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# The Transmission of High Frequency Data From Rocket Sleds Through Screen Boxes

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# THE TRANSMISSION OF HIGH FREQUENCY DATA FROM ROCKET SLEDS THROUGH SCREEN BOXES

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## ABSTRACT

A technique for obtaining high frequency data from a rocket sled traveling at hypersonic velocities is discussed. The technique, using standard screen box systems, has been known for many years but may have been overlooked for the application of retrieving high frequency data. Included is a brief discussion of rocket sled impact testing in general and a description of the specific tests used to demonstrate data transmission capabilities.

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# THE TRANSMISSION OF HIGH FREQUENCY DATA FROM ROCKET SLEDS THROUGH SCREEN BOXES

## Introduction

High speed impact testing is a branch of environmental testing that lends itself well to the use of rocket sleds. In fact, impact testing is one of the most often used capabilities of Sandia's 5000 foot (1524m) test track. Rocket sled impact velocities may range up to 8000fps (2438 m/s) given a long enough track. The length of the Sandia track limits impact testing to about 6600 fps (2012 m/s) for reasonably sized test items and standard rocket motors.

Two types of impact testing are commonly used. The first method, standard impact testing, consists of accelerating the test item to the desired velocity and impacting it into a stationary target. The second method, turnaround testing, consists of propelling the target into a stationary unit. Generally, the disadvantages of one system are the advantages of the other. Disadvantages of standard testing include the fact that mitigation and isolation are necessary to prevent the unit from being exposed to the shock and vibration environment of the track, and, before the technique discussed in this report was developed, retrieval of high frequency (megahertz or higher) data was either extremely expensive or impossible. Disadvantages of turnaround testing include limitations on the target size and weight that can be propelled successfully down the track. The expense and complications of a removable aerodynamic fairing may be necessary to keep the air drag low enough to achieve the desired impact velocity. Additionally, the aerodynamic shock waves produced in a turnaround test are not the same as those of a standard test, leading to a modification of the response of the unit to impact.

In order to utilize the advantages of standard testing, it is necessary to be able to record high frequency data from the impact by communicating with the test item carried on the sled.

## The Screen Box

For years, the most common method of providing electrical communication with a moving rocket sled from a particular location along the track was through screen boxes. A screen box system (Figure 1) consists of two U-shaped metal channels with window screening (or any other conductive substance) placed across the open face of the "U." The boxes are electrically isolated from each other and from ground, and are fastened on the track structure at the desired location for communication with the sled. To complete the circuit, two electrically isolated metal cutter bars or knife blades are mounted on the rocket sled in a position to slice through the screening as the sled passes the boxes.

Classically, a voltage is applied across the isolated boxes. This voltage is transmitted to the sled as the cutter bars pass through the boxes.

The screen box technique works so well in the classical usage that it was decided to modify the technique slightly and investigate the possibility of transmitting high frequency data generated on the rocket sled through screen boxes to a ground-based recording station located near the track.

## Uncertainties

A fairly extensive list of questions was compiled when considering the screen box data transmission idea. A list of undertainties would include the following.

1. In Sandia's experience, screen boxes had not been used for any purpose at velocities over Mach 3.5, and in order to make standard impact testing possible, testing to Mach 6 is necessary.

2. A question existed regarding the possibility of the aerodynamic shock wave created by the sled pushing the screen or even the boxes away from the cutter bars to prevent proper contact.

3. Could sufficient contact be maintained in the boxes without simply shearing the cutter bars at supersonic and hypersonic speeds?

4. Would screen contact be continuous and of low enough resistance to eliminate drop outs, distortions, and attenuation of the data?

5. Would the possible ionization of air near the shoes (hence near the cutter bars) caused by aerodynamic shock waves and intense frictional heating alter or degrade the data?

6. Would the tremendous energy release caused by the impact affect the data transmission process?

7. Would the ejecta from the impact damage the screen box assembly?

8. Would the sled structure and electrical connections survive long enough in the face of the extreme impact forces to transmit data?

9. Would the fact that the screen box assemblies add an unshielded section to the otherwise shielded circuitry allow excessive noise or interference?

## Testing

In order to investigate the above uncertainties, several rocket sled tests were conducted.

For the preliminary sled test, it was decided to eliminate for undertainties associated with the impact process and concentrate on simply passing high frequency data through screen boxes. In order to achieve something of significance, it was decided to forgo low velocity testing and attempt a test at about Mach 5. A surplus five-inch monorail rocket sled was outfitted with cutter bars for the occasion (Figures 2, 3, and 4). In order to be aware of alterations to high frequency data caused by the use of screen boxes, it was necessary to record a signal of known quality. To achieve this degree of standardization for the data signal, the rocket sled with cutter bars was made into a passive device for simply connecting the signal from a laboratory signal generator to high frequency recording devices. A continuous series of pulses was generated, one every ten microseconds, with each pulse having a rise time of about five microseconds, a sustained portion at four volts for about one microsecond, and a one quarter microsecond fall time to zero volts. These pulses were cabled to one screen box. The other screen box was wired to an oscilloscope and a 1.5 MHz disc recorder. The cutter bars on the sled were wired together with a shorting bar. As the sled passed through the screen boxes, the circuit from the signal generator to the recorders was completed. Figures 5 and 6 show the screen box installation before testing. Several pretest checks were made to record the quality of the signal without the presence of the moving sled, and then the sled was fired through the screen boxes at a velocity of 5334 fps (1626 m/s). Review of the data indicated no perceptible difference between pretest and test information. Figure 7 shows pretest and test data. Additionally, the screen boxes were undisturbed on the track and the screen was neatly severed (Figure 8).

