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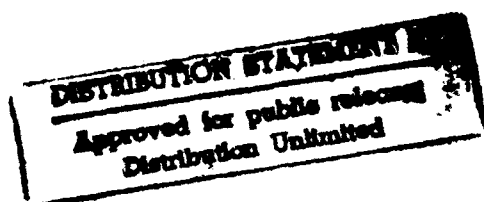


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FINAL REPORT
AUGUST 1990

REPORT NO. EVT 14-90

RAIL IMPACT TEST
OF
ROTARY TOWED SWEEPER



Prepared for:
U.S. Army Tank-Automotive Command
ATTN: AMSTA-ISFC
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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639



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FIELD	GROUP	SUB-GROUP				
19. ABSTRACT (Continue on reverse if necessary and identify by block number) The U. S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U. S. Army Tank-Automotive Command to rail impact test per MIL-STD-810D, Military Standard Environmental Test Methods and Engineering Guidelines, the rotary towed sweeper, manufactured by M-B Company, Incorporated, New Holstein, WI. Two MIL-STD-810D rail impact tests were performed on the rotary towed sweeper. While tying down the rotary towed sweeper for the first test, the forward tiedown provision bent. This was a failure of the provision. The sweeper was sent back to the factory and returned to USADACS on 20 August 1990 for retesting. The sweeper was tied to a flatcar with wire rope and subjected to 4, 6, and 8 mph impacts in one direction, and then the flatcar was turned 180 degrees and singly impacted at 8 mph. Cable tensions were monitored during this test. Tiedown provisions were also statically loaded to verify (continued)						
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19. ABSTRACT (continued)

conformance with MIL-STD-209G, Military Standard Slings and Tiedown Provisions for Lifting and Tying Down Military Equipment. Results of these tests are included in this report. The rotary towed sweeper passed all rail impact tests.

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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NUMBER EVT 14-90

RAIL IMPACT TEST OF ROTARY TOWED SWEEPER

AUGUST 1990

TABLE OF CONTENTS

PART	PAGE NO.
1. INTRODUCTION	1-1
A. BACKGROUND.....	1-1
B. AUTHORITY	1-1
C. OBJECTIVE.....	1-1
D. CONCLUSION	1-1
2. ATTENDEES	2-1
3. TEST PROCEDURES	3-1
4. TEST RESULTS.....	4-1
5. PHOTOGRAPHS	5-1
6. TEST DATA.....	6-1

PART 1

INTRODUCTION

A. **BACKGROUND.** The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Tank-Automotive Command to rail impact test the rotary towed sweeper, manufactured by M-B Company, Incorporated, New Holstein, WI. Two MIL-STD-810D, Military Standard Environmental Test Methods and Engineering Guidelines, rail impact tests were performed on the rotary towed sweeper. While tying down the sweeper for the first test, the forward tiedown provision bent. This was a failure of the provision. The sweeper was sent back to the factory and returned to USADACS on 20 August 1990 for retesting. The sweeper was tied to a flatcar with wire rope and subjected to 4, 6, and 8 mph impacts in one direction, and then the flatcar was turned 180 degrees and singly impacted at 8 mph. Cable tensions were monitored during this test. Tiedown provisions were also statically loaded to verify conformance with MIL-STD-209G, Military Standard Slings and Tiedown Provisions for Lifting and Tying Down Military Equipment.

B. **AUTHORITY.** This test was conducted IAW mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL 61299-6000. Reference is made to Change 4, 4 October 1974, to AR 740-1, 23 April 1971, Storage and Supply Operations; AMCCOMR 10-17, 13 January 1986, Mission and Major Functions of U.S. Army Defense Ammunition Center and School.

C. **OBJECTIVE.** The objective of this test was to determine if the rotary towed sweeper meets the test requirements of MIL-STD-810D and MIL-STD-209G.

D. CONCLUSION. The rotary towed sweeper was tested twice. The first rail impact test resulted in a deformed tiedown provision. For the second test with a redesigned tiedown provision, the rotary towed sweeper passed the MIL-STD-810D rail impact test and the test requirements of MIL-STD-209G.

PART 2

ATTENDEES

1 AND 21 AUGUST 1990

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PART 3

TEST PROCEDURES

A. Rail Impact Test.

1. Test Load (specimen). The rotary towed sweeper test load was prepared for rail testing IAW manufacturer's instructions. The sweeper was then loaded onto the railroad flatcar and, using the blocking and bracing methods specified in the outloading procedures in figures 1 and 2, secured to the flatcar. The railcar used in the test was inspected to ensure its adequacy for transportation.

2. Rail Impact Procedure. The test load was positioned on a railcar. Equipment needed to perform the test included the specimen (hammer) car, five empty railroad cars connected together to serve as the anvil, and a railroad locomotive (figure 3). These anvil cars were positioned on a level section of track with air and hand brakes set and with the draft gears compressed. The locomotive unit pulled the specimen car several hundred yards away from the anvil cars, then pushed the specimen car toward the anvil at a predetermined speed, and disconnected from the specimen car approximately 50 yards away from the anvil cars. This allowed the specimen car to roll freely along the track until it struck the anvil. This constituted an impact. Impacting is accomplished at speeds of 4, 6, and 8 mph in one direction and at a speed of 8 mph in the opposite direction. The 4 and 6 mph impact speeds are approximate; the 8 mph speed is a minimum. Impact speeds are to be determined by using an electronic counter to measure the time required for the specimen car to traverse an 11-foot distance immediately prior to contact with the anvil cars.

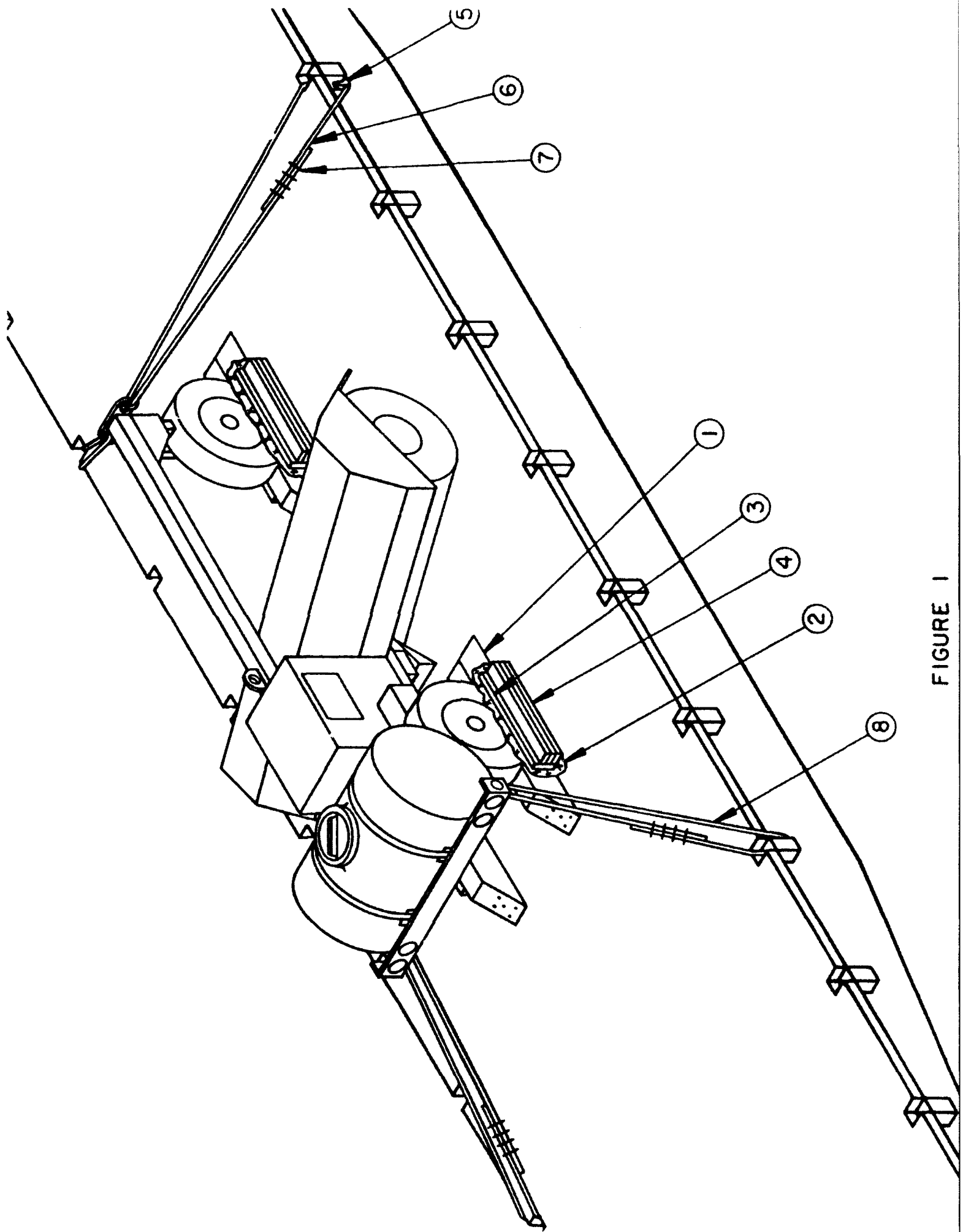


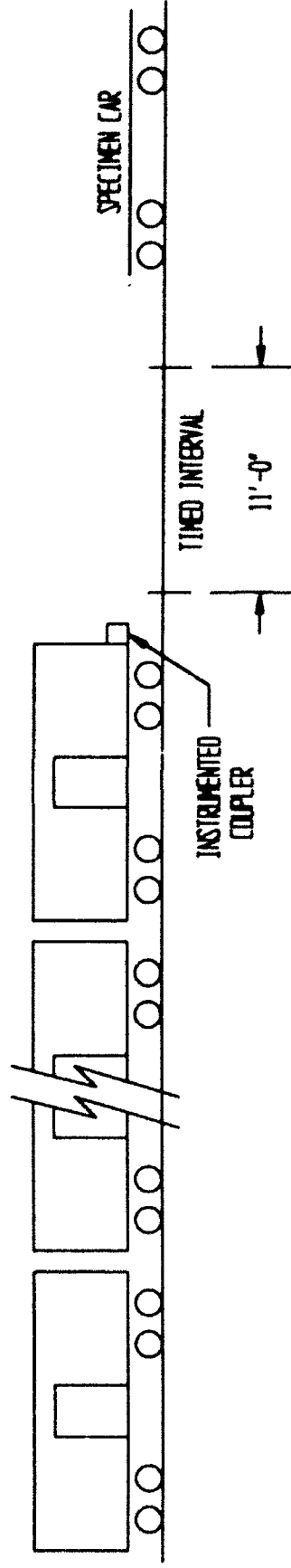
FIGURE 1

KEY NUMBERS

- ① CHOCK BLOCK (6 REQUIRED). 24" LONG BY 6" WIDE BY 8" HIGH. LOCATE 45 DEGREE END OF BLOCK AGAINST WHEEL. NAIL THROUGH HEEL OF BLOCK W/3-40d NAILS AND 2-60d NAILS. NAIL EACH SIDE TO THE CAR FLOOR W/2-40d NAILS.
- ② ANTI-CHAFING WATER-PROOF PAPER OF A SUFFICIENT SIZE TO POSITION UNDER AND EXTEND 2" ABOVE PIECE MARKED ③.
- ③ RUBBING STRIP, 2" BY 6" BY 30" (4 REQUIRED). POSITION ON EDGE AND NAIL TO LOWER PIECE MARKED 4 W/1-12d NAIL EVERY 8".
- ④ SIDE BLOCKING, 2" BY 4" BY 30" (TRIPLED) (4 REQUIRED). NAIL FIRST PIECE TO CAR FLOOR W/1-20d NAILS, EVERY 8". NAIL EACH ADDITIONAL PIECE IN THE SAME MANNER.
- ⑤ THIMBLE, STANDARD, SIZE 3/8" (8 REQUIRED). USE ONE PER STAKE POCKET AND ONE PER LADING TIE-DOWN AND/OR LIFTING DEVICE.
- ⑥ FRONT TIEDOWN, 3/8" DIAMETER STEEL WIRE ROPE, 24'-0" LONG (2 REQUIRED). INSTALL THE CABLE ANGULARLY, AS SHOWN, TO FORM A COMPLETE LOOP FROM THE STAKE POCKET ON THE CAR TO THE LADING TIEDOWN DEVICE AND BACK TO THE STAKE POCKET.
- ⑦ CLIP, SIZE 3/8" (16 REQUIRED). APPLY FOUR CLIPS PER CABLE JOINT.
- ⑧ REAR TIE-DOWN, 3/8" DIAMETER STEEL WIRE ROPE, 18'-0" LONG. SECURE IN THE SAME MANNER AS PIECE MARKED ⑥.

FIGURE 2

ASSOCIATION OF AMERICAN RAILROADS (AAR) STANDARD TEST PLAN



5 BUFFER CARS (ANVIL) WITH DRAFT GEAR
COMPRESSED AND AIR BRAKES IN A SET
POSITION
ANVIL CARS TOTAL WT 250,000 LBS (APPROX)

SPECIMEN CAR
IS RELEASED BY
SWITCH ENGINE TO

ATTAIN: IMPACT NO. 1 @ 4 MPH
IMPACT NO. 2 @ 6 MPH
IMPACT NO. 3 @ 8 MPH

THEN THE CAR IS REVERSED AND
RELEASED BY SWITCH ENGINE TO

ATTAIN: IMPACT NO 4. @ 8 MPH

FIGURE 3

B. Securing Provision Tests - MIL-STD-209G.

1. Tiedown Provisions. Class 2 provisions withstood 4.0 times the maximum shipping weight (MSW) in the fore-and-aft direction of the longitudinal axis of the equipment, 2.0 times the MSW in the downward direction of the vertical axis, and 1.5 times the MSW in each direction of the lateral axis. The force applied to each provision was its proportionate share of the MSW. Each load was maintained for a period of not less than 90 seconds. A suitable measuring device (dynamometer or load cell) was placed between the provision and the applied force.

2. Slinging Provisions. The MSW of the rotary towed sweeper is 2,170 pounds. A design load of 2.3 times the working load of each provision is required. The test load was applied to the lifting provision for a period of 90 seconds. A suitable measuring device (dynamometer or load cell) was placed between the provision and the applied force. Test load calculations are shown in figures 4 and 5.

M874 ROTARY TOWED SWEEPER

REAR LIFT PROVISION

DESIGN LOADS

1. DISTANCE FROM FRONT PROVISIONS TO REAR PROVISIONS ALONG CENTERLINE:

96.25 INCHES.

2. DISTANCE FROM FRONT PROVISIONS TO CENTER OF GRAVITY:

90.62 INCHES.

3. GROSS VEHICLE WEIGHT: 2,140 POUNDS.

4. VERTICAL FORCE COMPONENT AT REAR PROVISIONS:

$$V_r = \frac{(90.62)(2,140 \text{ LBS.})}{(96.25)} = 2,024.24 \text{ POUNDS}$$

5. VERTICAL FORCE IS SHARED BY TWO PROVISIONS: $2,024.24/2 = 1,012.12$ POUNDS.

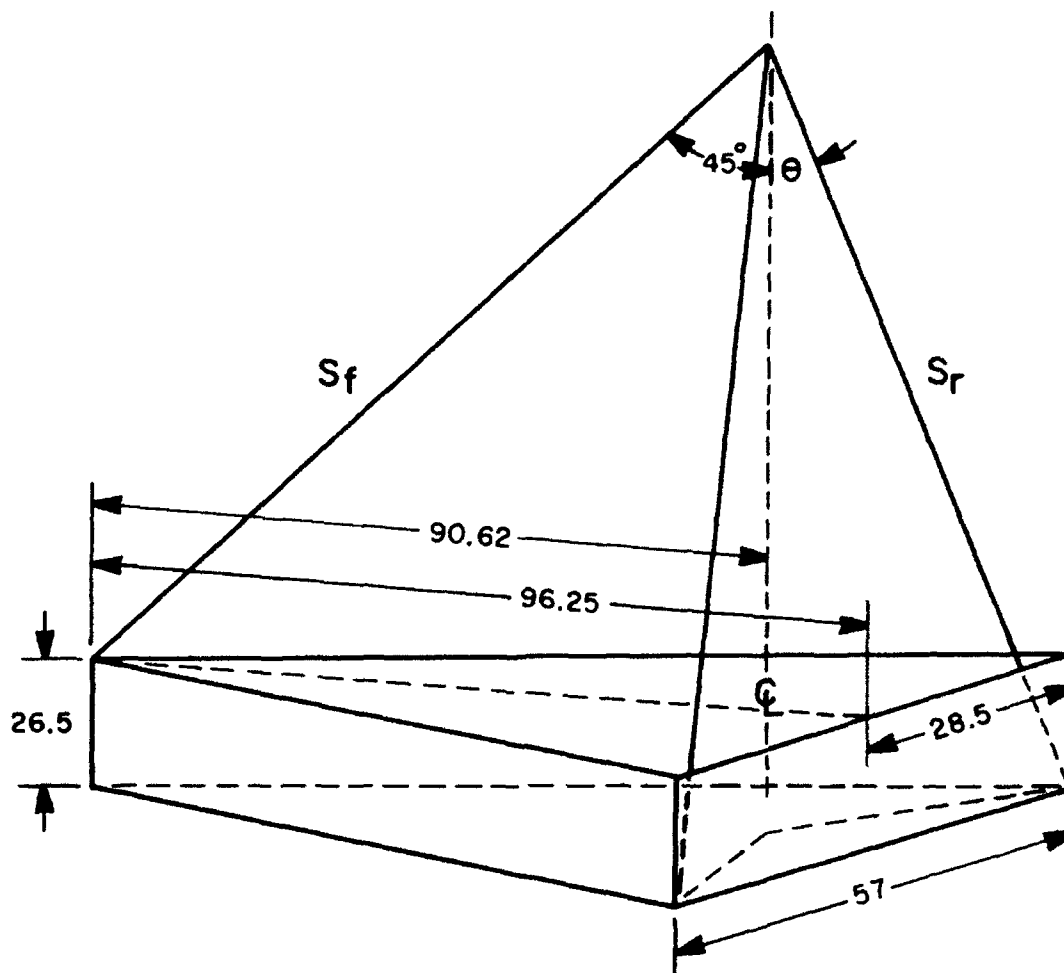
6. RESULTANT FORCE COMPONENT AT 45 DEGREES:

$$R_r = \frac{(1,012.12)}{\cosine 45^\circ} = 1,431.35 \text{ POUNDS}$$

7. DESIGN LOAD = $(1,431.35)(3.2) = 4,580.3$ POUNDS.

8. EACH REAR PROVISION SHOULD BE PULLED AT 45 DEGREES AND HELD AT 4,580 POUNDS FOR 90 SECONDS.

FIGURE 4



$S_f = 128.2$ inches

$S_r = 120.7$ inches

Apex height = 117.1 inches from base of figure

$\theta = 14.1$ degrees

FIGURE 5

PART 4

TEST RESULTS

TEST SPECIMEN AND RESULTS

RAIL IMPACT DATA

Test No.: 1

Load No.:

Date: 1 August 1990

Specimen Load: Rotary Towed Sweeper

Flatcar No.: BN 603022

Lt. Wt.: 55,500 lbs.

Load Type: Rotary Towed Sweeper

Wt.: 2,150 lbs.

Total Specimen Wt.: 57,650 lbs.

Buffer Car (five cars) Wt.: 250,000 lbs.

<u>Impact</u>	<u>End Struck</u>	<u>Velocity (MPH)</u>	<u>Remarks:</u>
1	Towed End	4.9	No load movement.
2	Towed End	6.46	Rear tiedown spread 1/4-inch.
3	Towed End	8.62	Rear tiedown spread an additional 1/8-inch.
4	Tank End	8.56	No additional damage.

The rotary towed sweeper failed rail impact testing. The rear tiedown provision deformed. It was recommended that the tiedown provision be strengthened.

TEST SPECIMEN AND RESULTS

RAIL IMPACT DATA

Test No.: 2

Load No.:

Date: 21 August 1990

Specimen Load: Rotary Towed Sweeper

Flatcar No.: BN 603022

Lt. Wt.: 55,500 lbs.

Load Type: Rotary Towed Sweeper

Wt.: 2,150 lbs.

Total Specimen Wt.: 57,650 lbs.

Buffer Car (five cars) Wt.: 250,000 lbs.

<u>Impact</u>	<u>End Struck</u>	<u>Velocity (MPH)</u>	<u>Remarks:</u>
1	Towed End	4.15	No load movement.
2	Towed End	6.35	No load movement.
3	Towed End	8.62	No load movement.
4	Tank End	8.52	No load movement.

