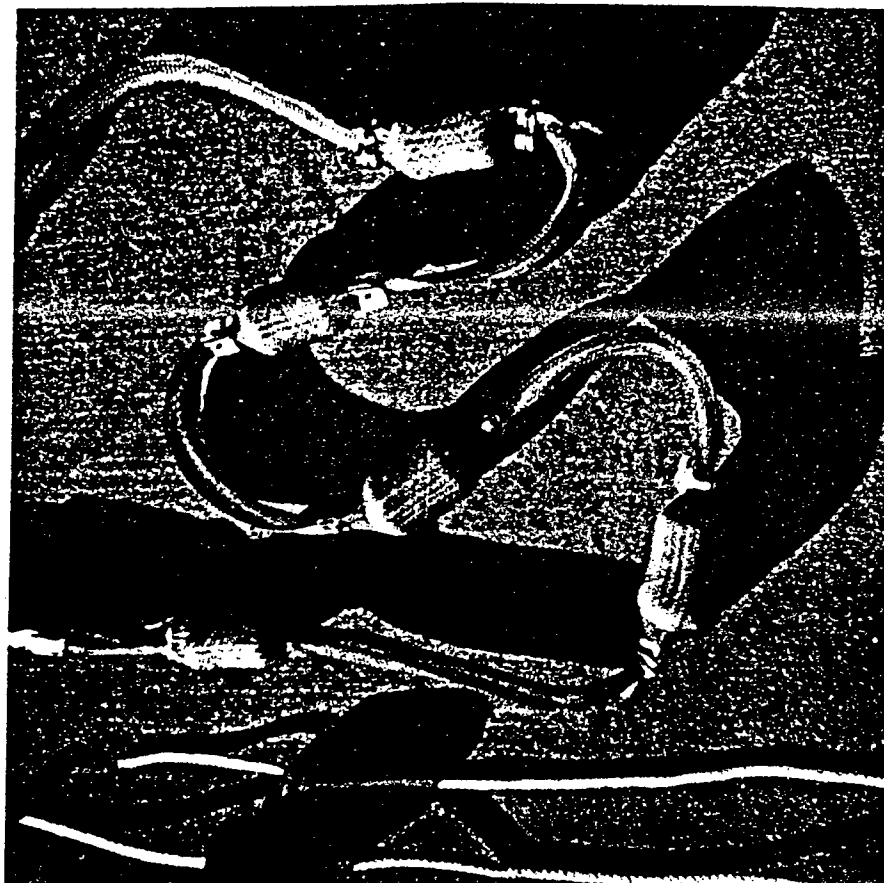


Figure 20 - Inner Core of Line Fastened to Bands





WHERE ARE WE NOW? WHAT DO WE KNOW?

- ▶ We understand, in great detail, the issues and constraints related to the APOBS grenade attachment technique.
- ▶ We understand the manufacturing and cost issues.
- ▶ We understand how product improvements can be inserted at the proper time.
- ▶ A Phase II program can address all of these issues in a very efficient manner.
- ▶ We currently have unique resources that ensure a successful and cost effective program.

RECOMMENDED PHASE II PROGRAM

- ▶ Fabricate at least two complete inert line charges and dynamically test performance.
- ▶ Use analytical and test results to select a configuration and validate performance and cost.
- ▶ Revise design to reflect modified configuration.
- ▶ Investigate relative safety issues for a modified configuration
- ▶ Investigate logistics and manprint issues.