Results of this first test were encouraging but not altogether representative in that no impact was in progress during data transmission. The sled for the second test (Figures 9, 10 and 11) incorporated a test item and was elongated to allow some separation of the cutter bars from the ejecta to result from impact. The sled was fitted with a signal generator producing a continuous 228 KHz sawtooth pulse having an amplitude of about three volts. A polyethylene target was positioned at the end of the track with the screen boxes immediately preceding (Figures 12 and 13). As in the first test, the results of the second test showed no signal distortion even though the sled impacted the target at about 5550 fps (1692 m/s). A continuous signal with no dropouts or distortions was recorded through the entire length of the screen boxes.

After the two completely successful tests, a third test was planned in which an actual RV nose tip containing a contact fuse would be impacted. For this test, of course, the exact pulse

shape would not be known beforehand, but it was necessary to demonstrate the ability to shock isolate and protect the nose cone and its electronic contents from the track environment and to record an actual fuze output during impact. Some uncertainty in the pulse shape was removed by choosing a nose tip and fuze that had been tested previously under similar circumstances. Figure 14 shows the sled assembly, and Figure 15 depicts the impact target and screen boxes before testing. The sled impacted the target at about 5220 fps (1591 m/s) and, as well as can be determined, the nose cone survived the track environment and the screen box data system worked without error. No noise from the screen box system was present before impact, and the impact pulse appeared intact with no dropouts or unexpected deviations.

## Conclusions

Based on a vast log of past experience using screen boxes to supply electrical communication with rocket sleds traveling at velocities up to Mach 3.5 and three highly successful high frequency data tests at speeds near Mach 5, it is believed that high frequency data generated during a rocket sled impact of any velocity achievable at Sandia can be transmitted to recording stations through a conventional rocket sled screen box system. It has been shown that the presence of a rocket sled traveling at hypersonic velocities through a screen box does not degrade, distort, or otherwise alter data being transmitted through the screen box. Additionally, no dropouts or loss of signal of any type was in evidence while using screen boxes as data links.

Between the completion of the test series described above and the publication of this report, six additional RV contact fuse tests were conducted using the screen box technique to record fuse output during impact. Velocities ranged from 2575 fps (785 m/s) to 5456 fps (1663 m/s), and all data were successfully recovered using screen boxes.

Though valuable for certain types of testing, screen boxes do have limitations as data transmitting devices. For one thing, without multiplexing, the number of data channels that can be accommodated is limited by the number of screen boxes and cutter bar combinations that can be fitted. Additionally, the system does not lend itself to situations where data must be recorded over a long period of sled travel in that, a continuous screen box over the entire area would be needed. Standard impact testing, however, can be handled effectively with this technique.