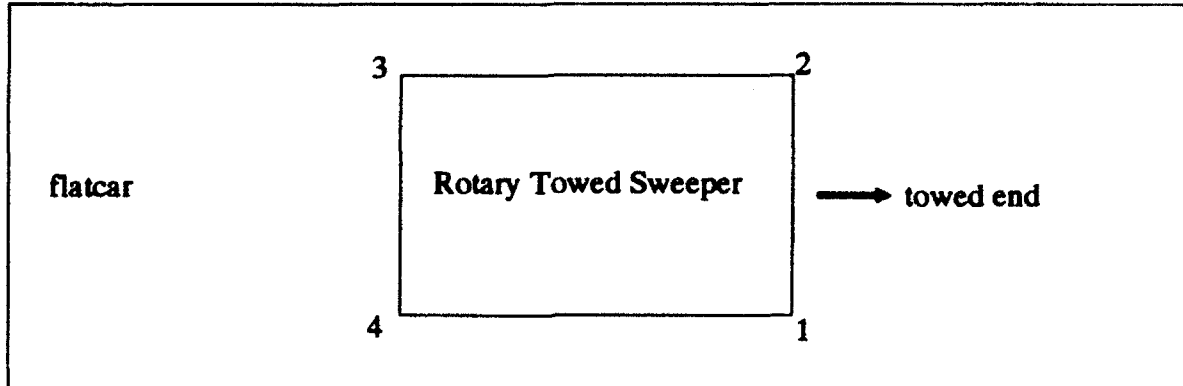
The rotary towed sweeper passed rail impact testing.

MIL-STD-209G pull test of rear provisions. Each provision was pulled to 5,000 pounds and held for a period of 90 seconds. No deformation to the tiedown provisions was observed.

Rotary Towed Sweeper

Tiedown Cable Tension

21 August 1990



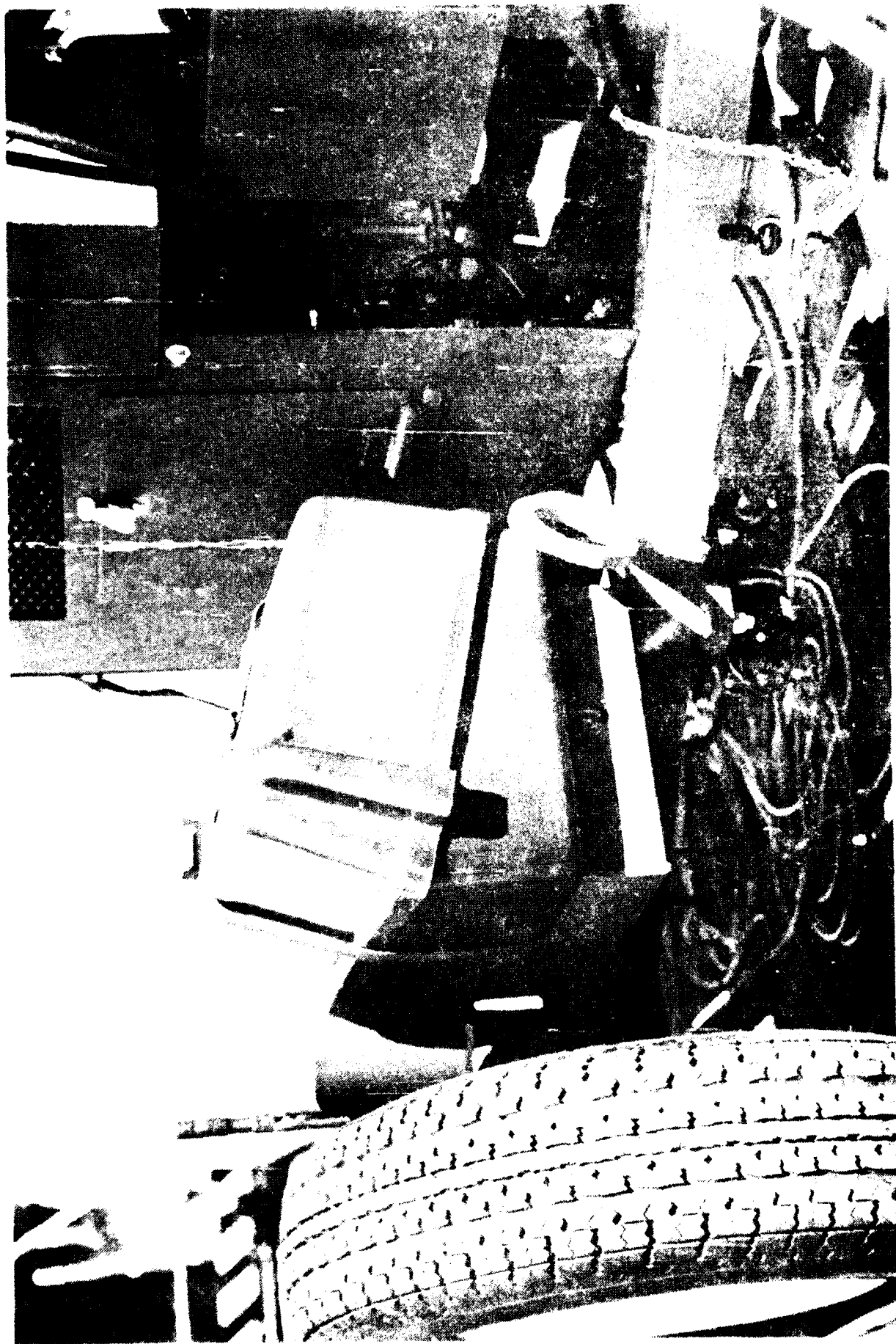
The diagram shows a layout of the rotary towed sweeper positioned on a flatcar. Nos. 1 - 4 label each tiedown cable that secured the sweeper to the flatcar. Cable tension was measured after each impact and is recorded below.

<u>Impact/Cable</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
0	2,600	2,000	1,250	1,300
1	1,350	1,220	1,120	1,110
2	1,100	1,050	1,040	1,070
3	1,050	1,100	880	950
4	800	800	950	1,060

Impact 0 is the tension on each cable before rail impacting the rotary towed sweeper. Impacts nos. 1 - 3 were in the towed direction, impact no. 4 was in the reverse direction. The decrease in cable tension with successive impacts was attributed to the cables cutting into the wooden flatcar deck from the jerk occurring with each impact.

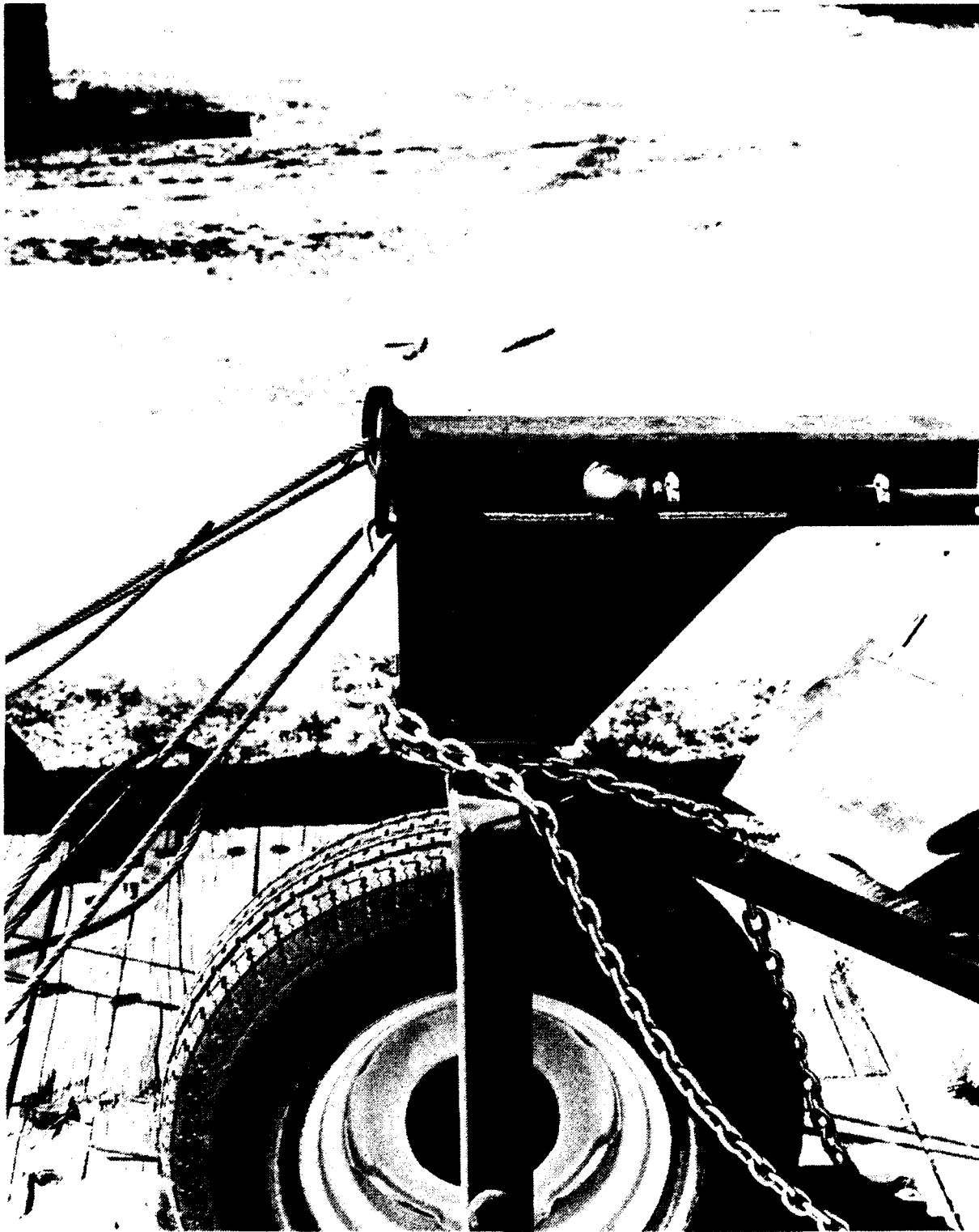
PART 5

PHOTOGRAPHS



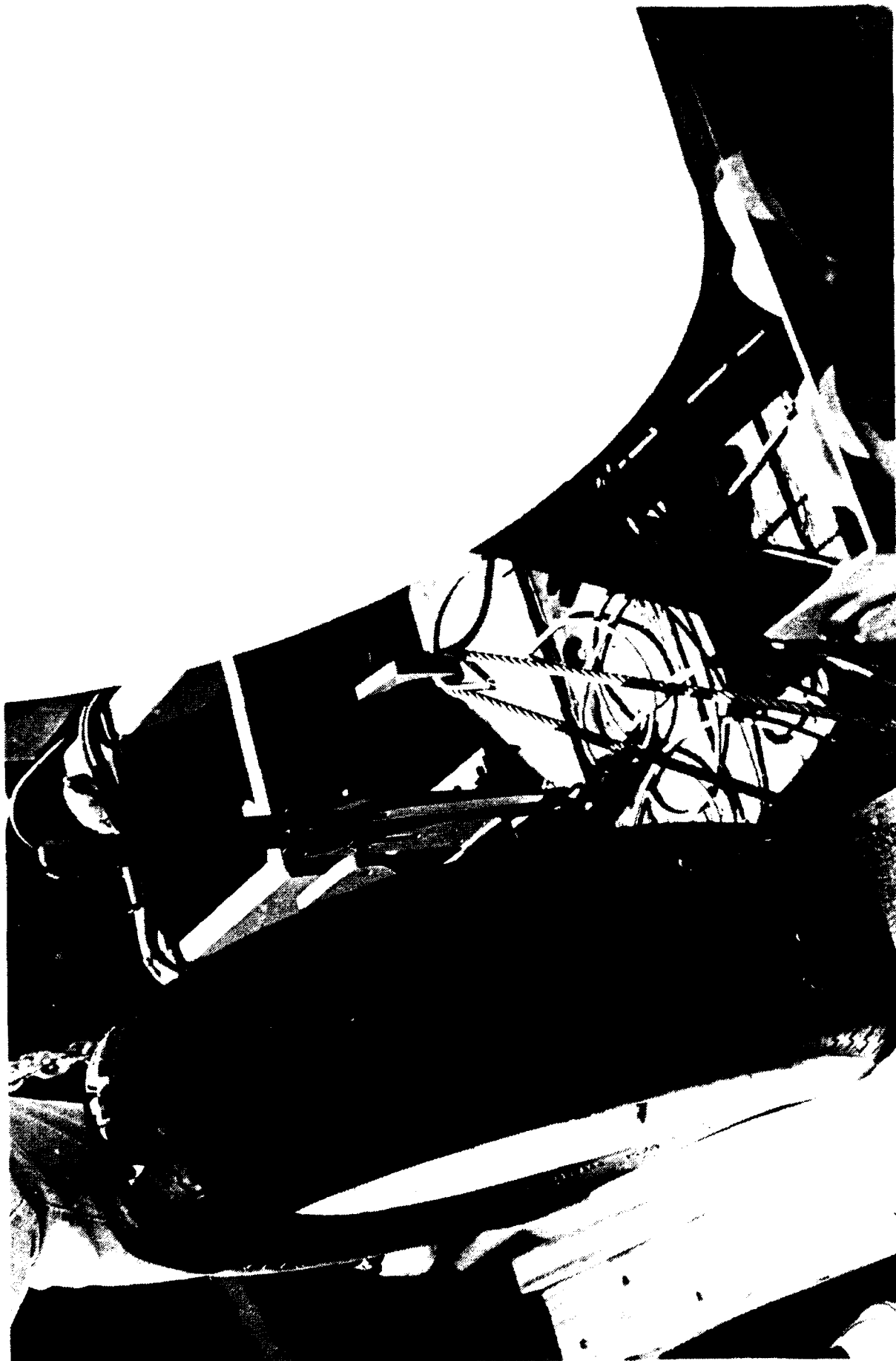
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Photo No. A0317-SPN-90-328-3905. This photo shows the rotary towed sweeper battery case after a rail impact. Tightening the battery case cover strap did not improve holding the cover in its operating position.



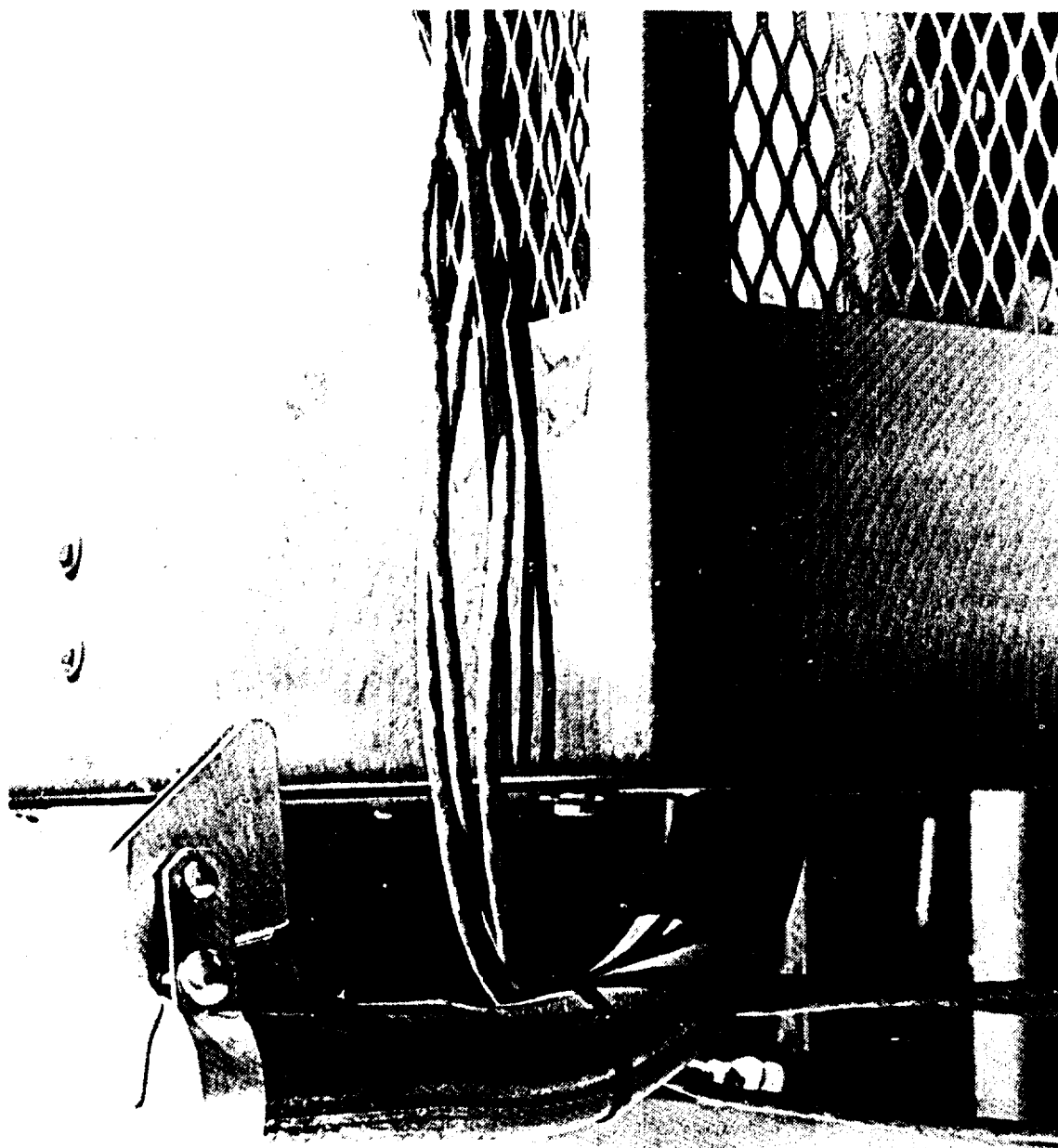
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Photo No. A0317-SPN-90-328-3906. This photo shows the forward tiedown provisions on the towed end of the rotary towed sweeper. Note the deformation of the tiedown. Initial deformation occurred during equipment tie-down. Additional deformation occurred during rail impact testing.



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Photo No. A0317-SPN-90-328-3910. This photo shows the rear tiedown fitting on the rotary towed sweeper. Wire cable is used to secure the sweeper to the railcar. Note the wheel blocking.



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Photo No. A0317-SPN-90-328-3912. This photo shows the exhaust stack from the engine of the rotary towed sweeper. The water tank is to the rear. To access the engine compartment from this side, the metal panel through which the exhaust protrudes must be removed. The wires attached to the exhaust are for test instrumentation and are not a part of the sweeper.