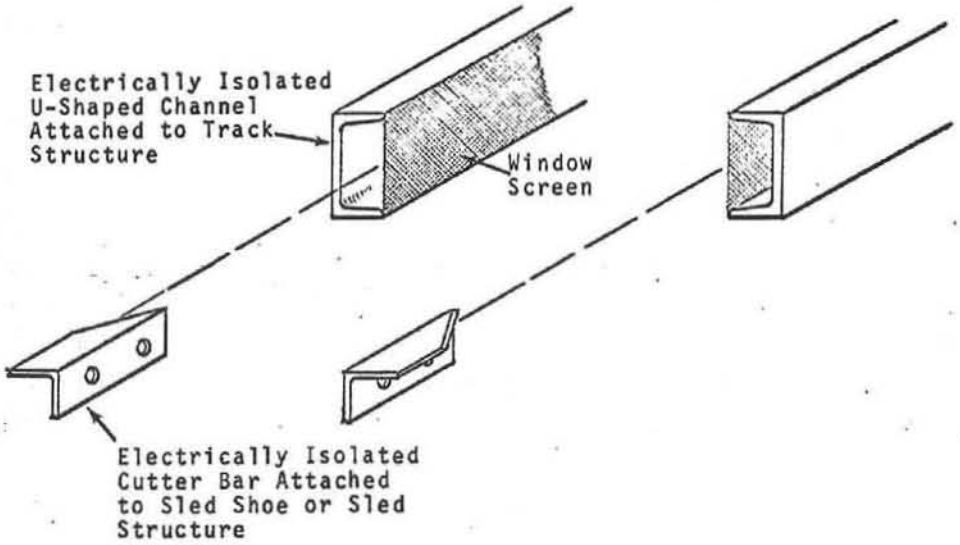



Figure 1. Screen Box System

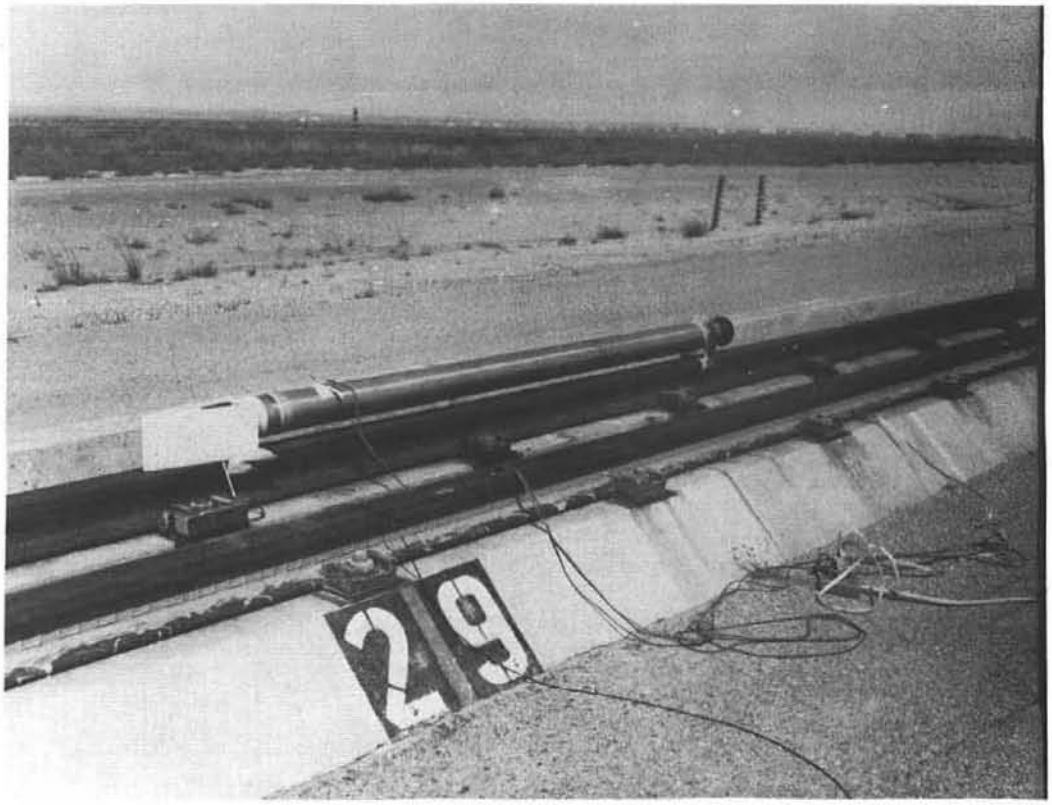



Figure 2. Rocket Sled for Preliminary Sled Test

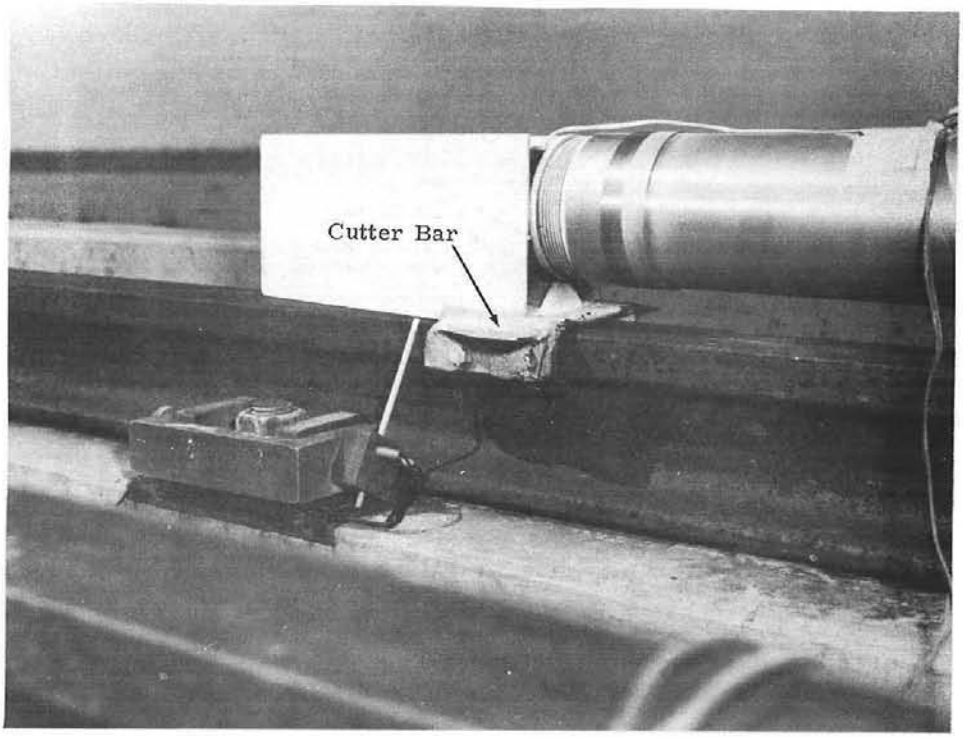



Figure 3. Rocket Sled for Preliminary Sled Test

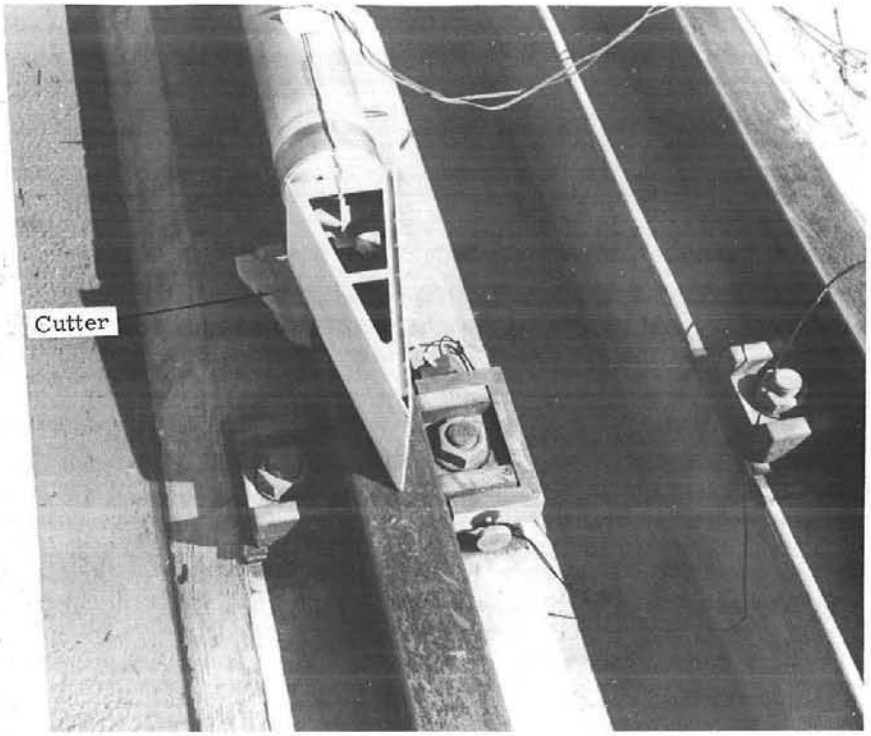



Figure 4. Rocket Sled for Preliminary Sled Test

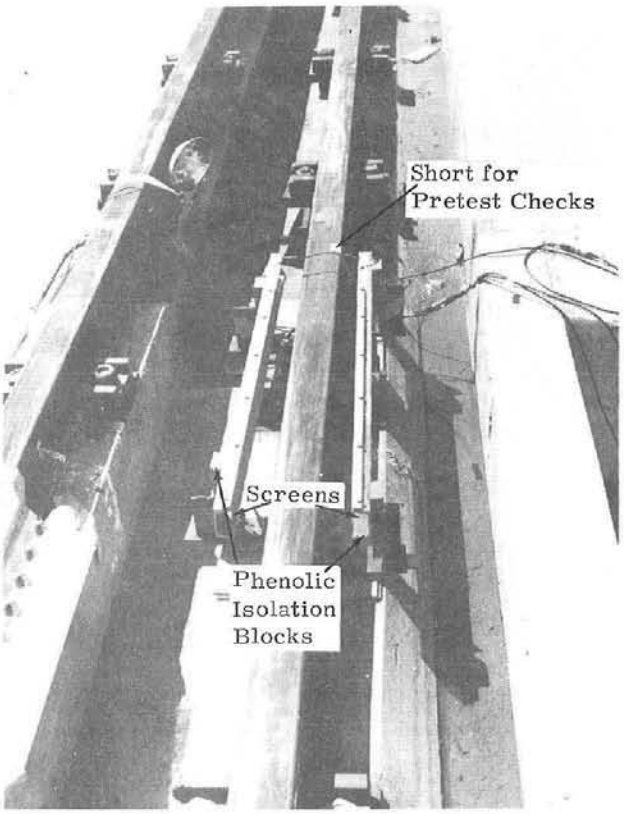