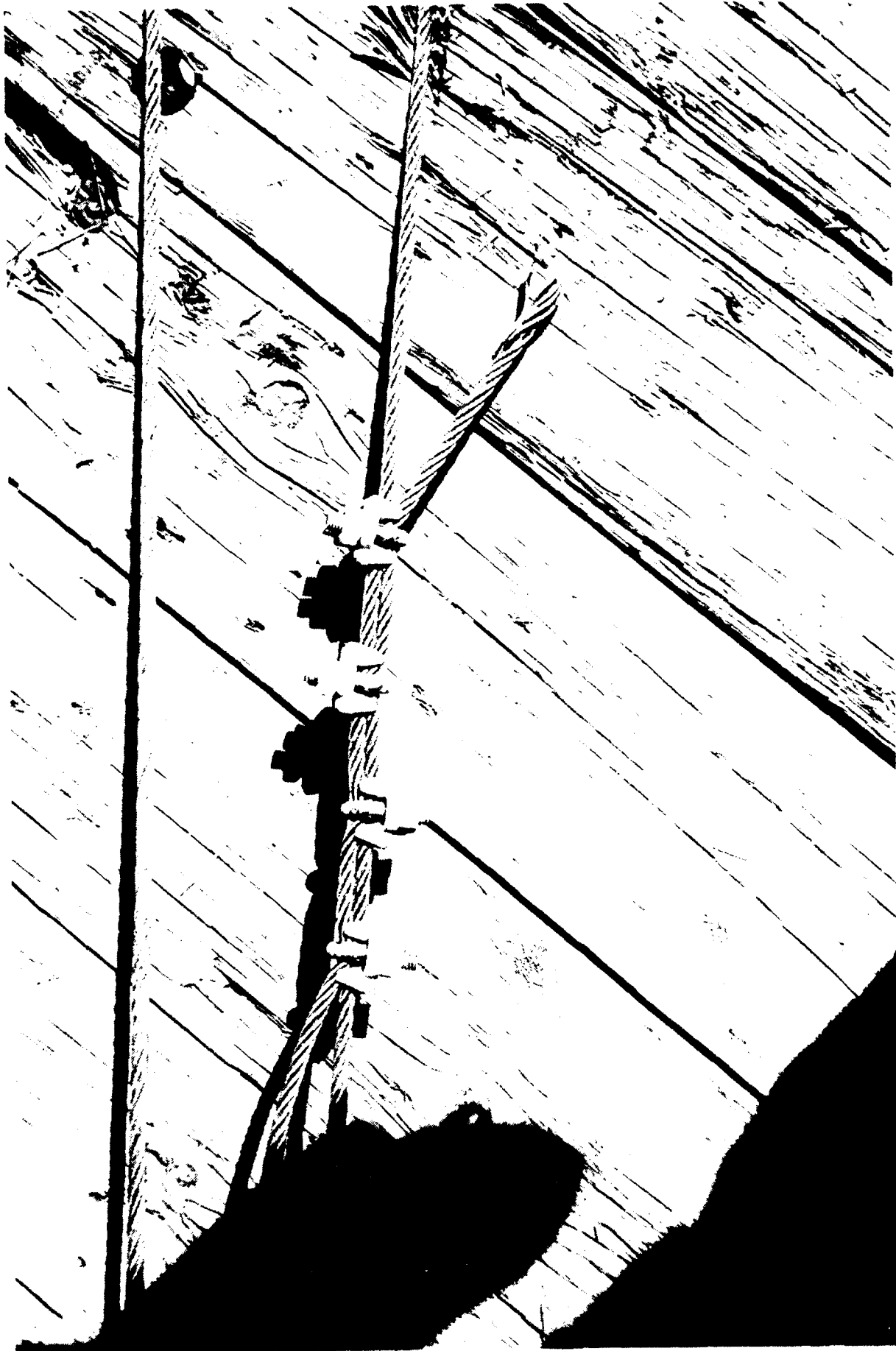
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Photo No. A0317-SPN-90-328-3914. This photo shows a top view of the rear tiedown provision on the rotary towed sweeper. A 3/8-inch cable is used to tie the sweeper to the railcar. Note the set hand brake at the left.



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Photo No. A0317-SPN-90-328-3919. This photo shows the hydraulic power lines and method of securement at the rear of the broom shield. The chain is used to maintain the broom direction (sweep to the right or left) when in use.



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Photo No. A0317-SCN-90-353-5220. This photo shows the cable configuration used in securing the rotary towed sweeper for rail transportation.
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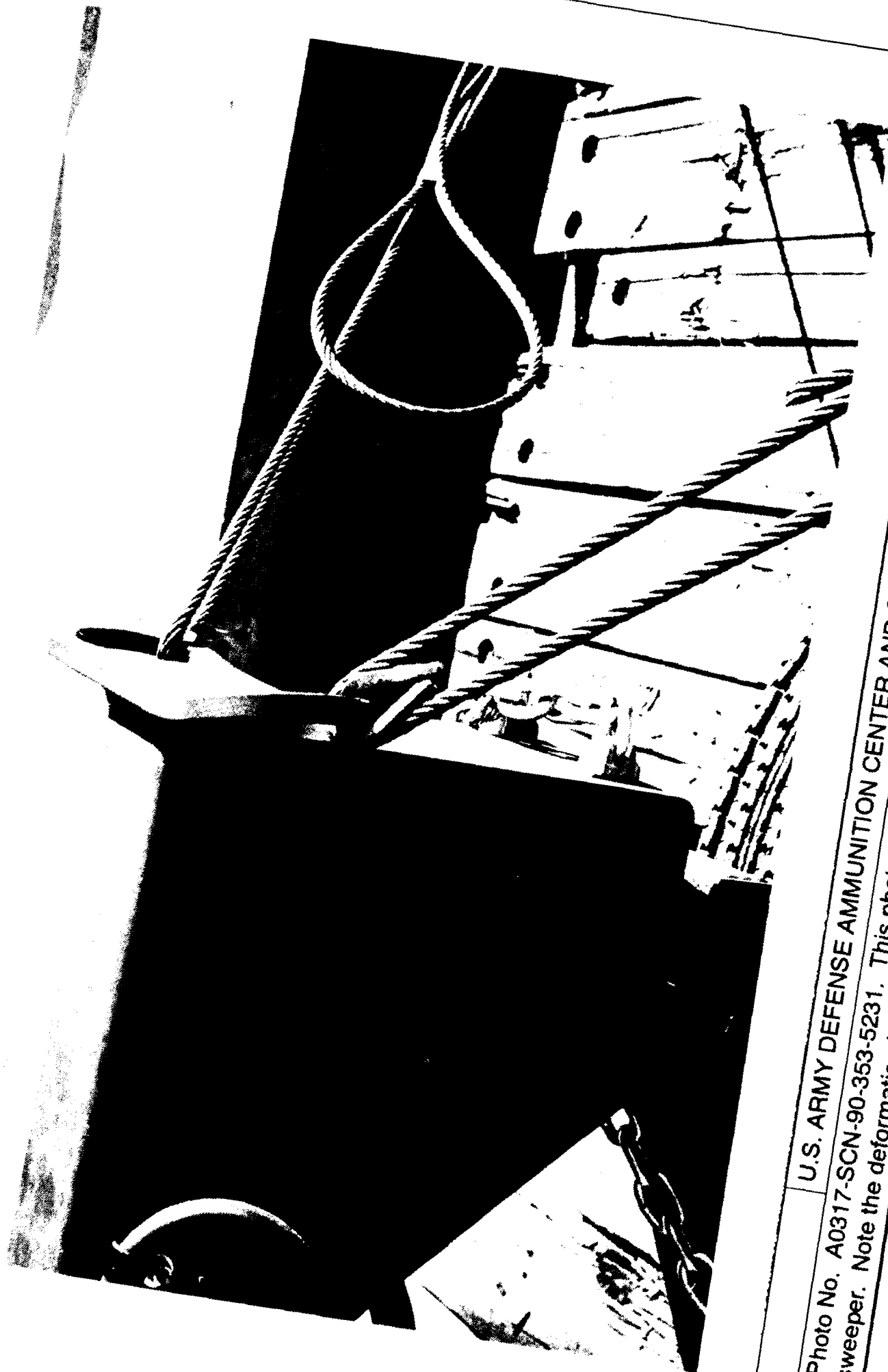
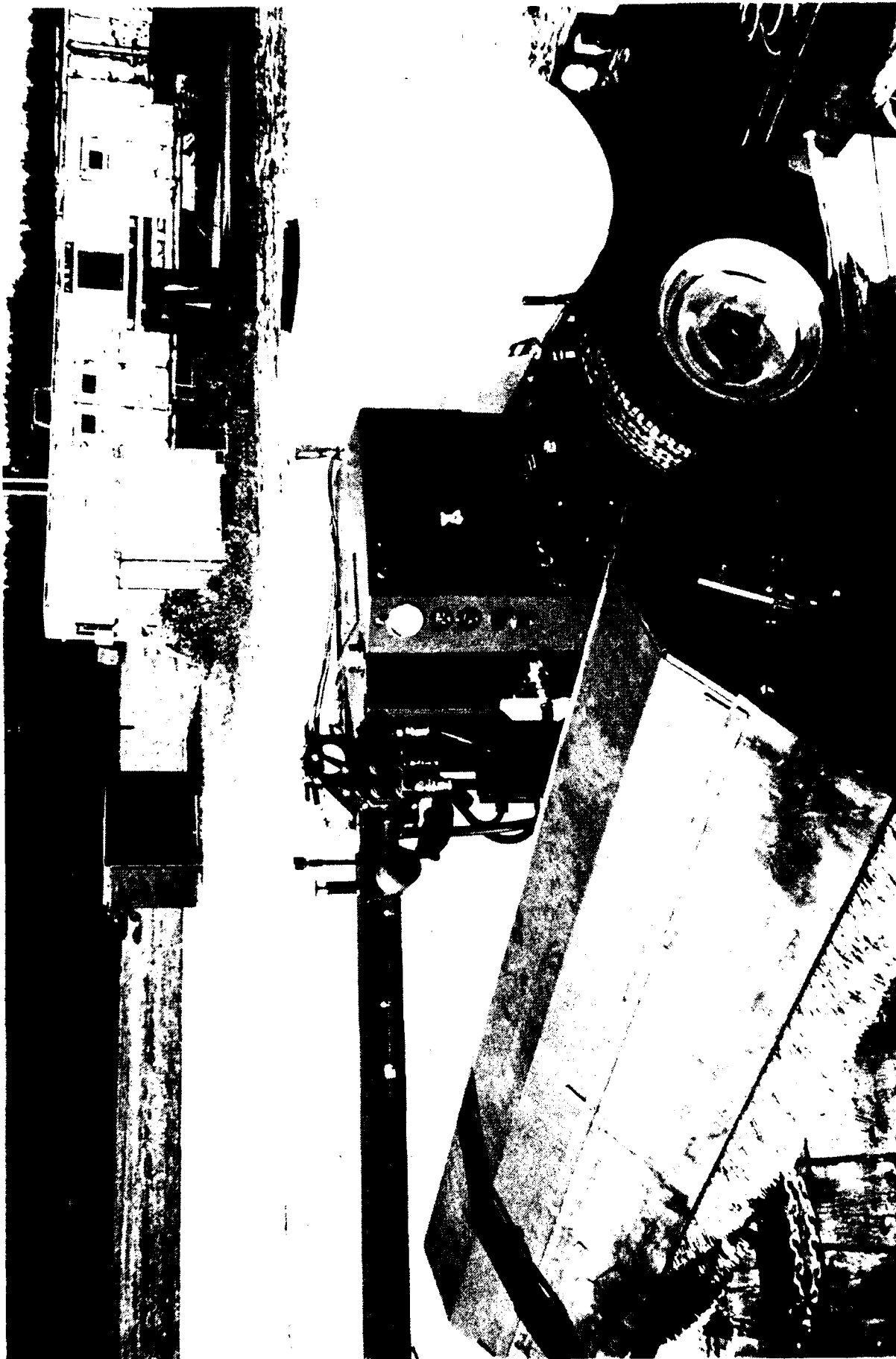


Photo No. A0317-SCN-90-353-5231. This photo shows the towed end tiedown/lifting provision of the rotary towed sweeper. Note the deformation in the provision.	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL
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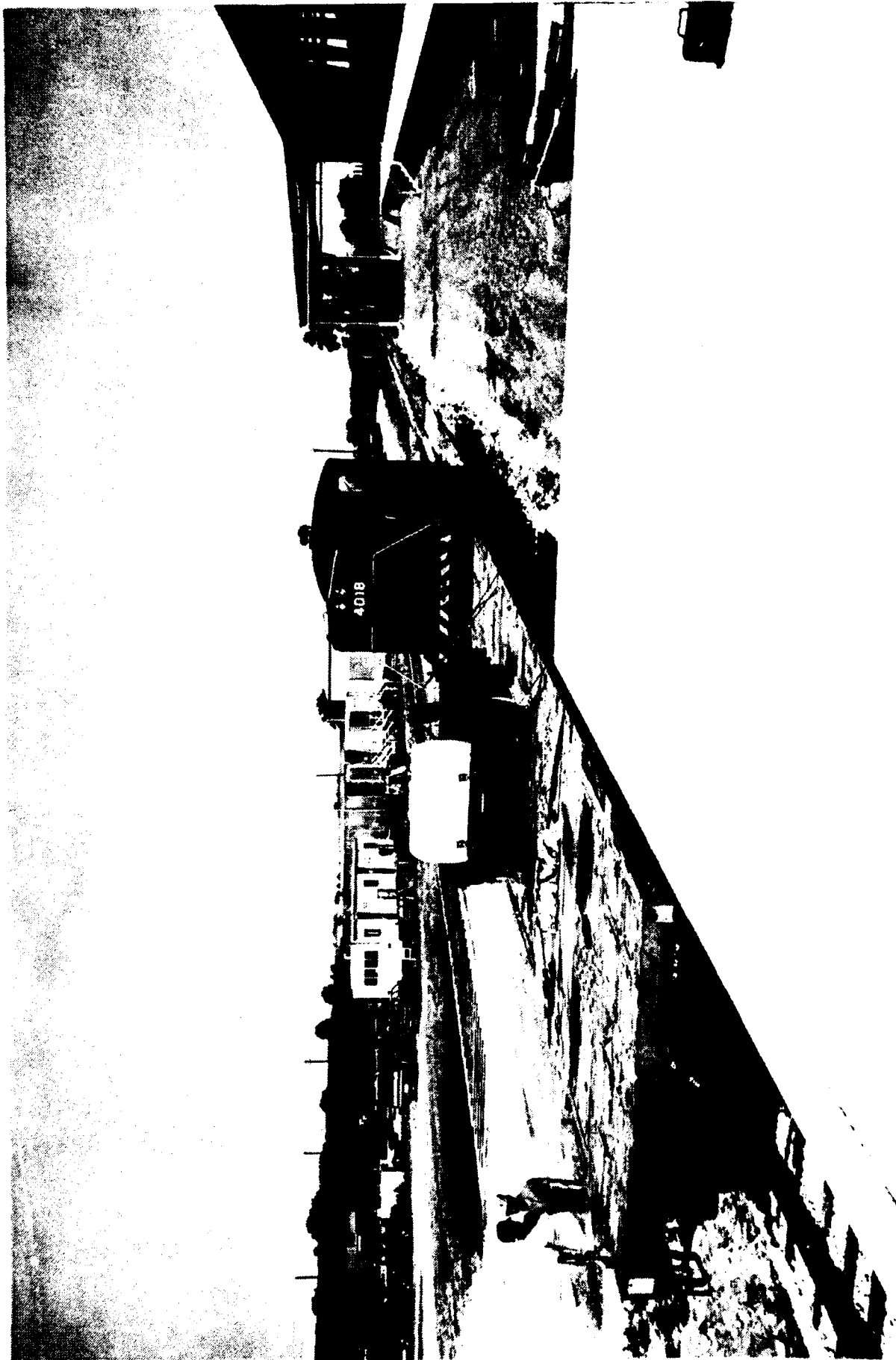
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Photo No. A0317-SCN-90-353-5234. This photo shows a side view of the rotary towed sweeper. The brush is at the left, control panel in the center, and the water tank at the right. Note the wheel side blocking.

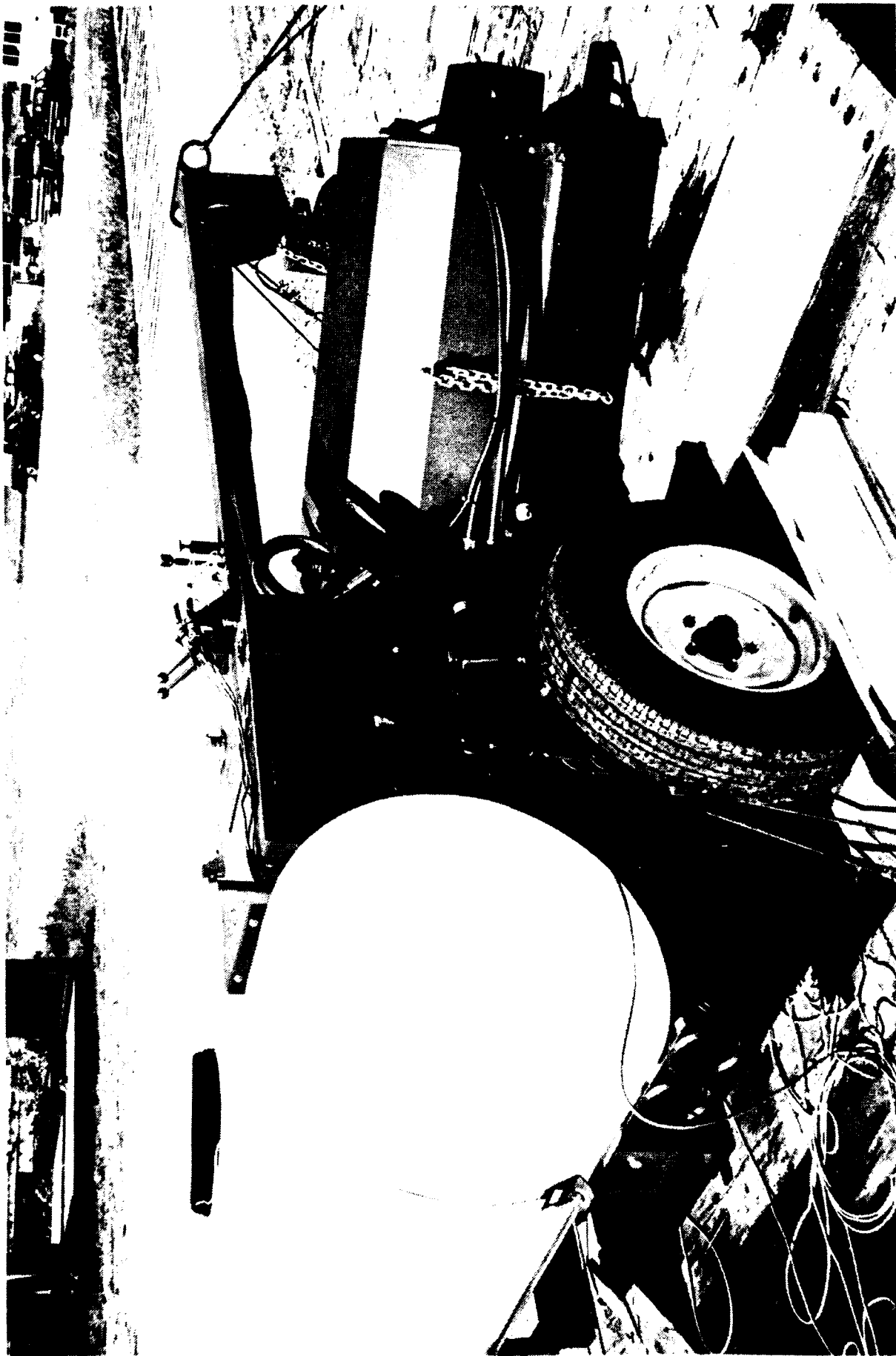


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Photo No. A0317-SCN-90-353-5236. This photo shows a rear view of the rotary towed sweeper. Note the taut tiedown cables holding the sweeper to the railcar. Data recording instrumentation is in the foreground.

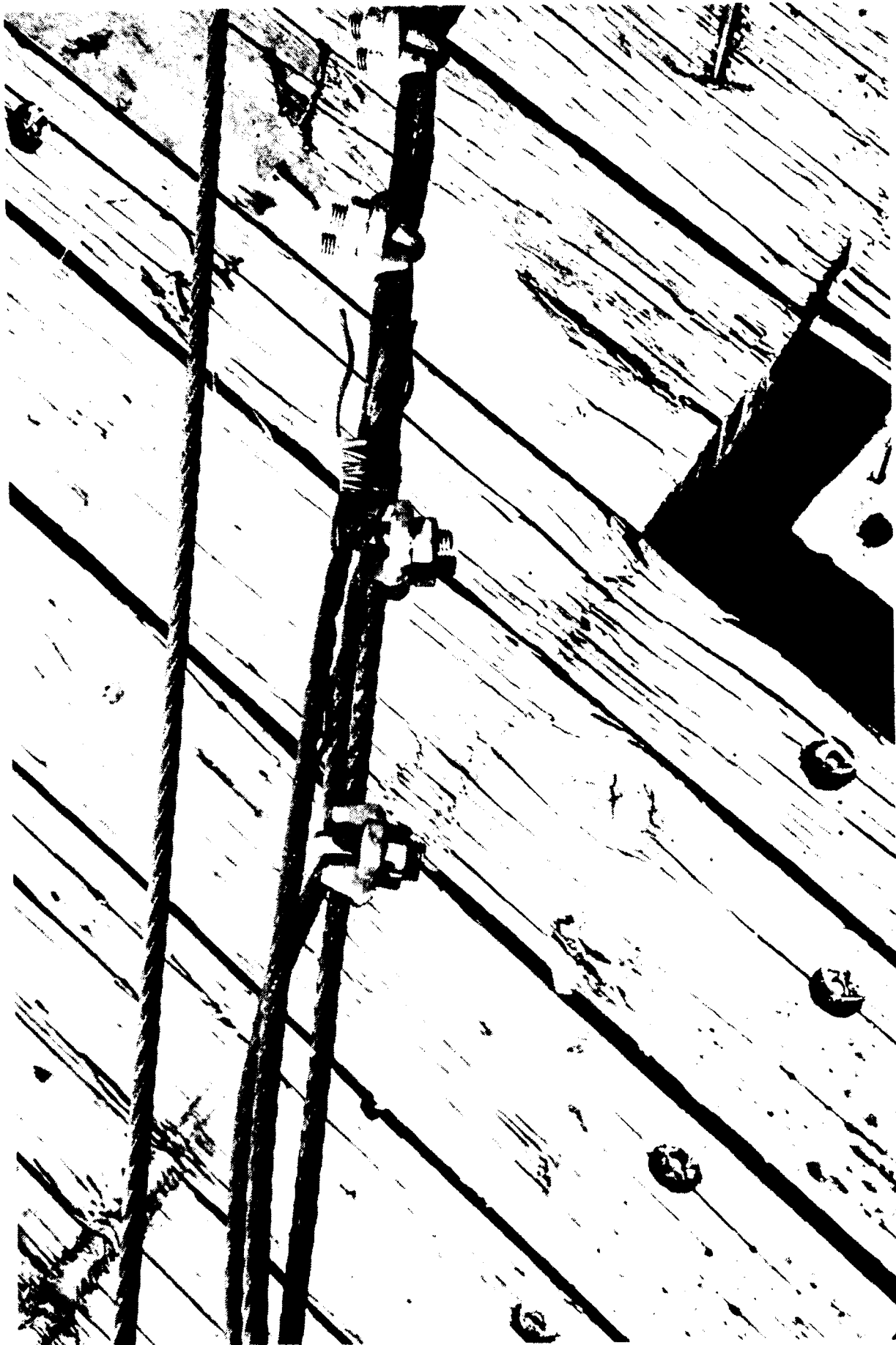


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Photo No. A0317-SCN-90-353-5242. This photo shows the rotary towed sweeper moving down the rails just prior to impact.		