Figure 5. Screen Box Before Preliminary Sled Test

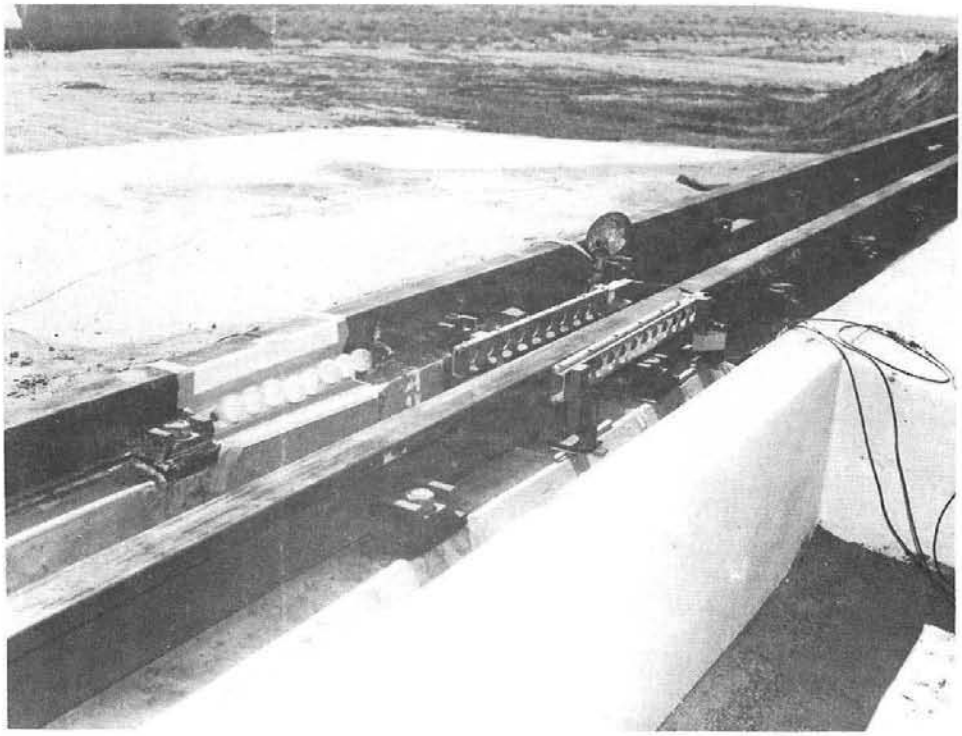
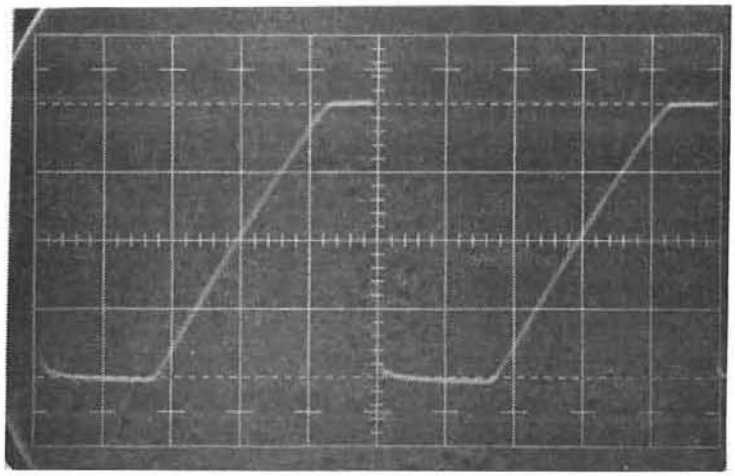
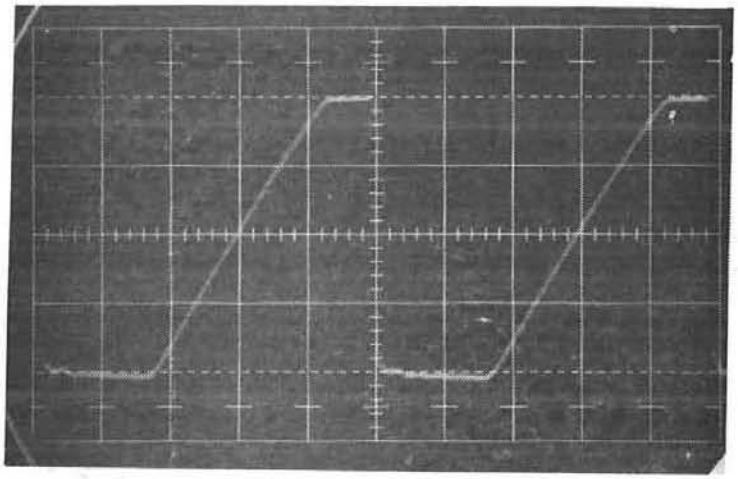