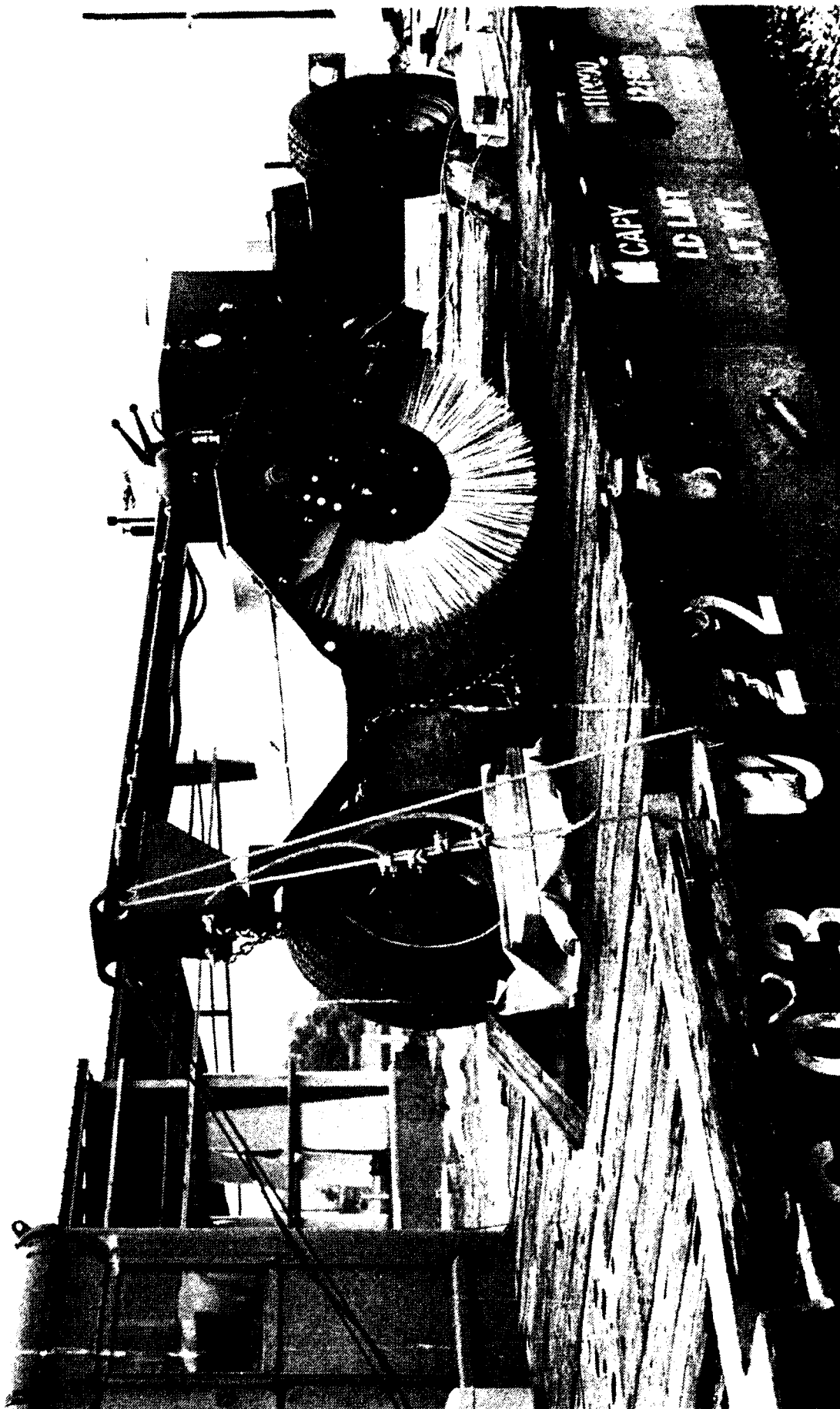
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Photo No. A0317-SCN-90-353-5245. This photo shows a side view of the rotary towed sweeper. Note the wheel blocking and bracing.



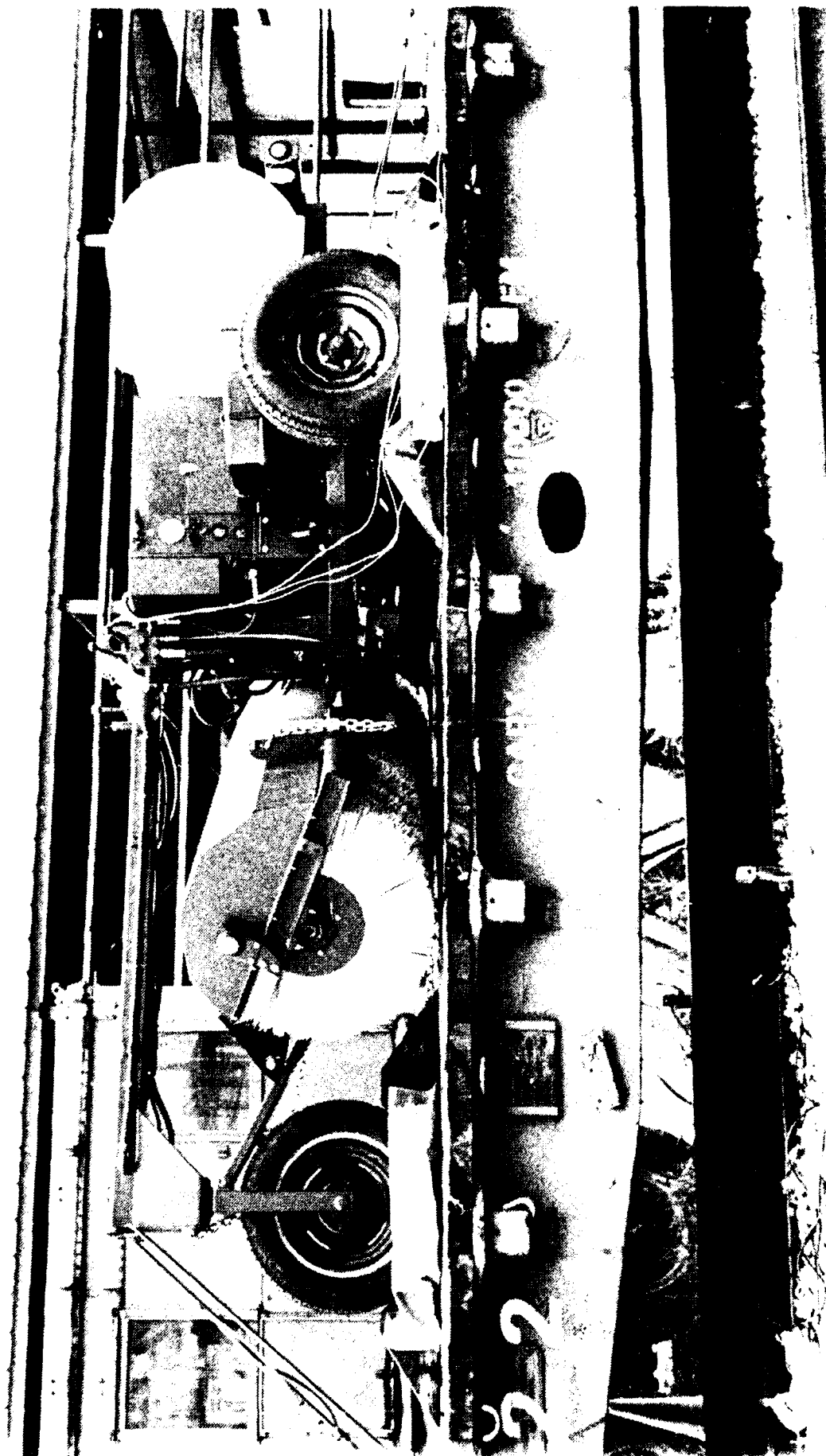
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Photo No. A0317-SCN-90-353-5249. This photo shows the method of securing the tiedown cables used during the rotary towed sweeper test. Note the condition of the floor of the flatcar.



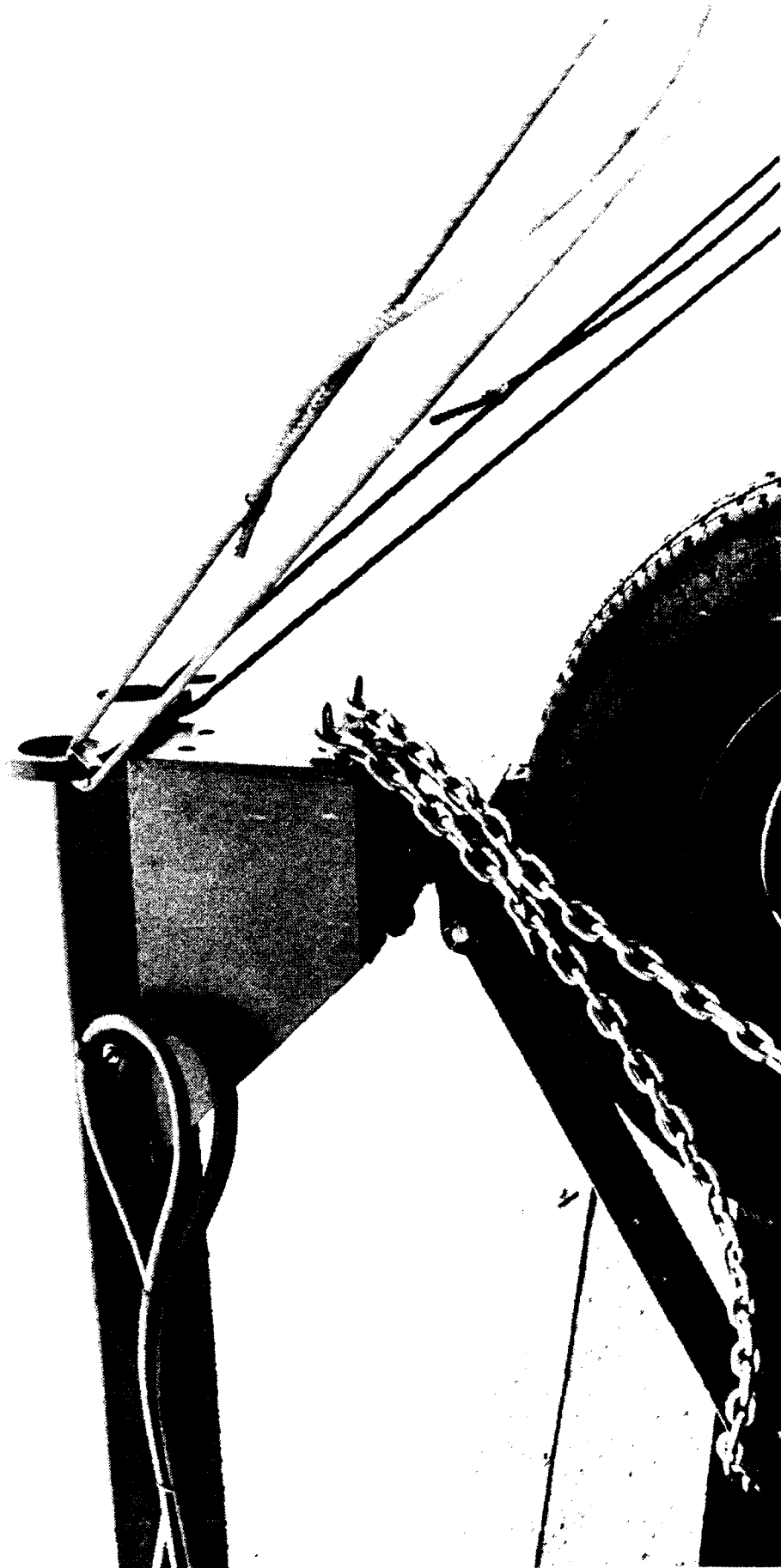
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Photo No. A0317-SPN-90-353-5279. This photo shows the rotary towed sweeper blocked, braced, and tied down to a flatcar ready for rail impact testing. What appears to be a half-filled water tank is the tank mold mark. The 250-gallon tank was empty during testing.



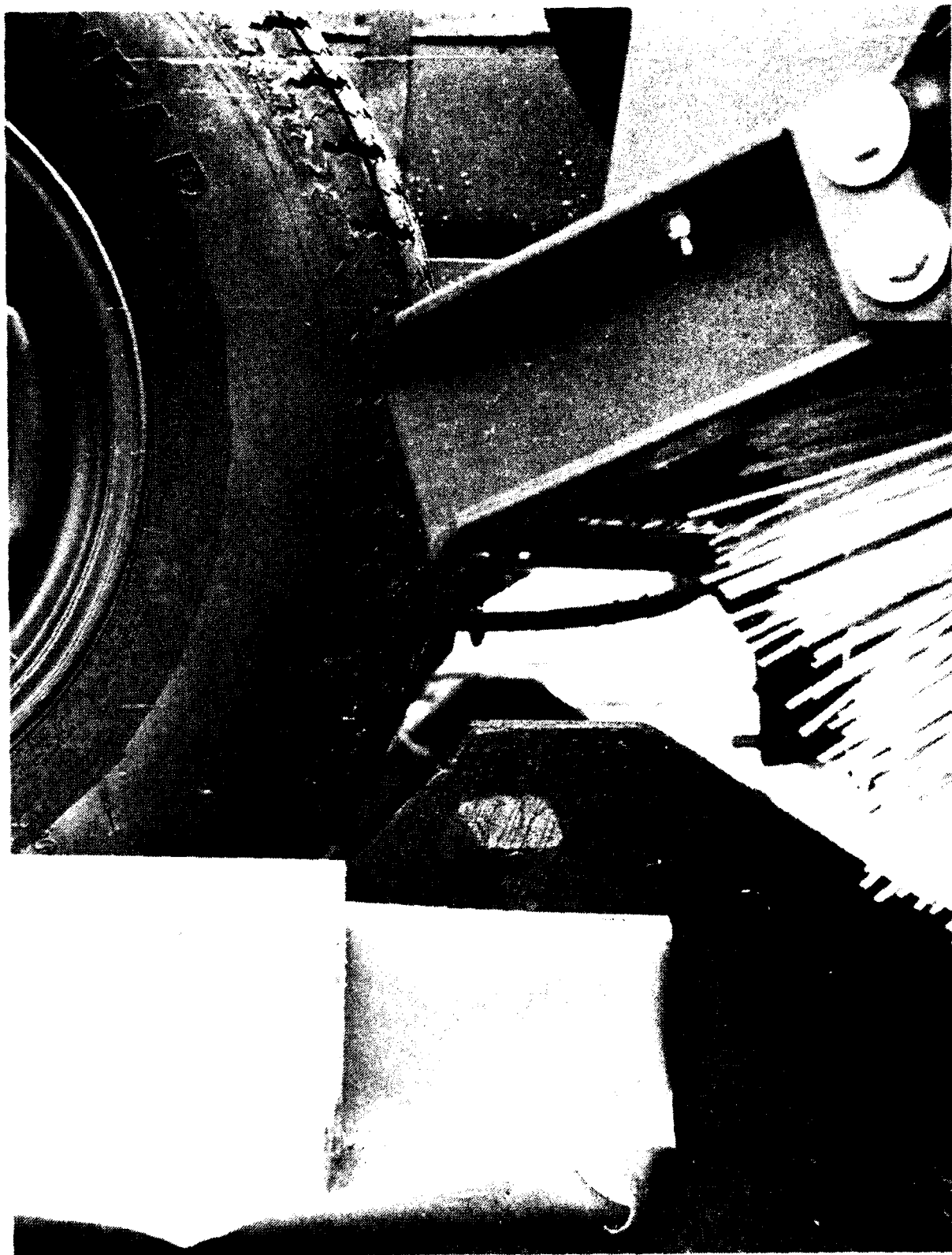
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Photo No. A0317-SPN-90-353-5278. This photo shows the rotary towed sweeper blocked, braced, and tied down to a flatcar ready for rail impact testing.



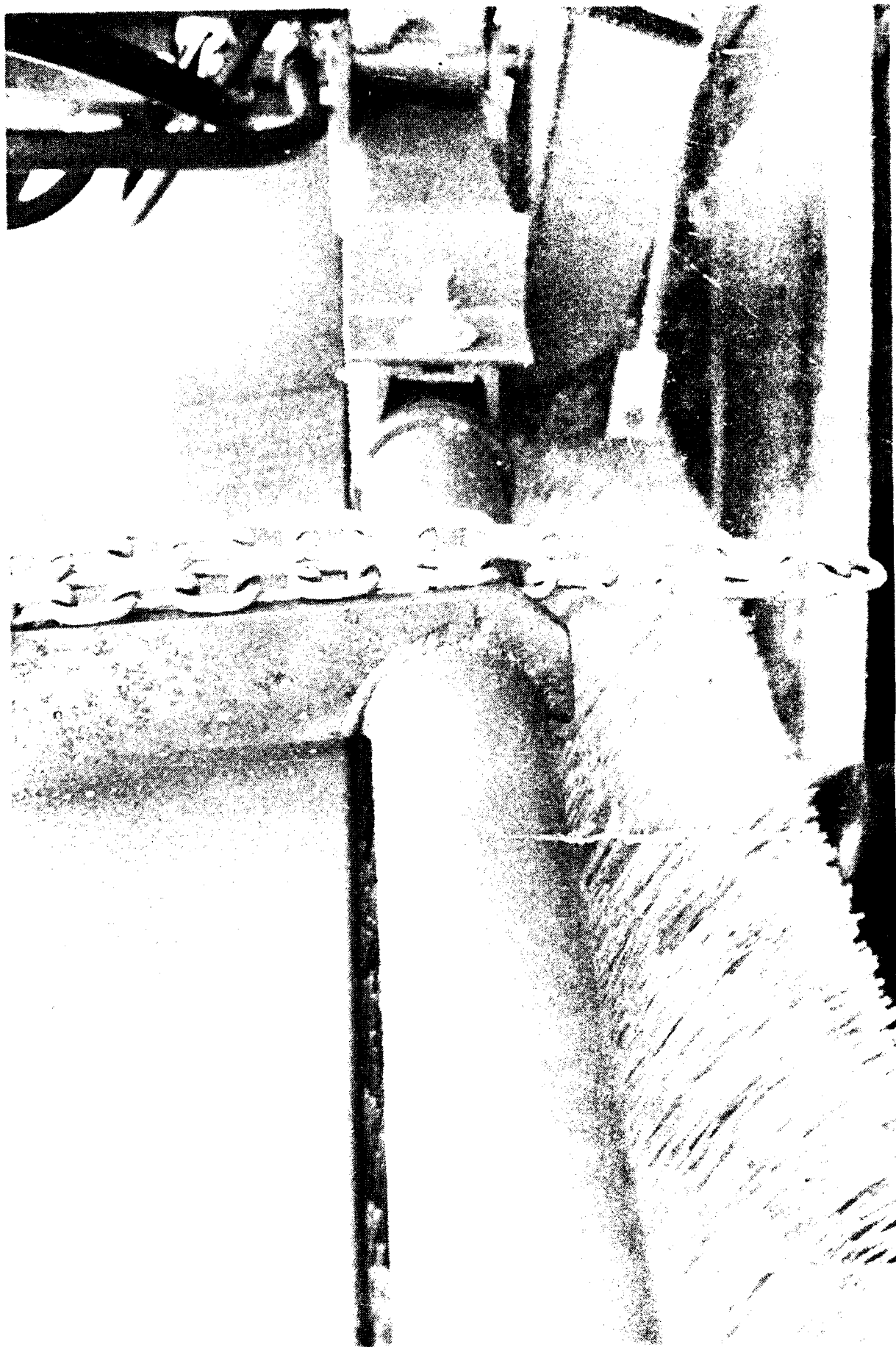
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Photo No. A0317-SPN-90-353-5277. This photo shows the rotary towed sweeper's towed end tiedown provision with tiedown cables used to secure it to a flatcar.



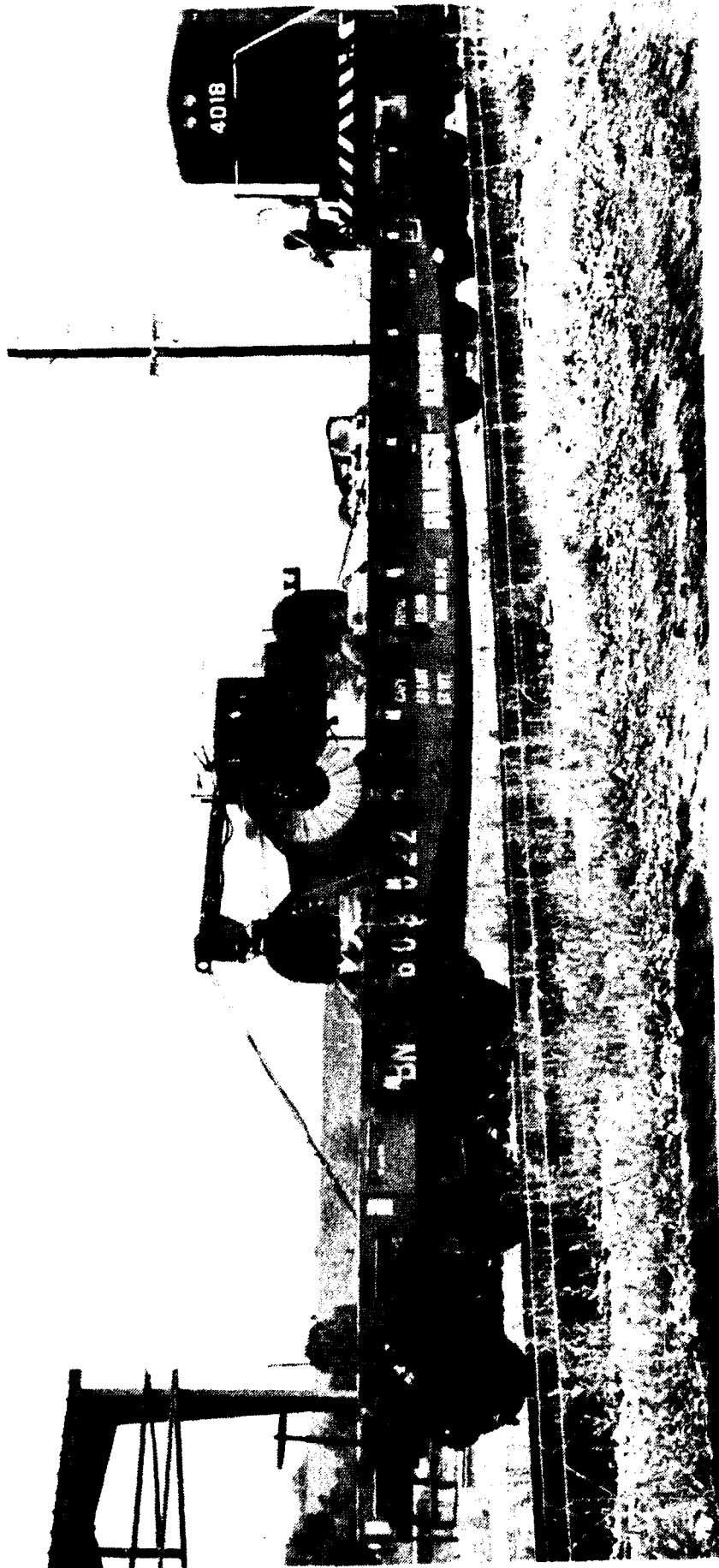
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
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Photo No. A0317-SPN-90-353-5276. This photo shows the wheel blocking and bracing used to keep the rotary towed sweeper from moving during rail transportation.
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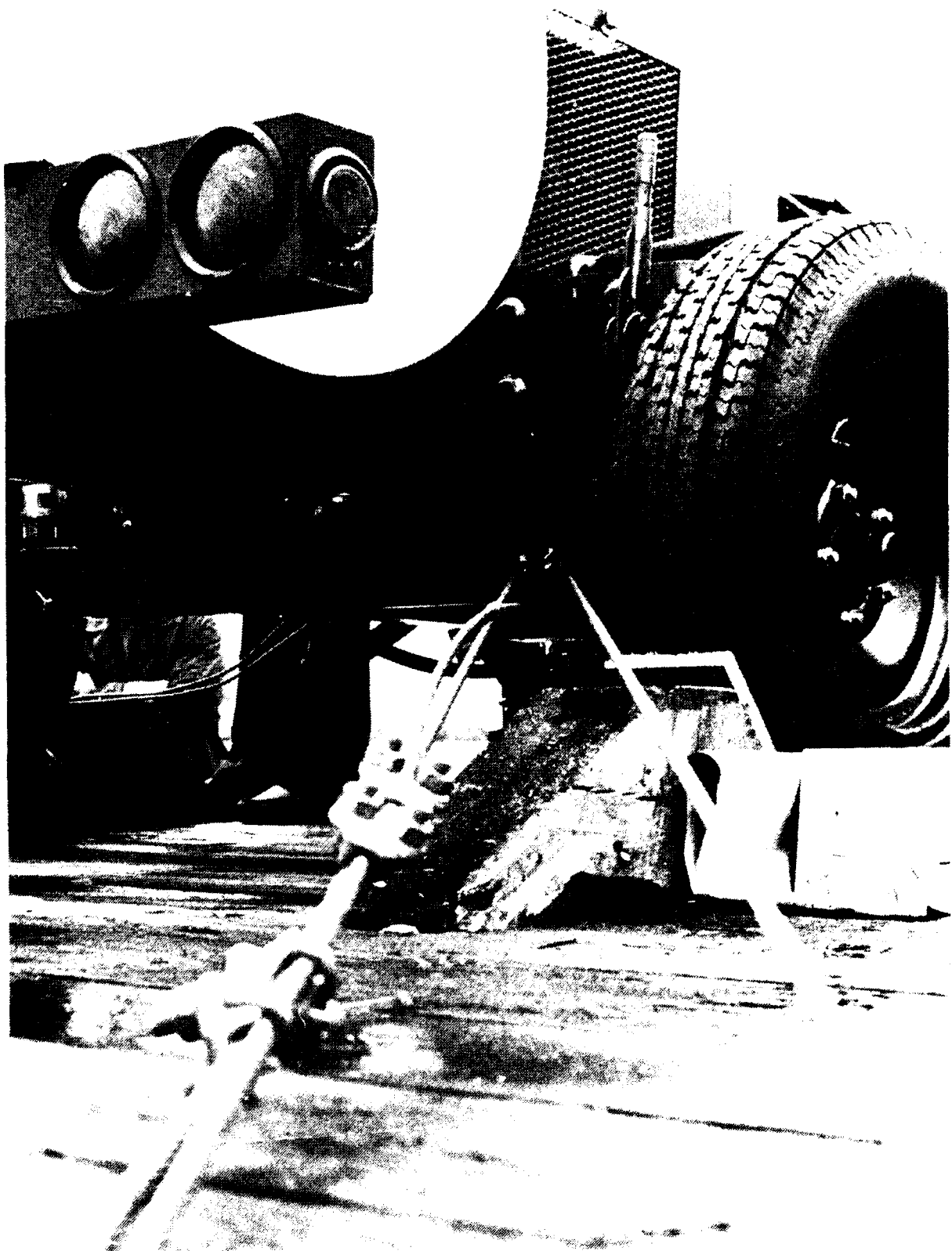
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. A0317-SPN-90-353-5280. This photo shows a chain used in restraining the rotary towed sweeper broom. This chain remains free to move during transportation.



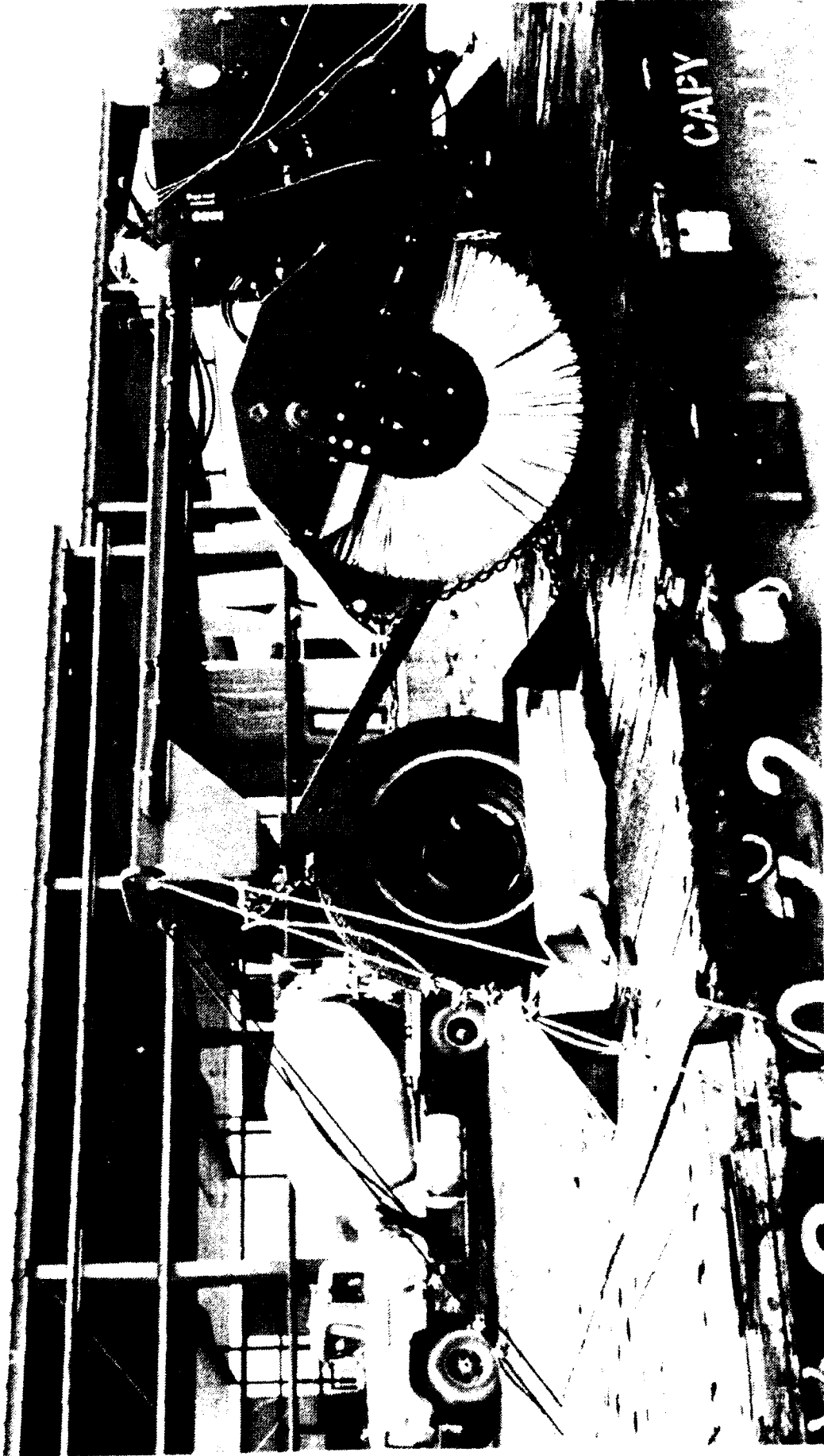
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. A0317-SPN-90-353-5281. This photo shows the rotary towed sweeper blocked, braced, and tied down to a flatcar ready for rail impact testing.



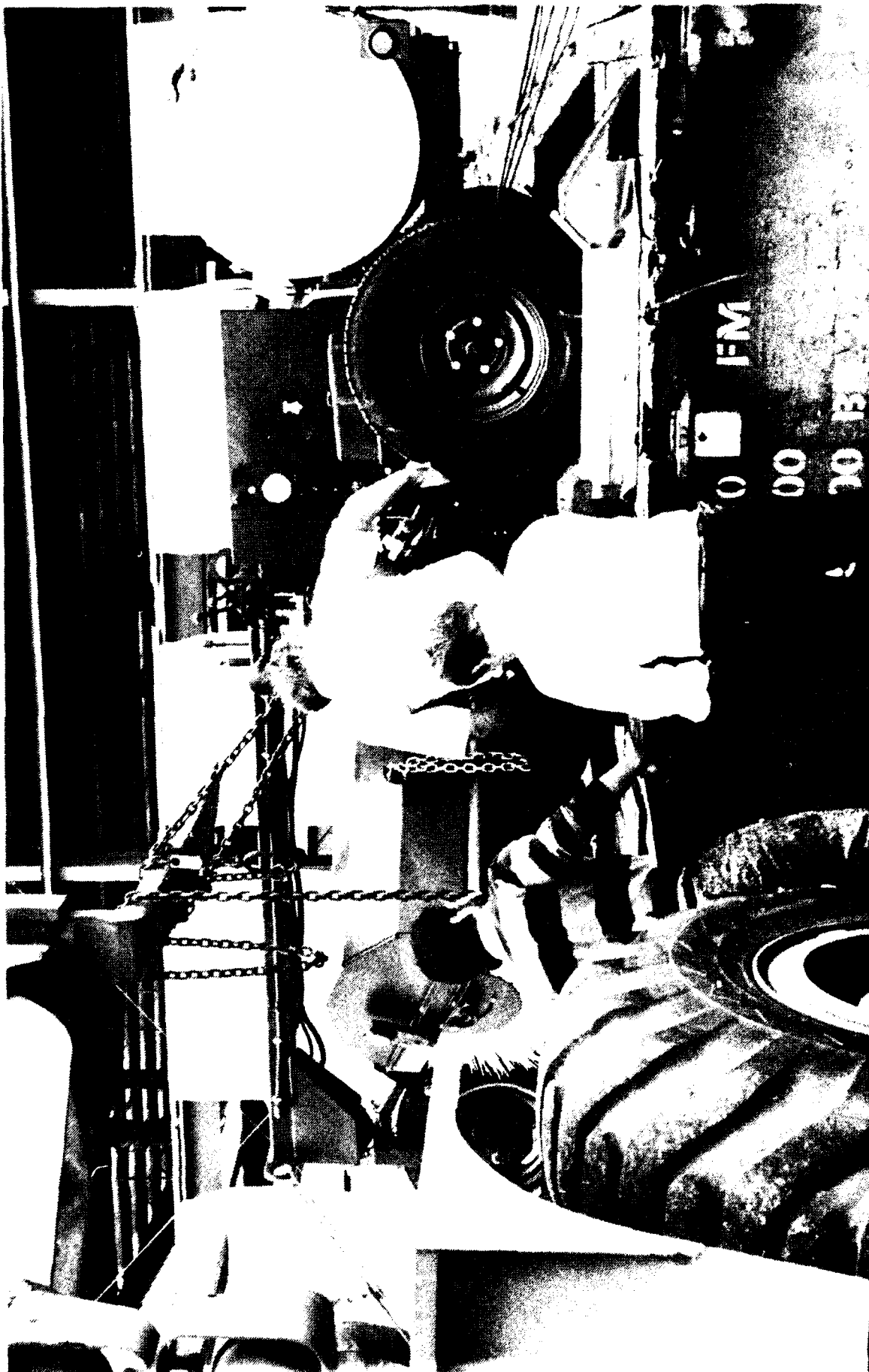
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
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	Photo No. A0317-SPN-90-353-5284. This photo shows a tiedown provision on the rear of the rotary towed sweeper with a cable securing it to a flatcar. Note the wheel chocks and side bracing with anti-scuff material.	
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	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL
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Photo No. A0317-SPN-90-353-5293. This photo shows the front tie-downs used to secure the rotary towed sweeper to a flatcar for rail transportation. Note the front wheel chocks and side bracing. The towing tongue is secured under the brush.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. A0317-SPN-90-353-5302. This photo shows the procedure used to test the load capability of the slinging provisions on the rotary towed sweeper. Representatives from USADACS, MTMC-TEA, and the manufacturer are monitoring the test.