Figure 6. Screen Box Before Preliminary Sled Test



Pretest Data
2 $\mu$sec/cm, 1V/cm



Test Data
2 $\mu$sec/cm, 1V/cm

Figure 7. Pretest and Test Data

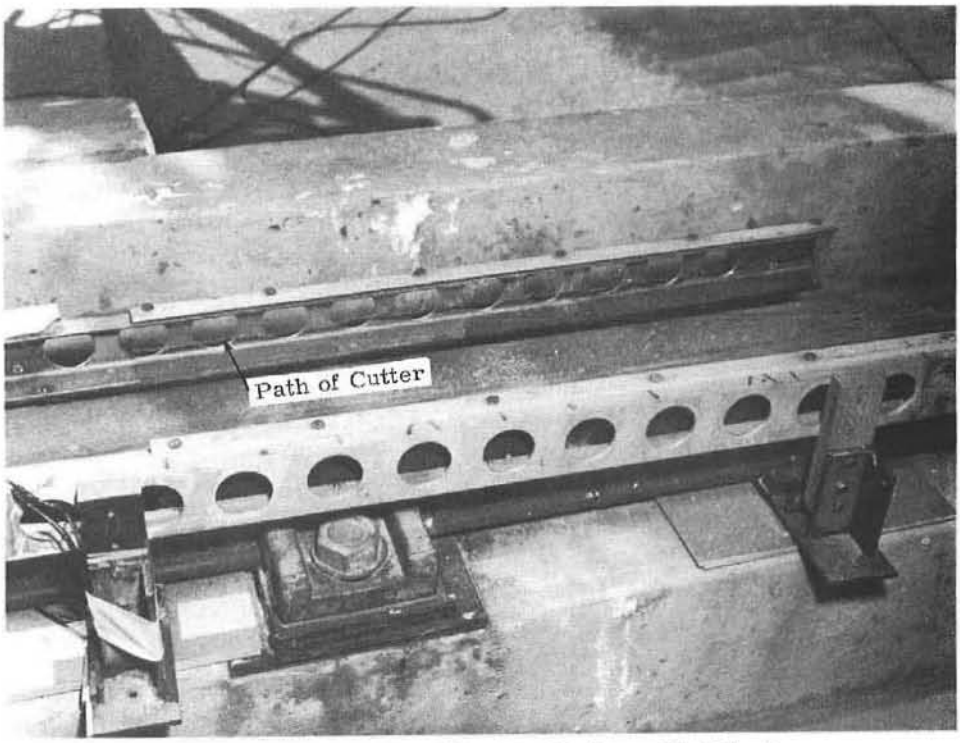



Figure 8. Screen Box After Preliminary Sled Test

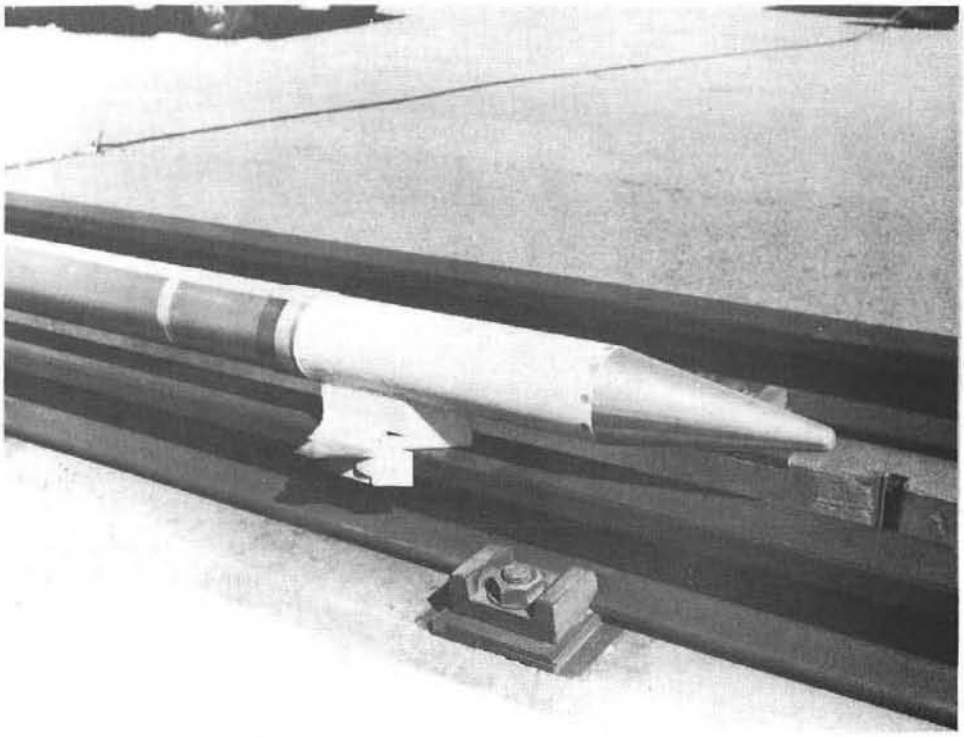


Figure 9. Rocket Sled Before Second Test