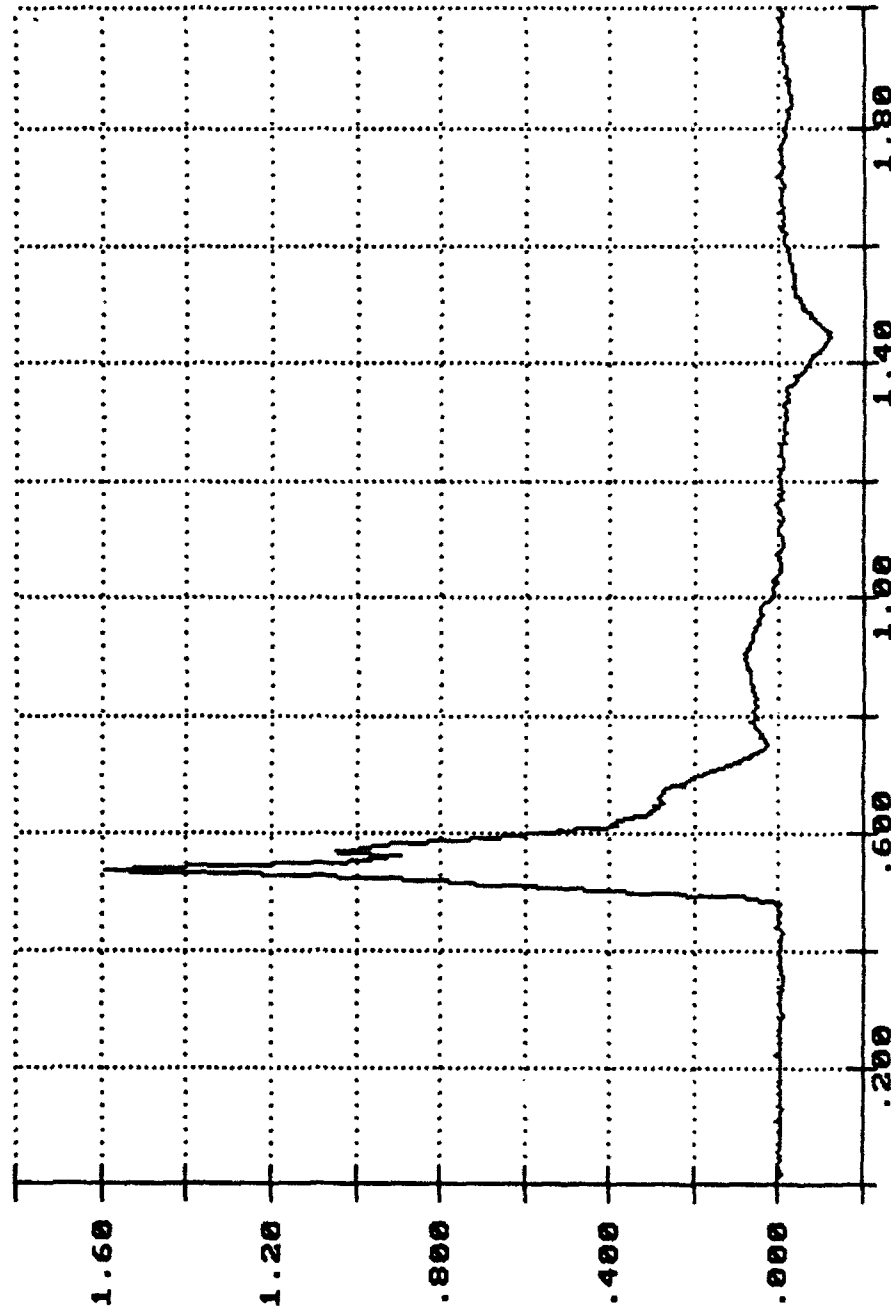
PART 6

TEST DATA

Rail Impact Test of Rotary Towed Sweeper

Date: 21 August 1990

Impact 1: 4.15 MPH



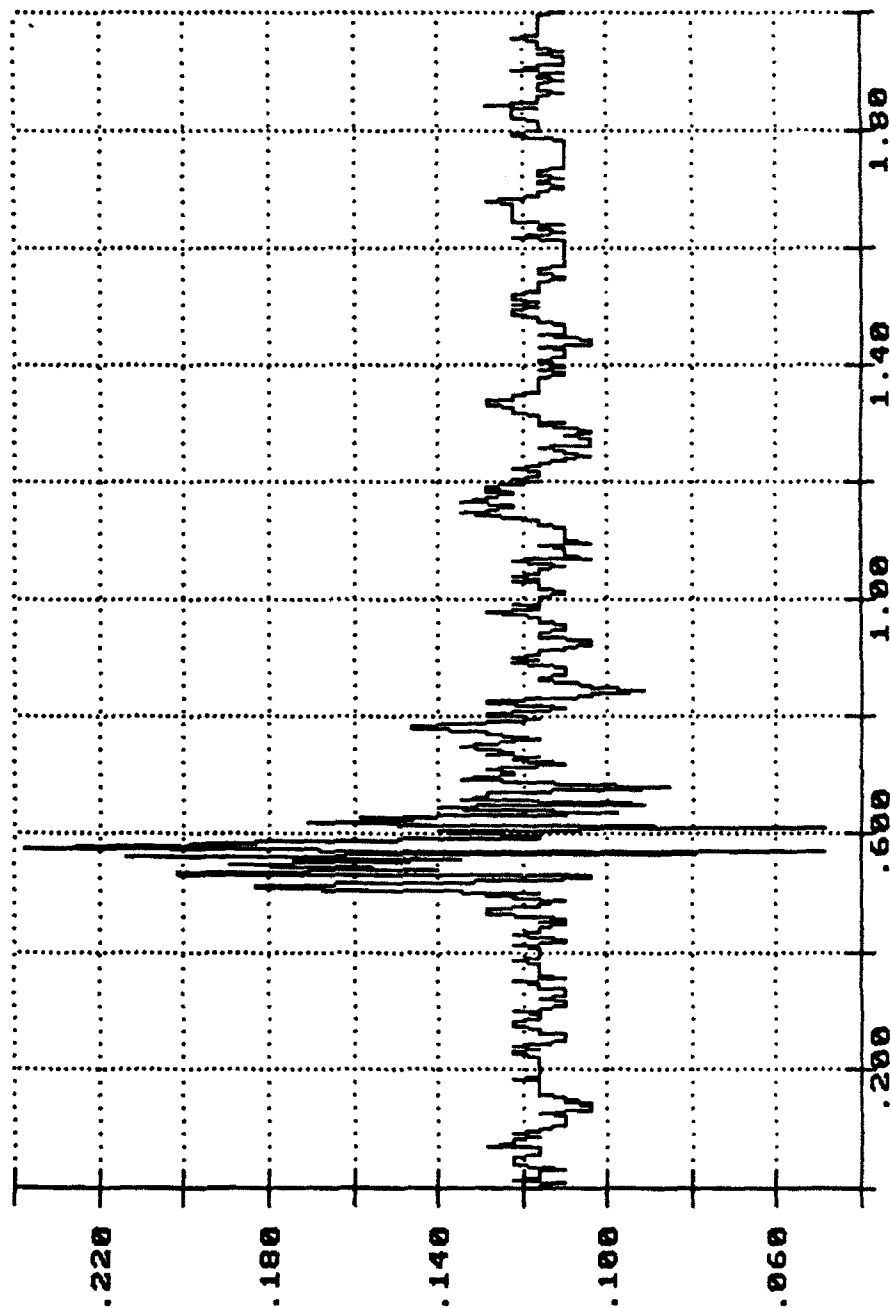
Longitudinal Acceleration on Sill

in G's X 1.0000

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
 Date: 21 August 1990
 Impact 1: 4.15 MPH



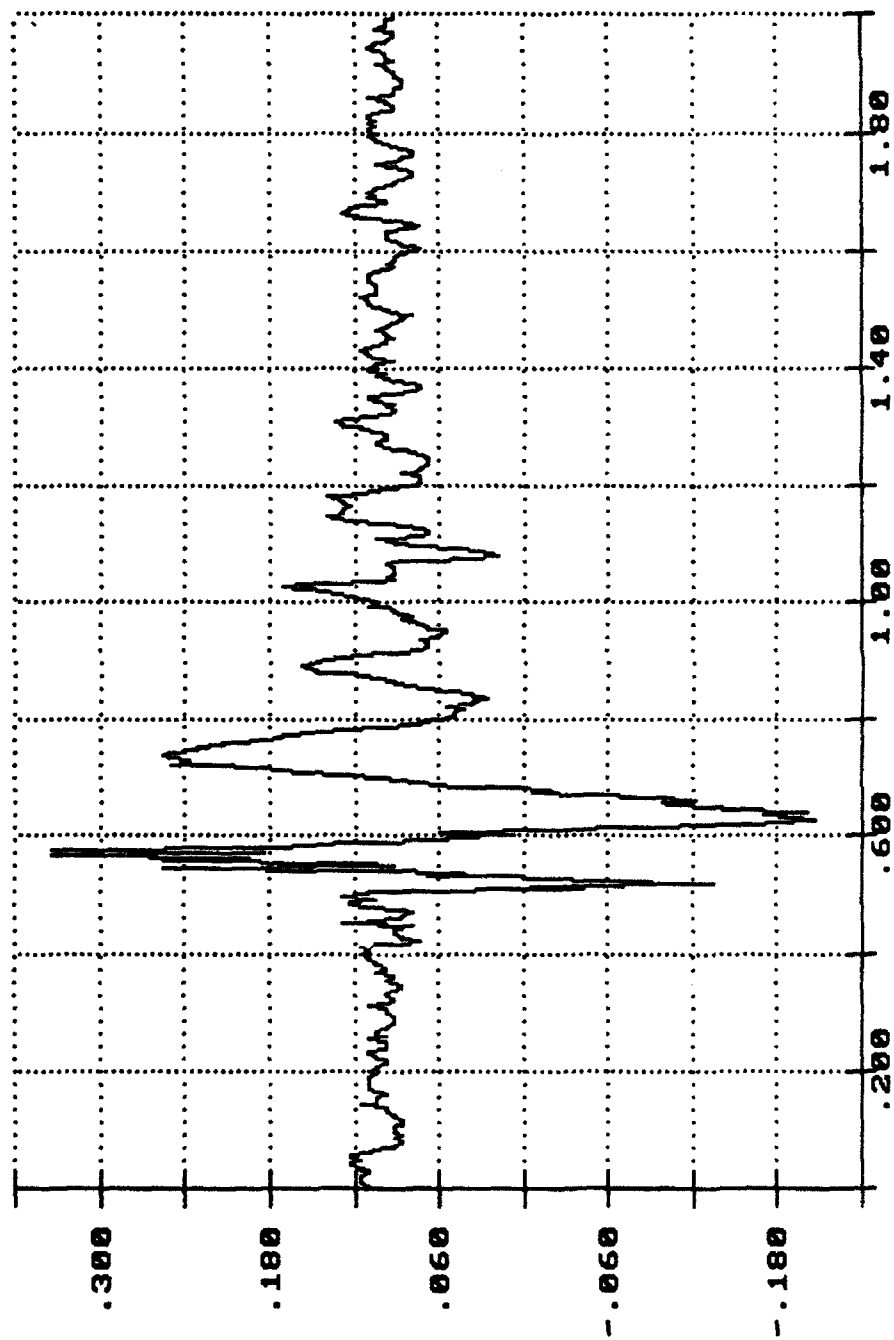
Sample Time in Seconds

X 1.0000

Lateral Acceleration on Sill

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 1: 4.15 MPH



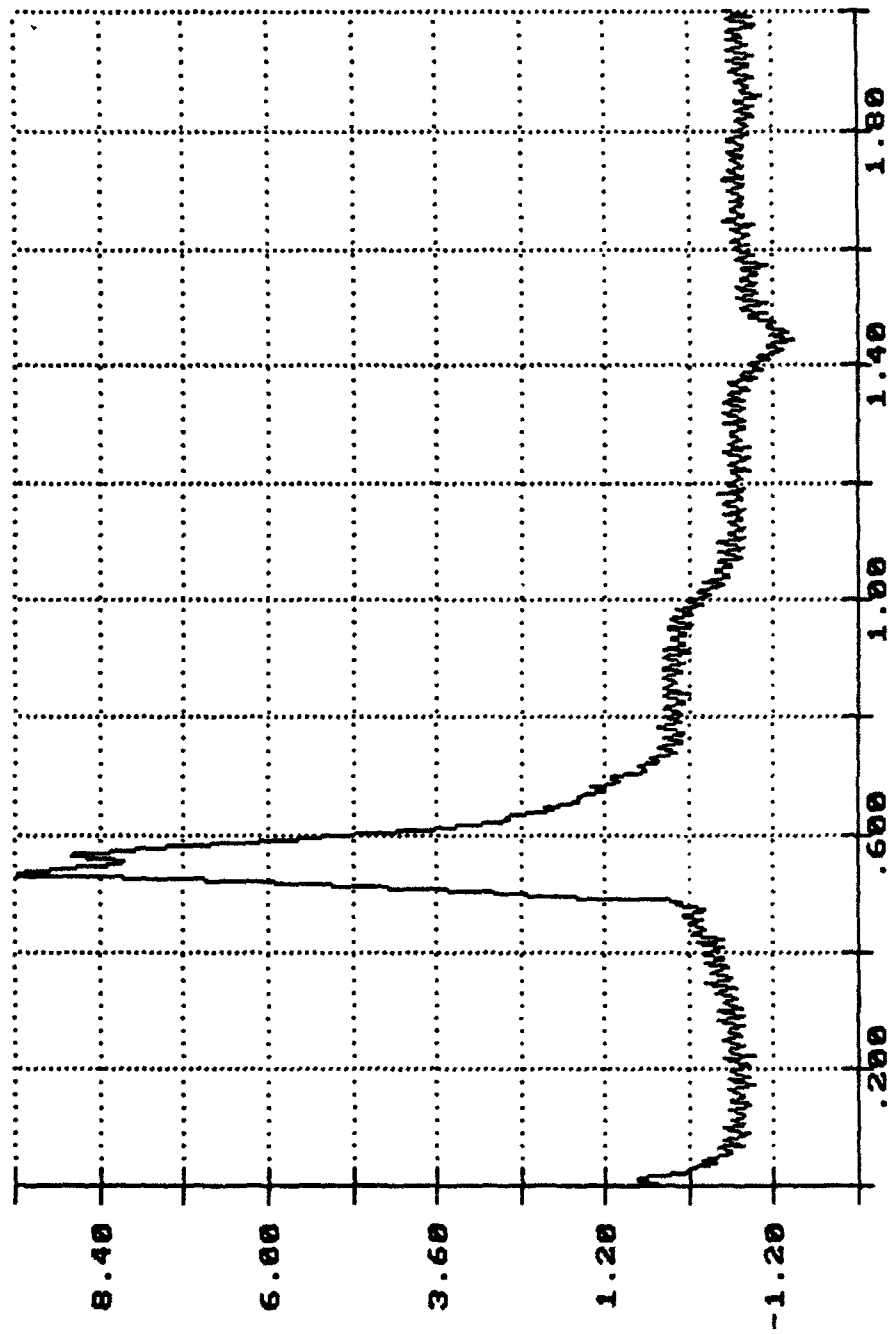
Sample Time in Seconds

X 1.0000

Vertical Acceleration on Still

1.5 G'S X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 1: 4.15 MPH

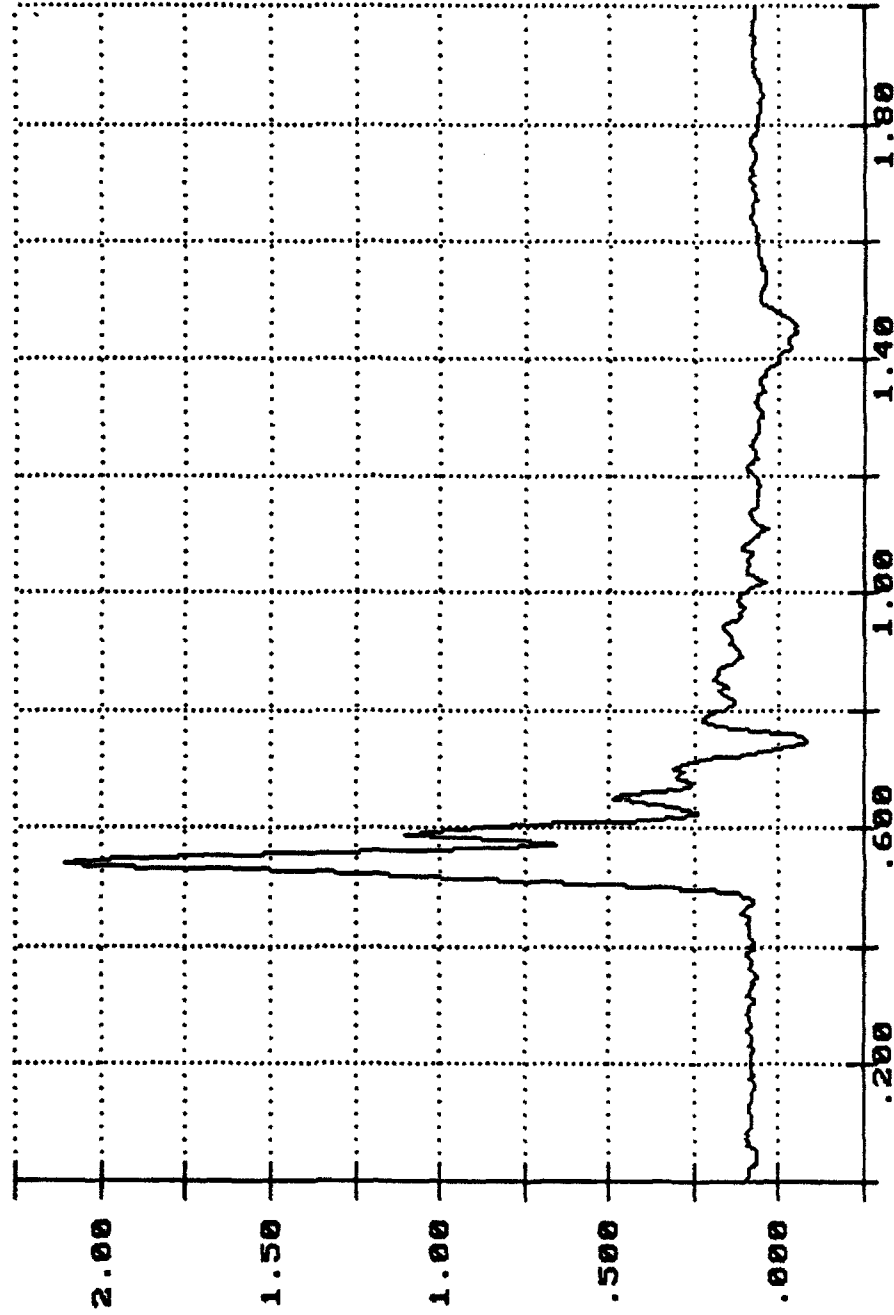


Rail Coupler Force
in Pounds X 10000.0000

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 1: 4.15 MPH



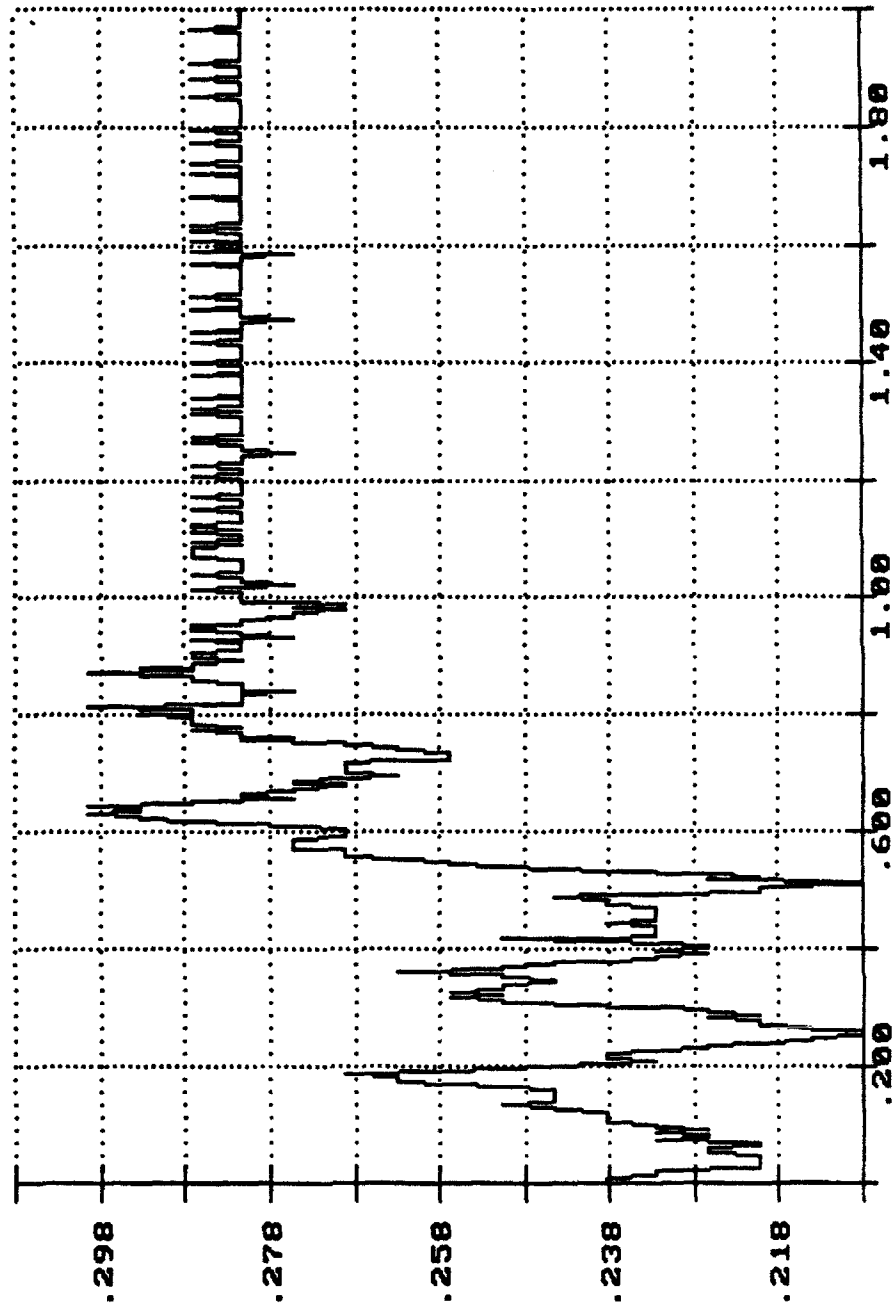
Sample Time in Seconds

X 1.0000

Longitudinal Acceleration on Frame

in G's X 1.0000

Rail Impact Test of Rotary Towed Sweeper
 Date: 21 August 1990
 Impact 1: 4.15 MPH