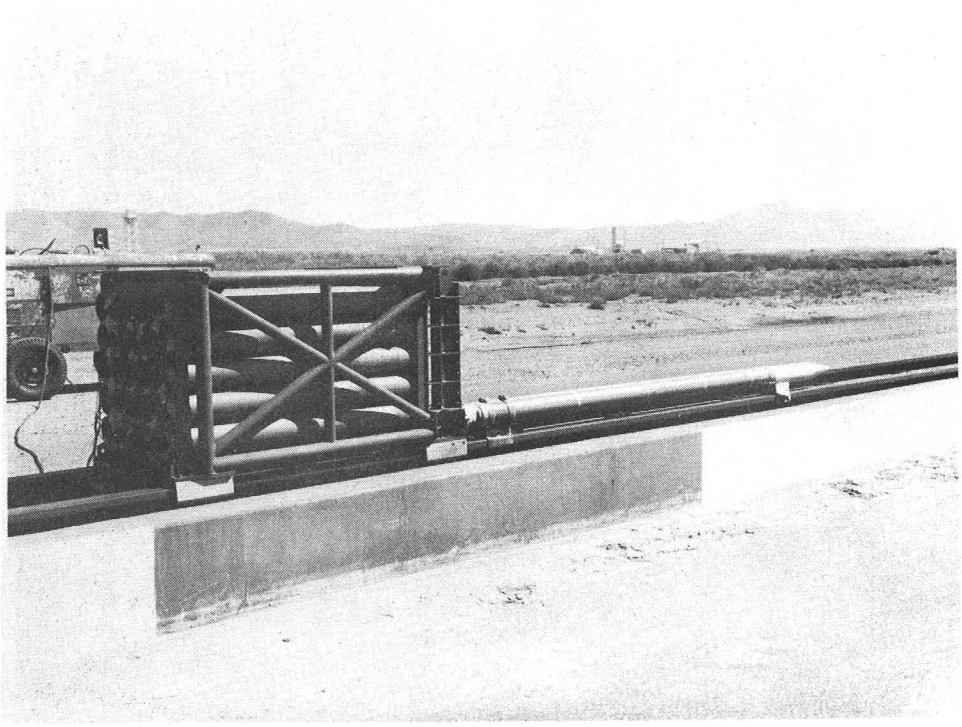


Figure 10. Rocket Sled and Pusher Before Second Test

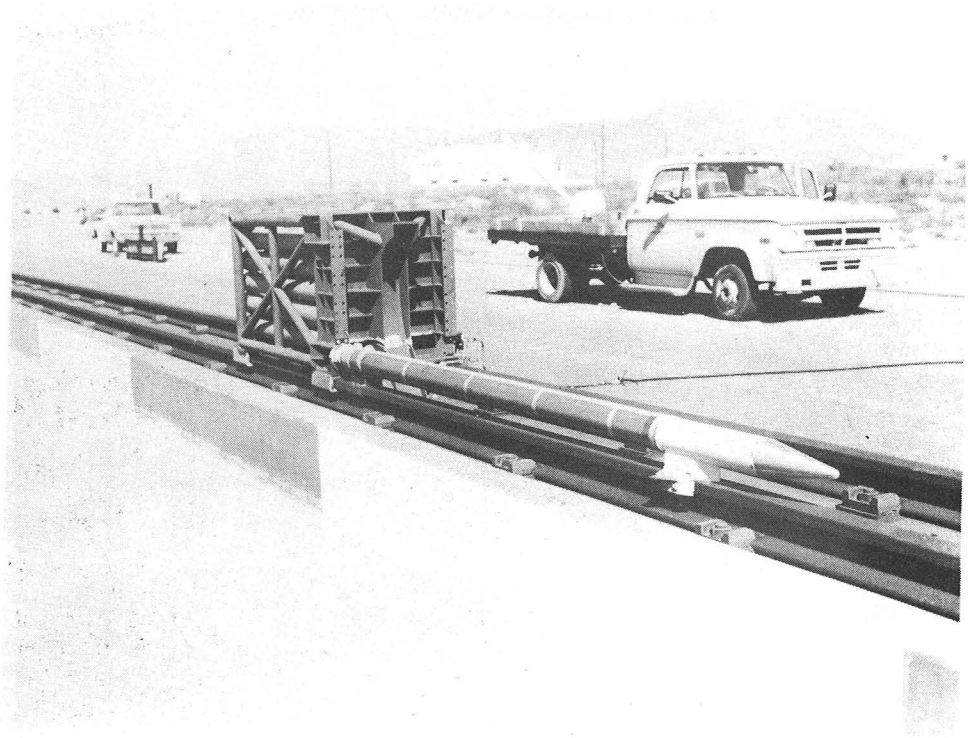


Figure 11. Rocket Sled and Pusher Before Second Test

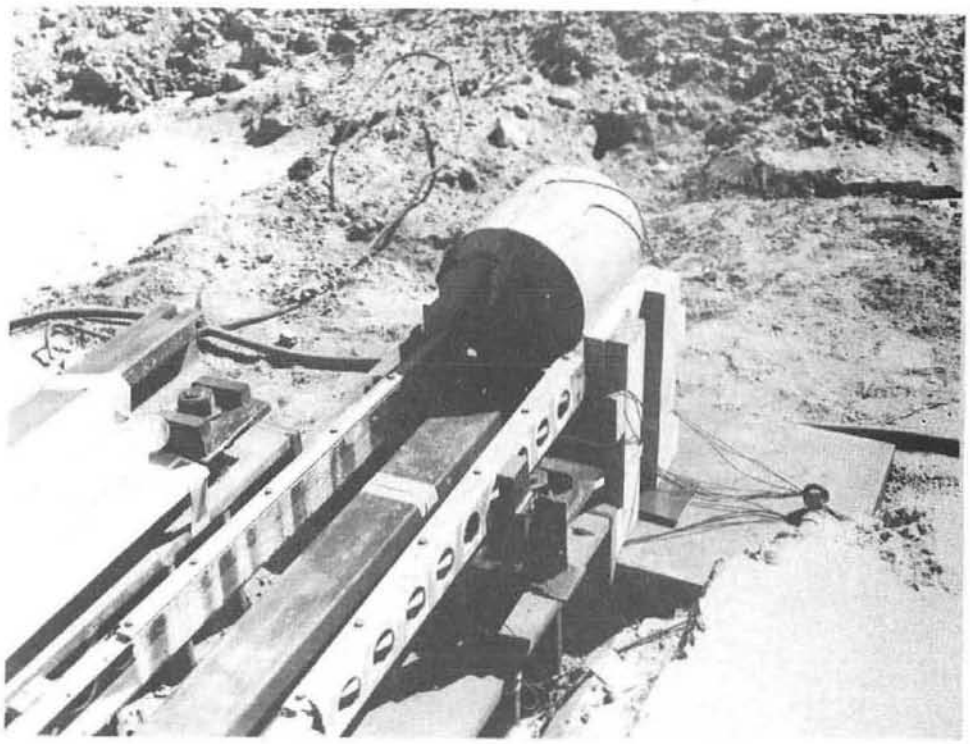


Figure 12. Screen Boxes and Target Before Second Test