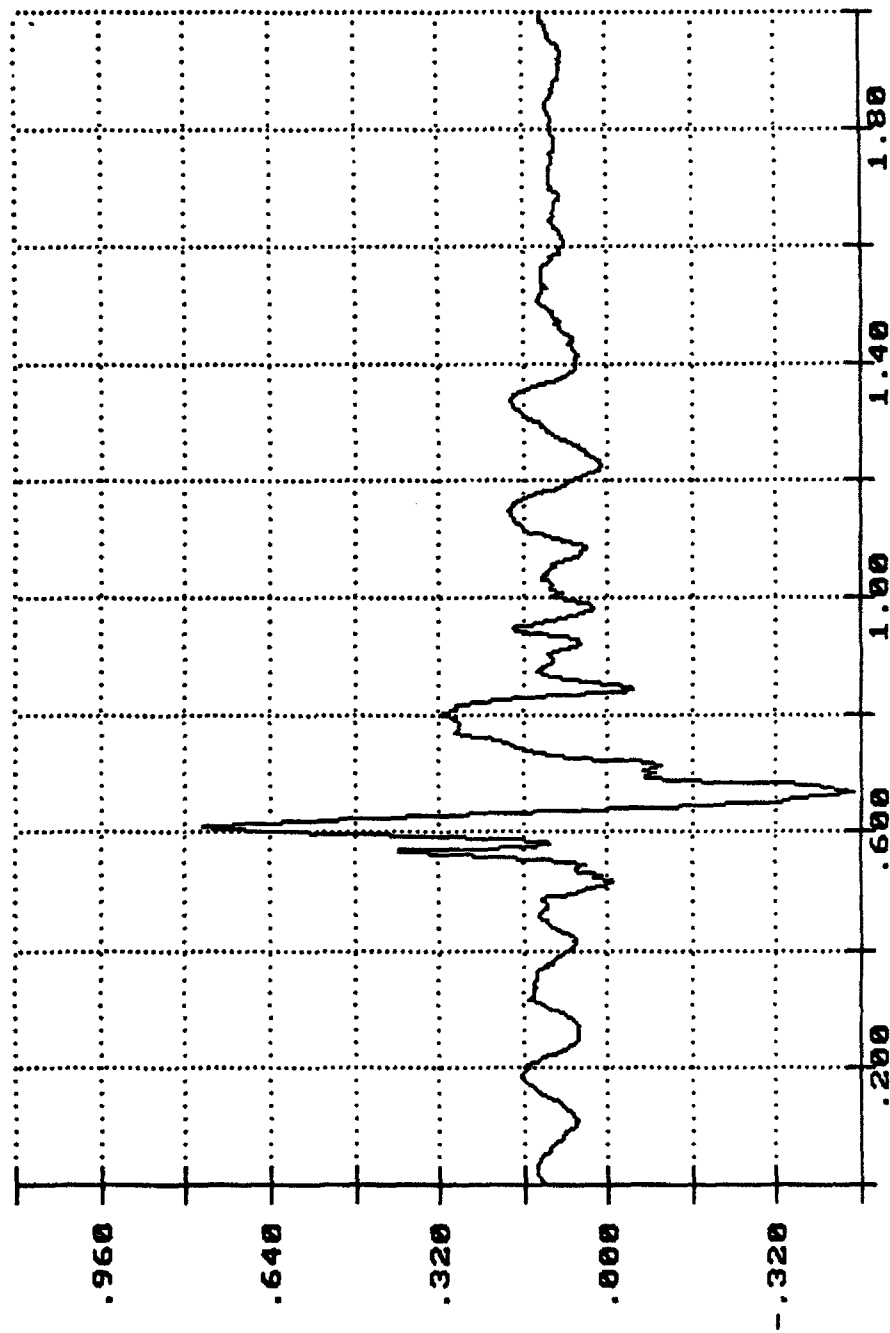
Sample Time in Seconds

X 1.0000

in G'S X 1.0000

Lateral Acceleration on Frame

Rail Impact Test of Rotary Towed Sweeper
 Date: 21 August 1990
 Impact 1: 4.15 MPH



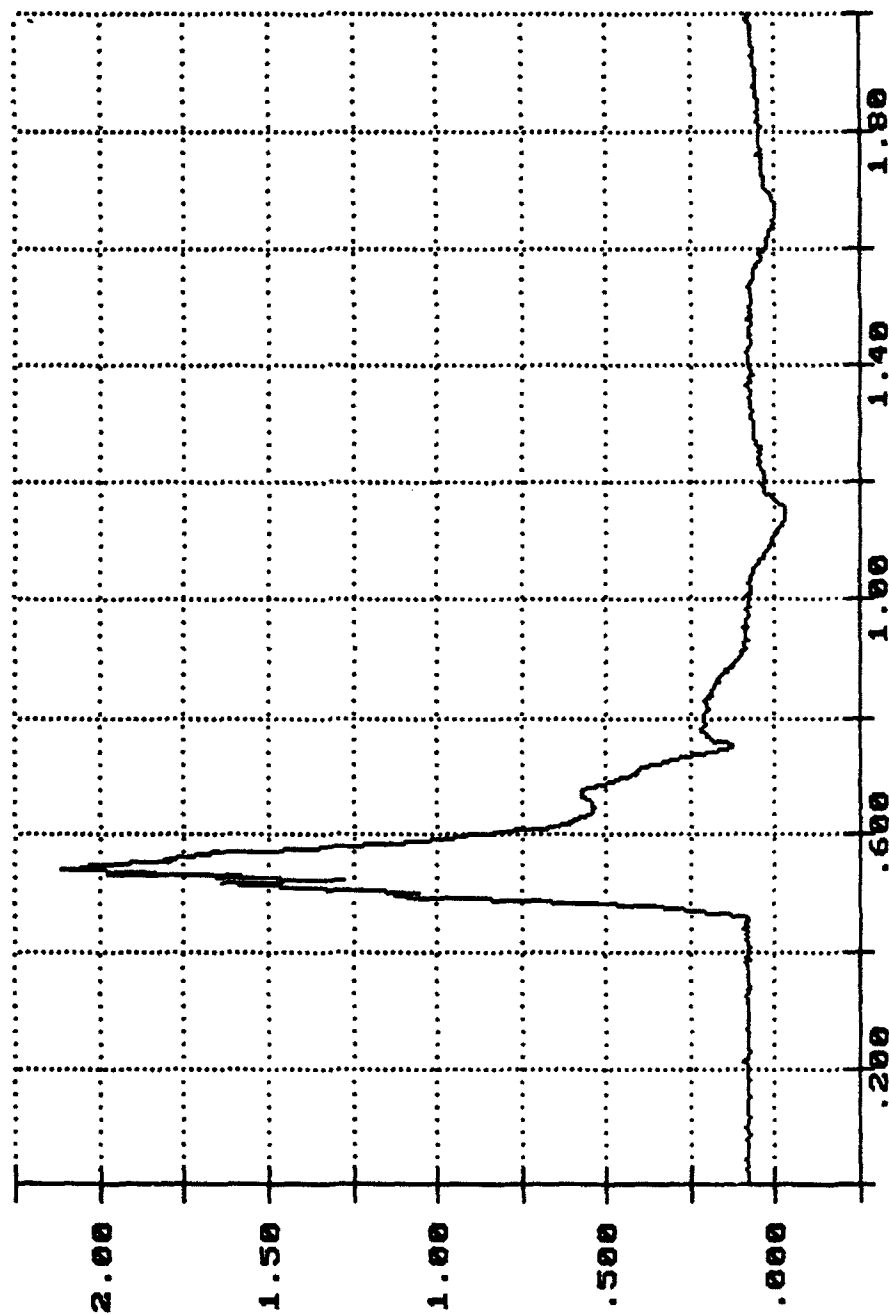
Sample Time in Seconds

X 1.0000

15 G'S X 1.0000

Vertical Acceleration on Frame

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 2: 6.35 MPH



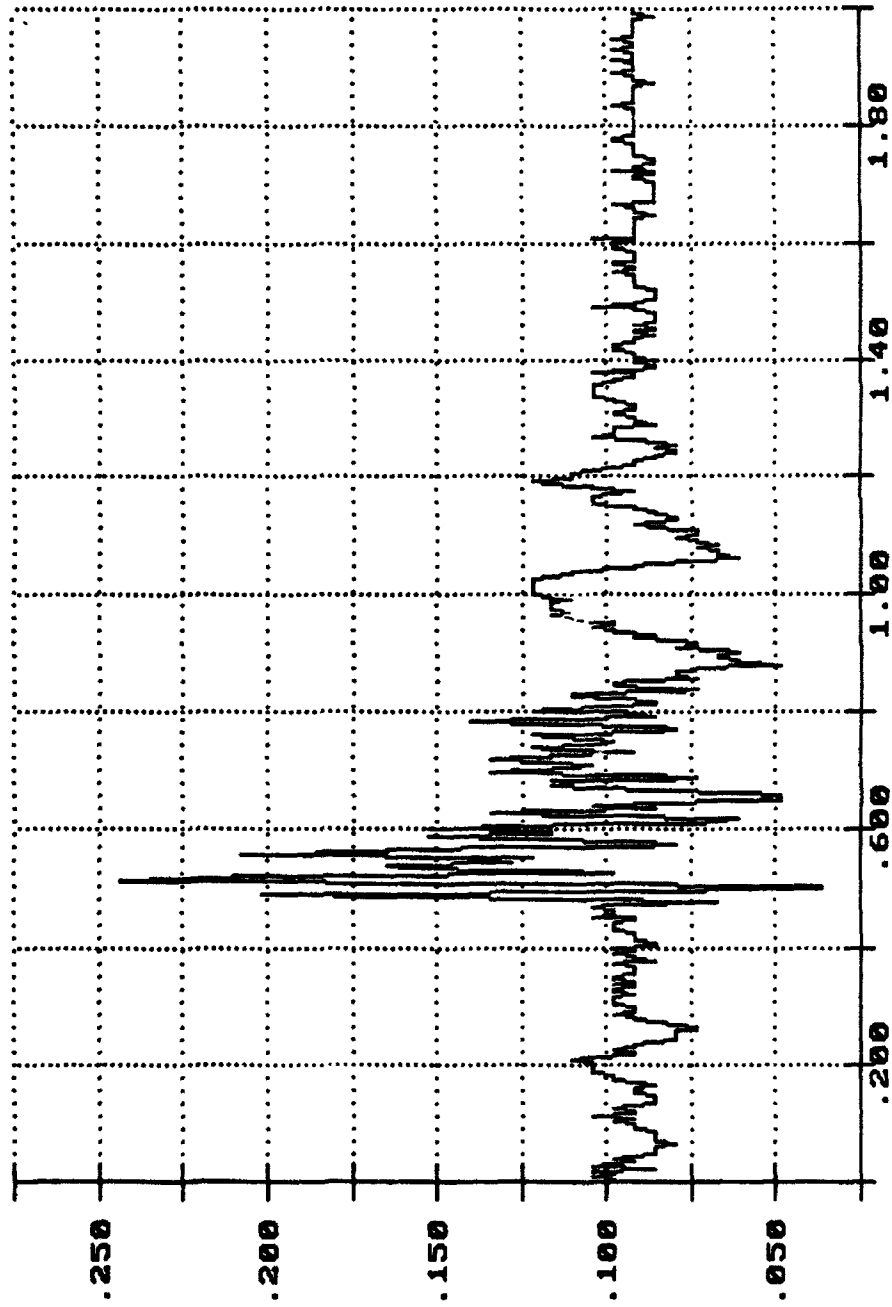
Sample Time in Seconds

X 1.0000

Longitudinal Acceleration on Sill

in G's X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 2: 6.35 MPH

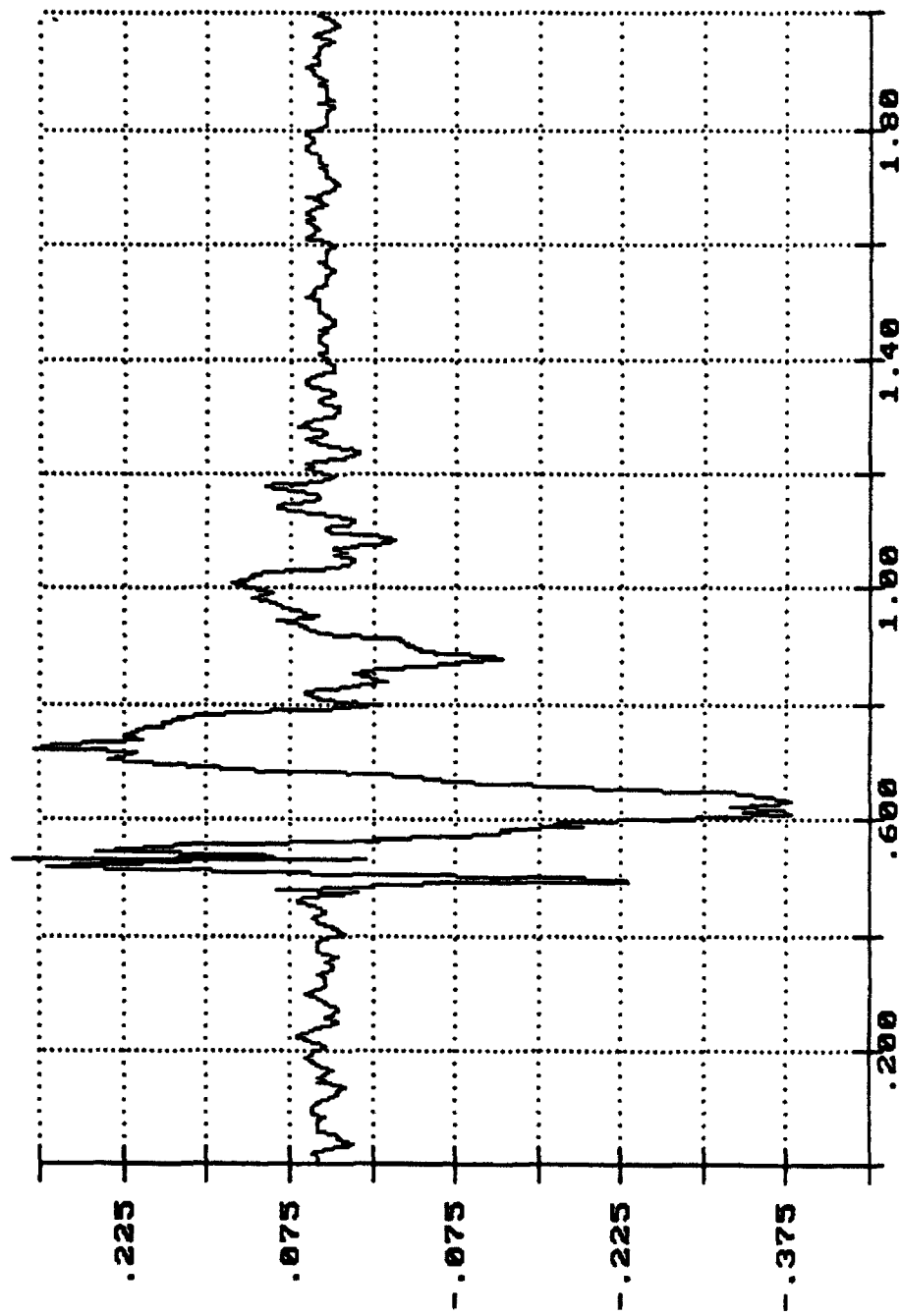


Sample Time in Seconds
X 1.0000

in G's X 1.0000

Lateral Acceleration on Sill

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 2: 6.35 MPH



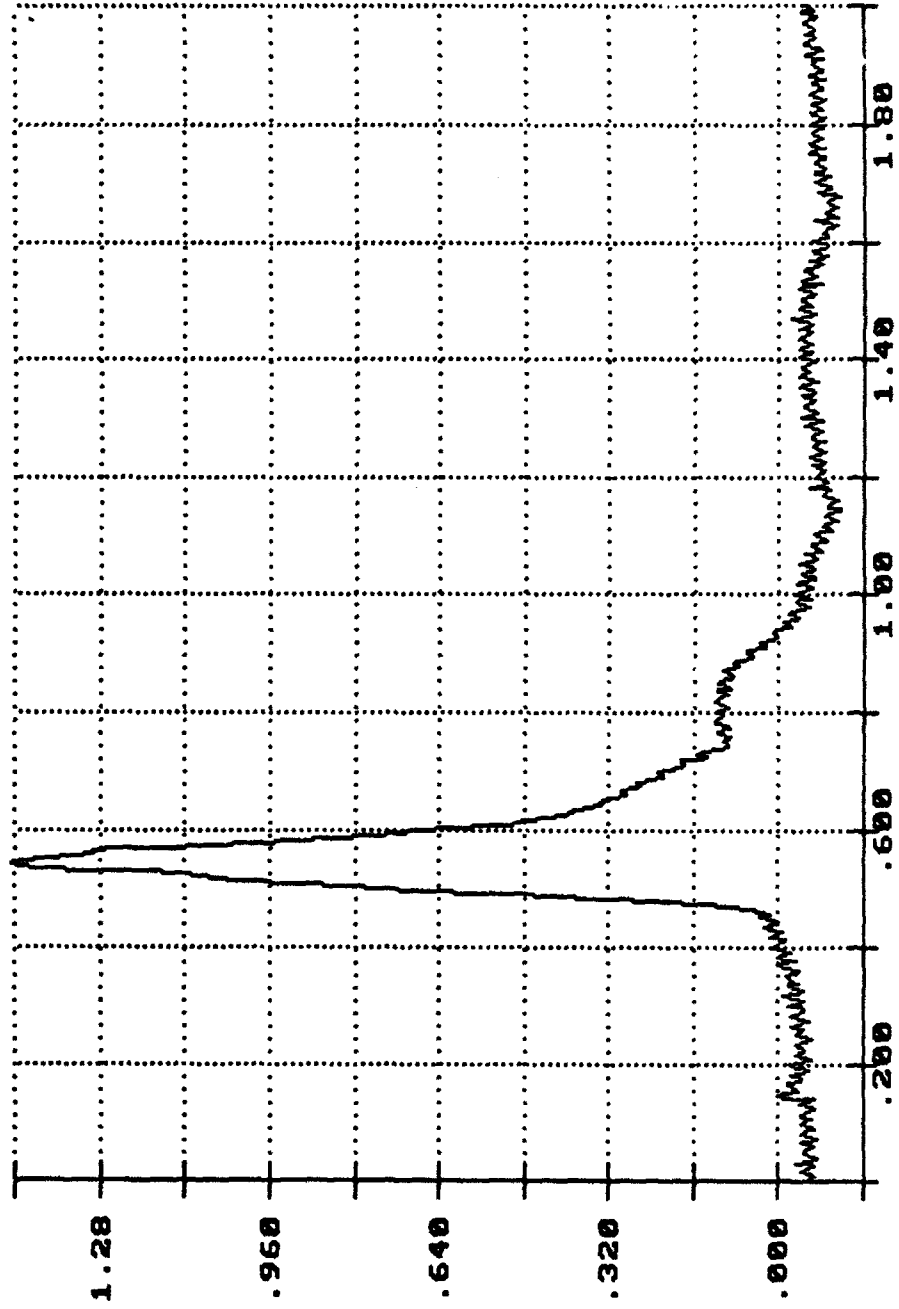
Sample Time in Seconds

X 1.0000

Vertical Acceleration on Sill

in G's X 1.0000

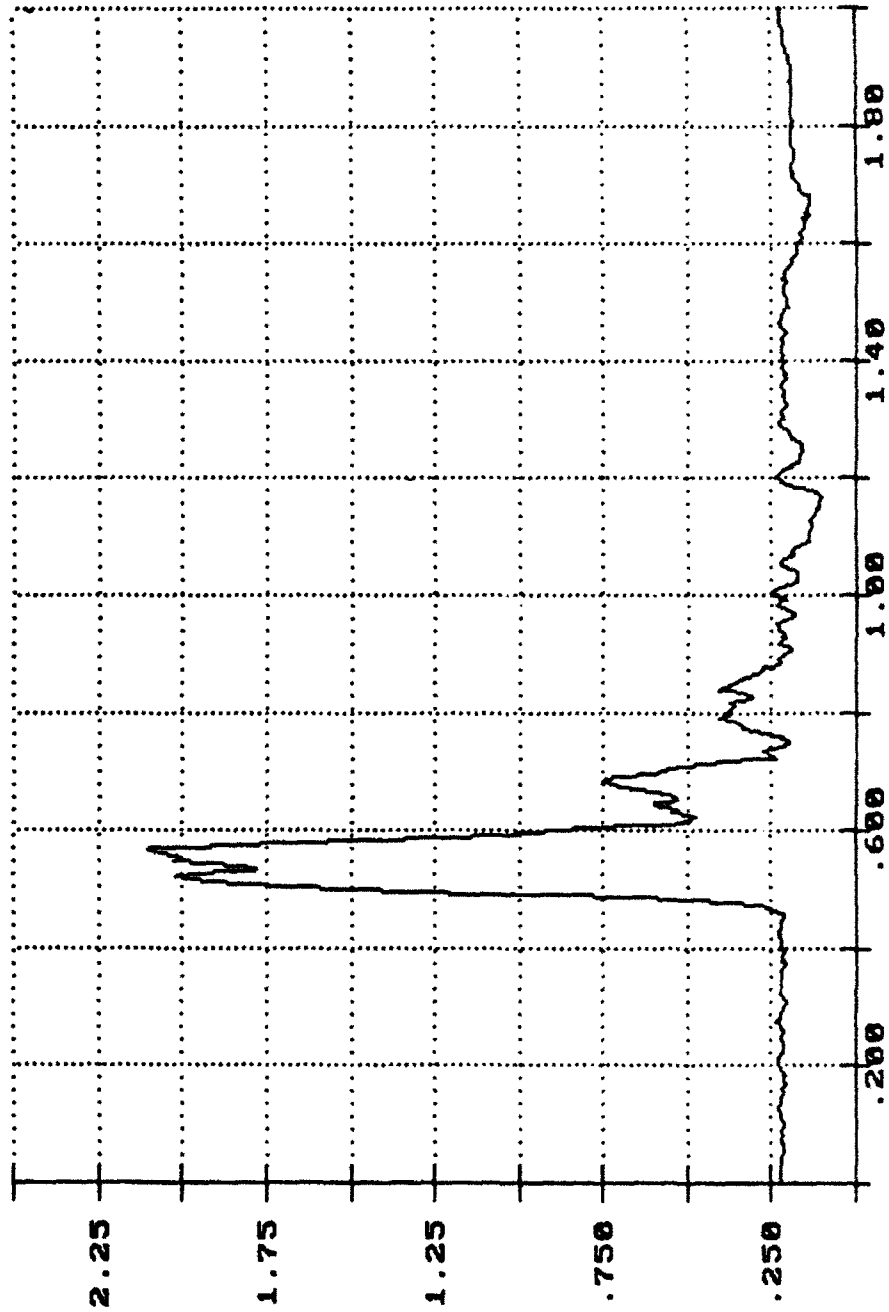
Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 2: 6.35 MPH