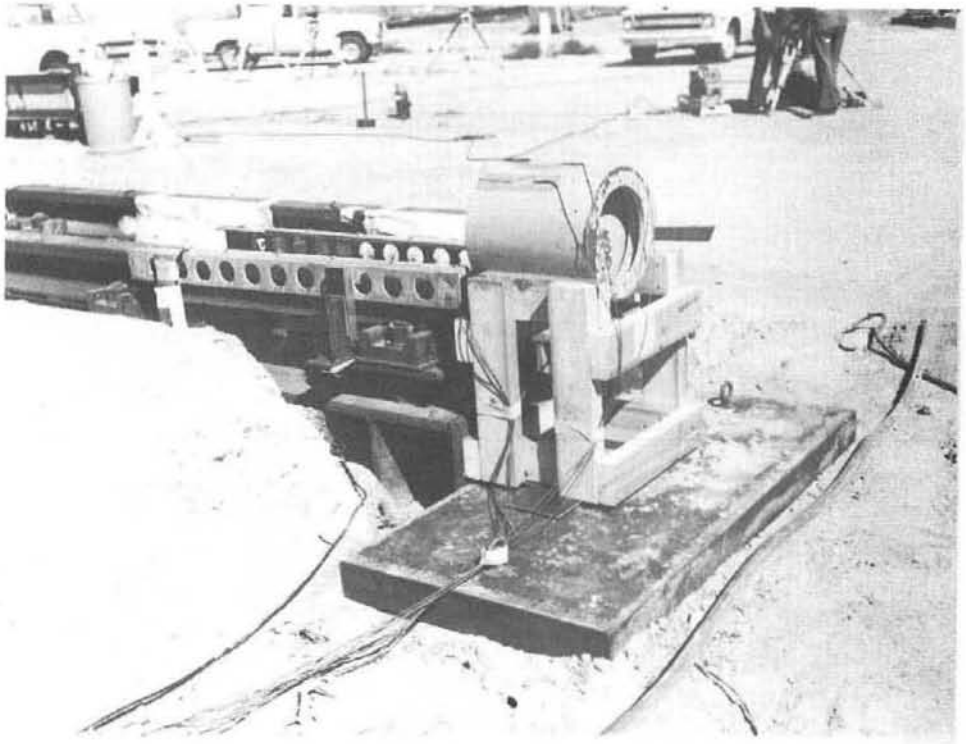


Figure 13. Screen Boxes and Target Before Second Test

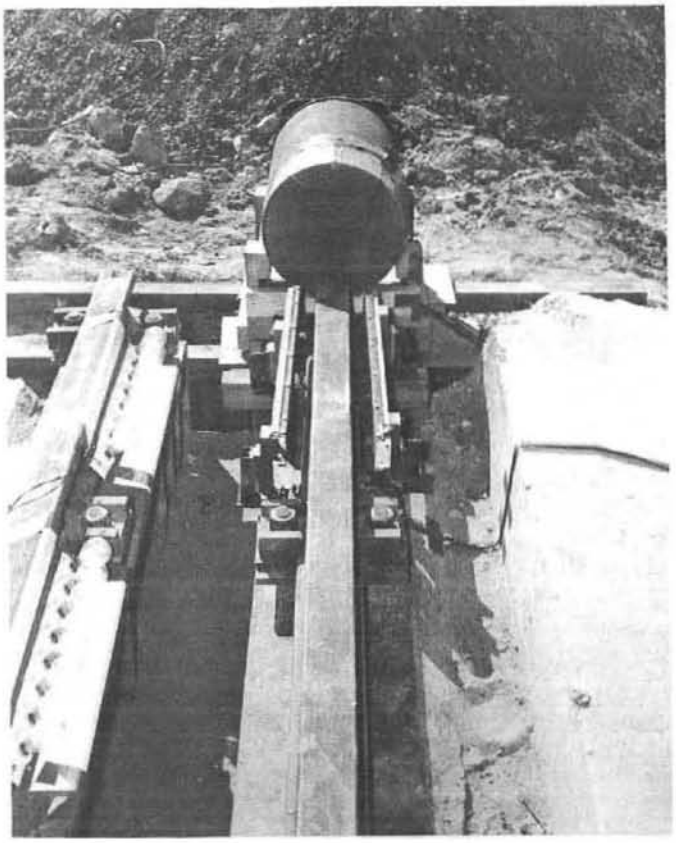


Figure 14. Screen Boxes and Target Before Final Test

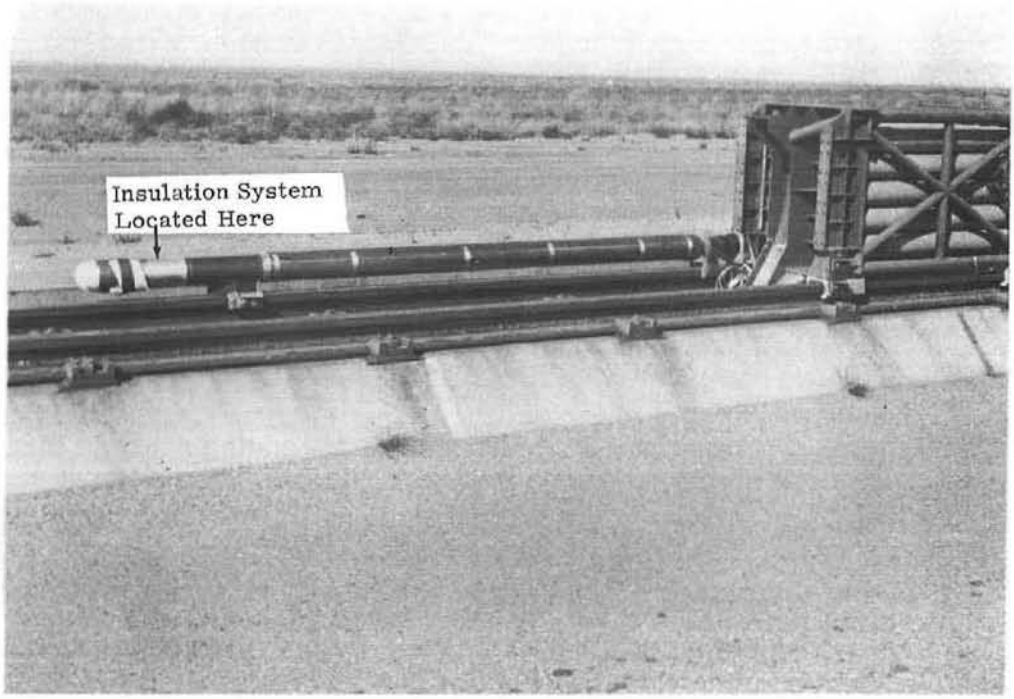



Figure 15. Rocket Sled and Pusher Before Final Test

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