Rail Coupler Force
in Pounds X 100000.0000

Sample Time in Seconds
X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 2: 6.35 MPH



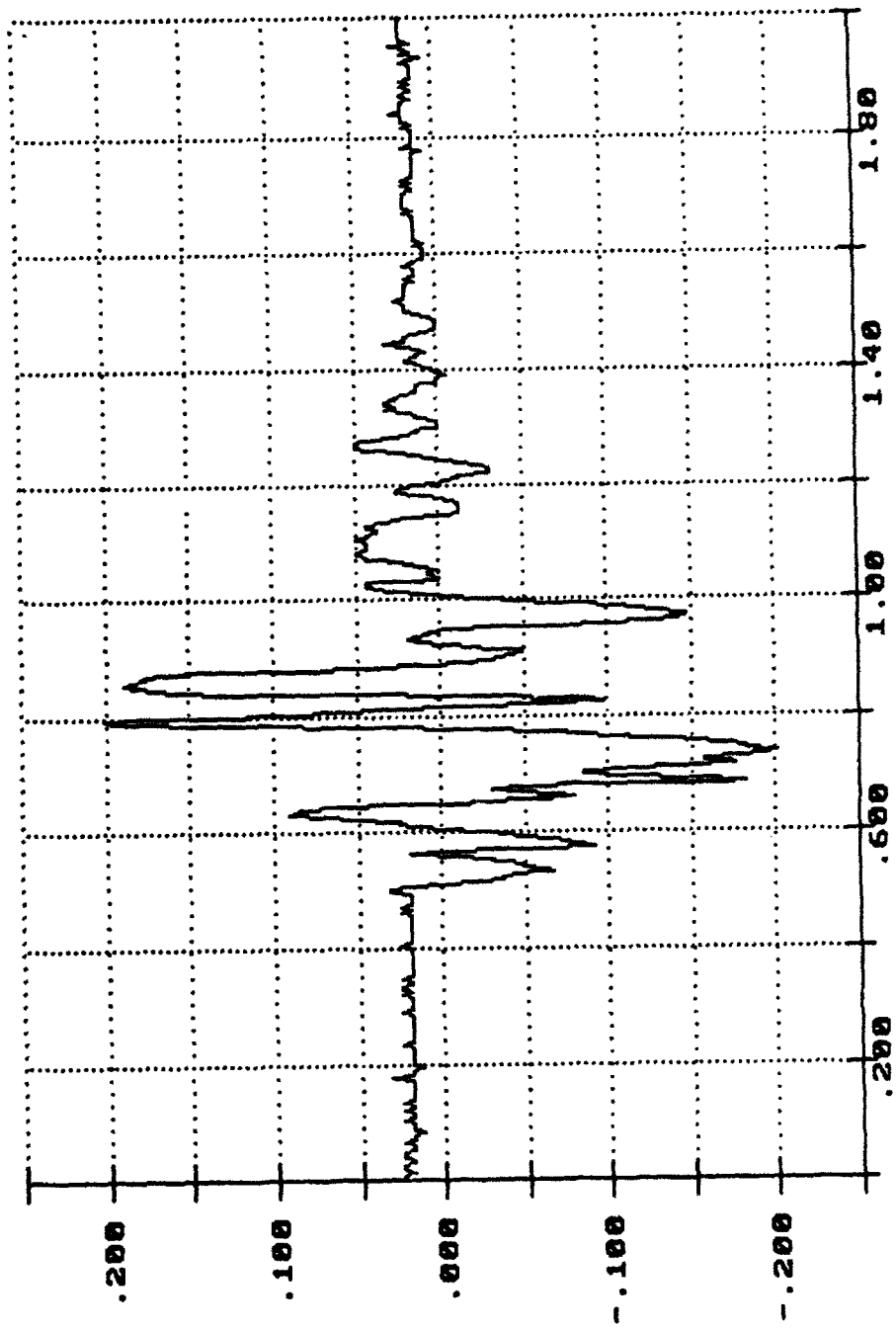
Sample Time in Seconds

X 1.0000

Longitudinal Acceleration on Frame

in G'S X 1.0000

Rail Impact Test of Rotary Towed Sweeper
 Date: 21 August 1990
 Impact 2: 6.35 MPH



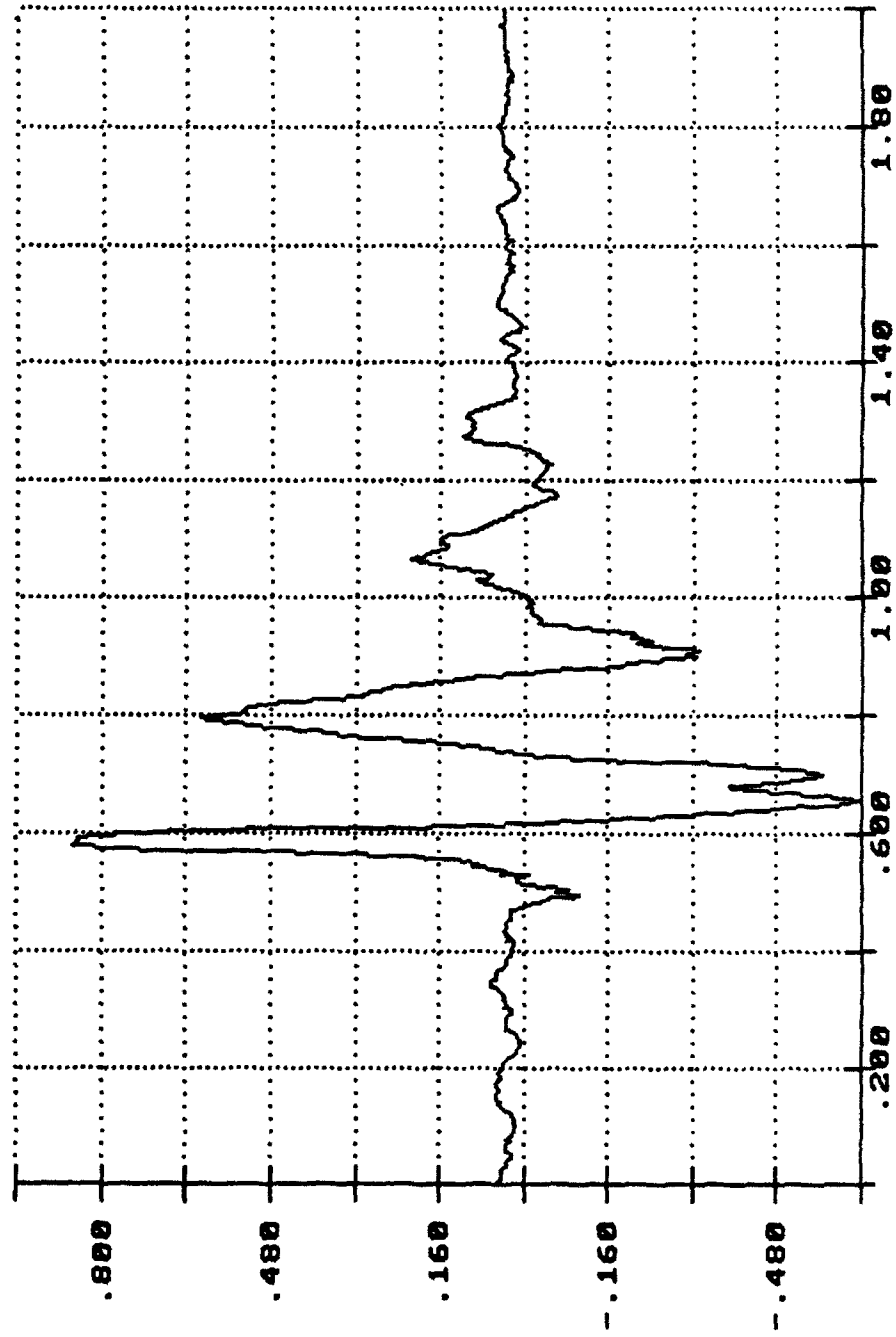
Sample Time in Seconds

X 1.0000

Lateral Acceleration on Frame

is G'S X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 2: 6.35 MPH



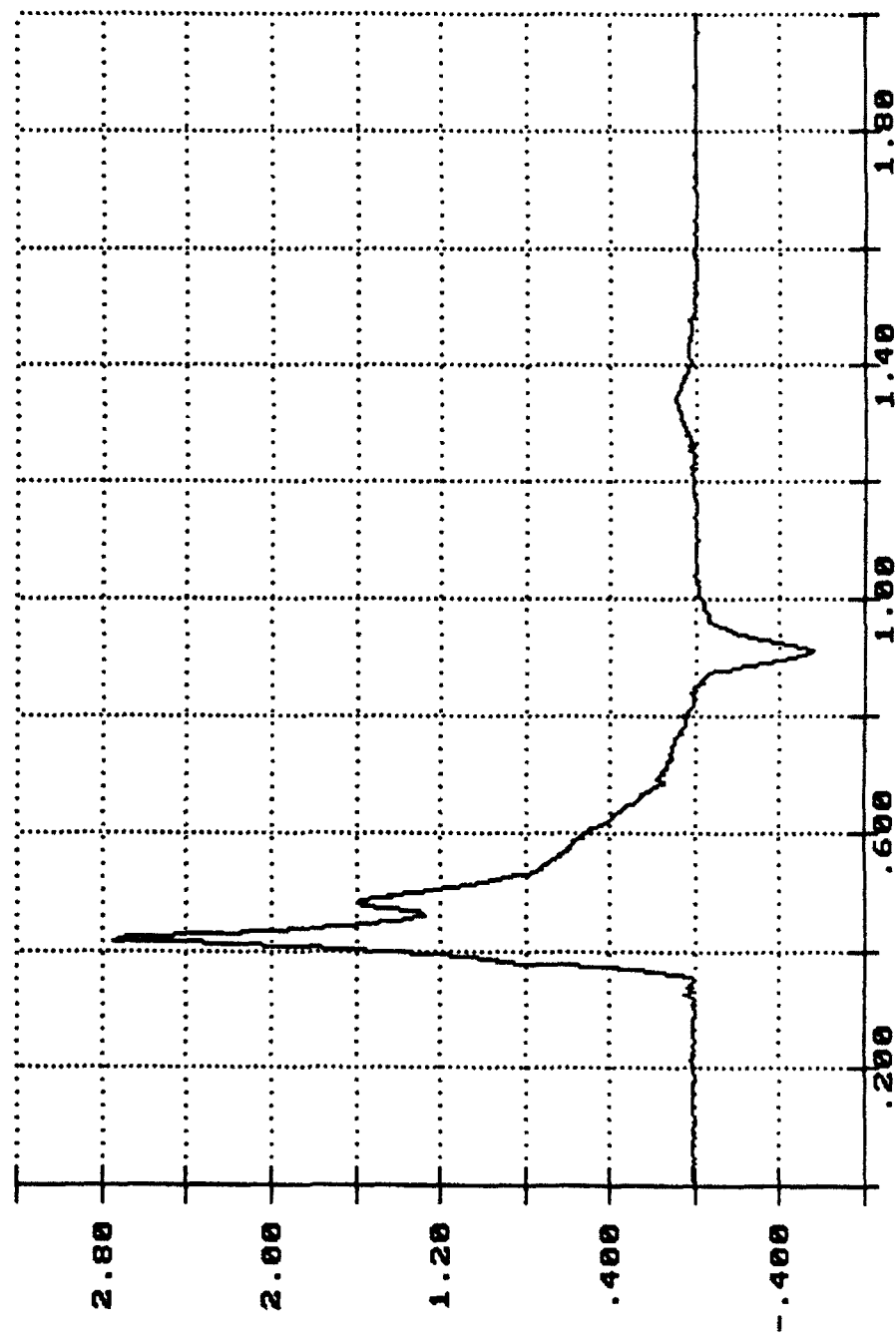
Vertical Acceleration on Frame

1.5 G'S X 1.0000

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 3: 8.62 MPH

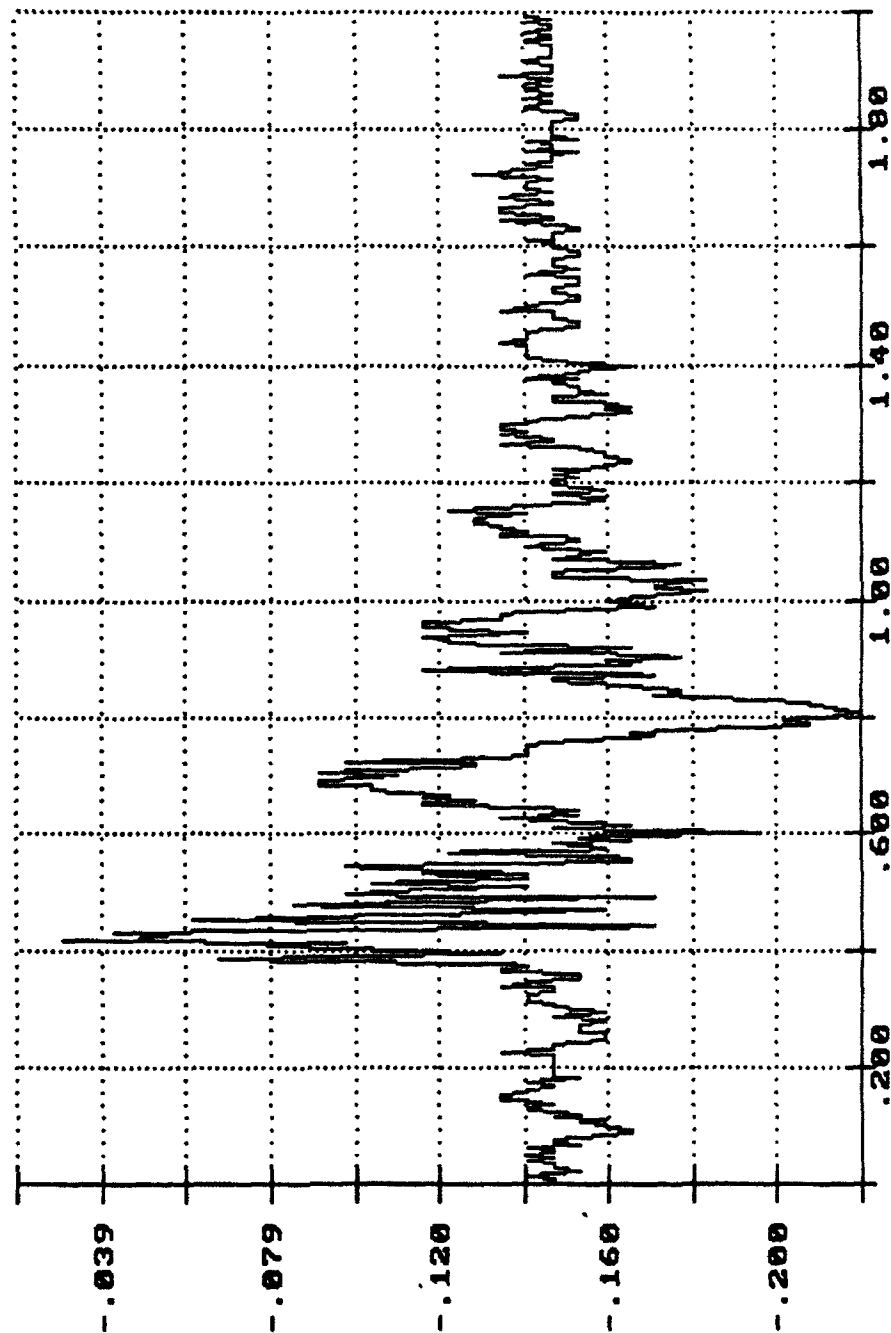


Sample Time in Seconds
X 1.0000

Longitudinal Acceleration on Sill

in G's X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 3: 8.62 MPH



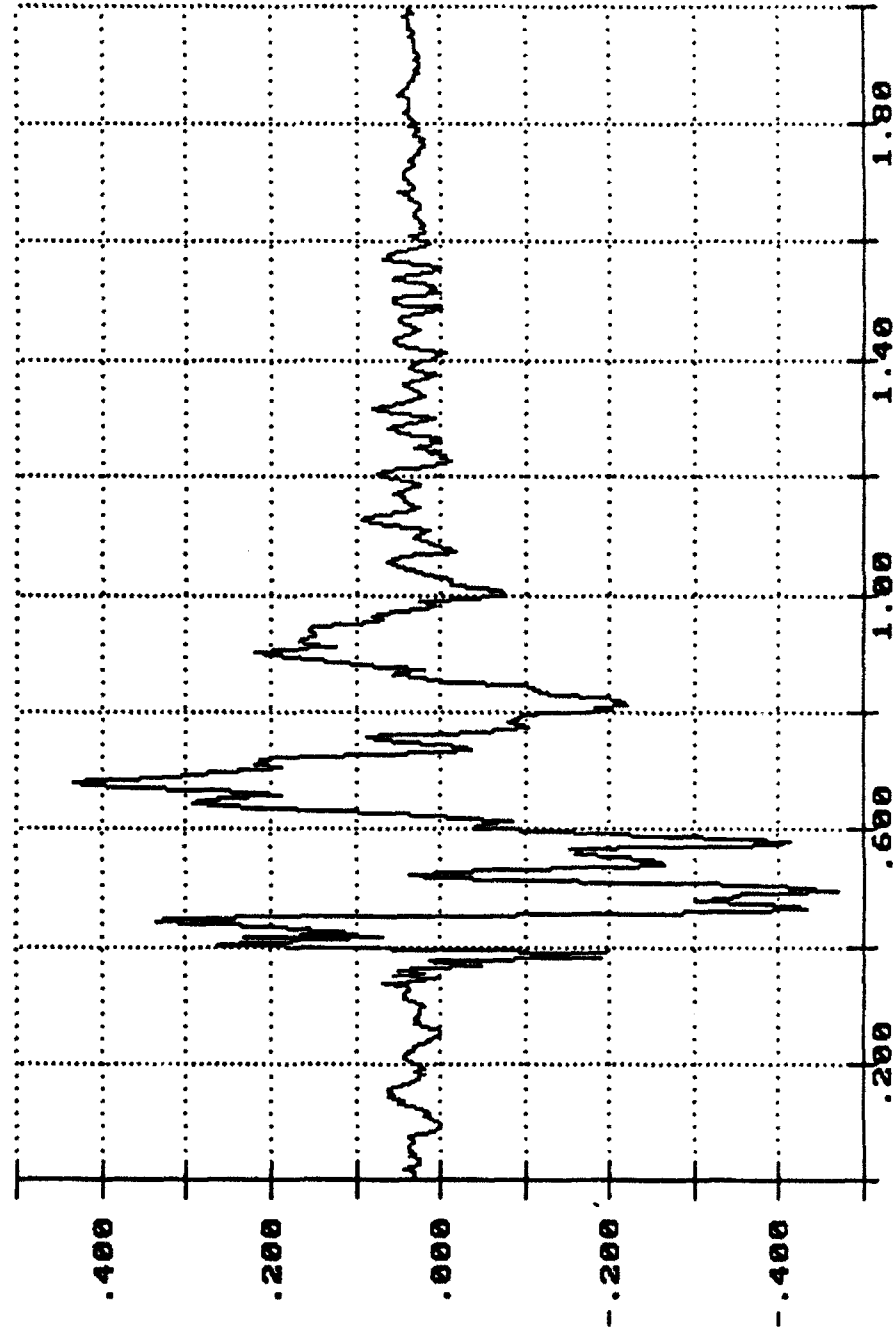
Lateral Acceleration on Sill

in G's X 1.0000

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1998
Impact 3: 8.62 MPH



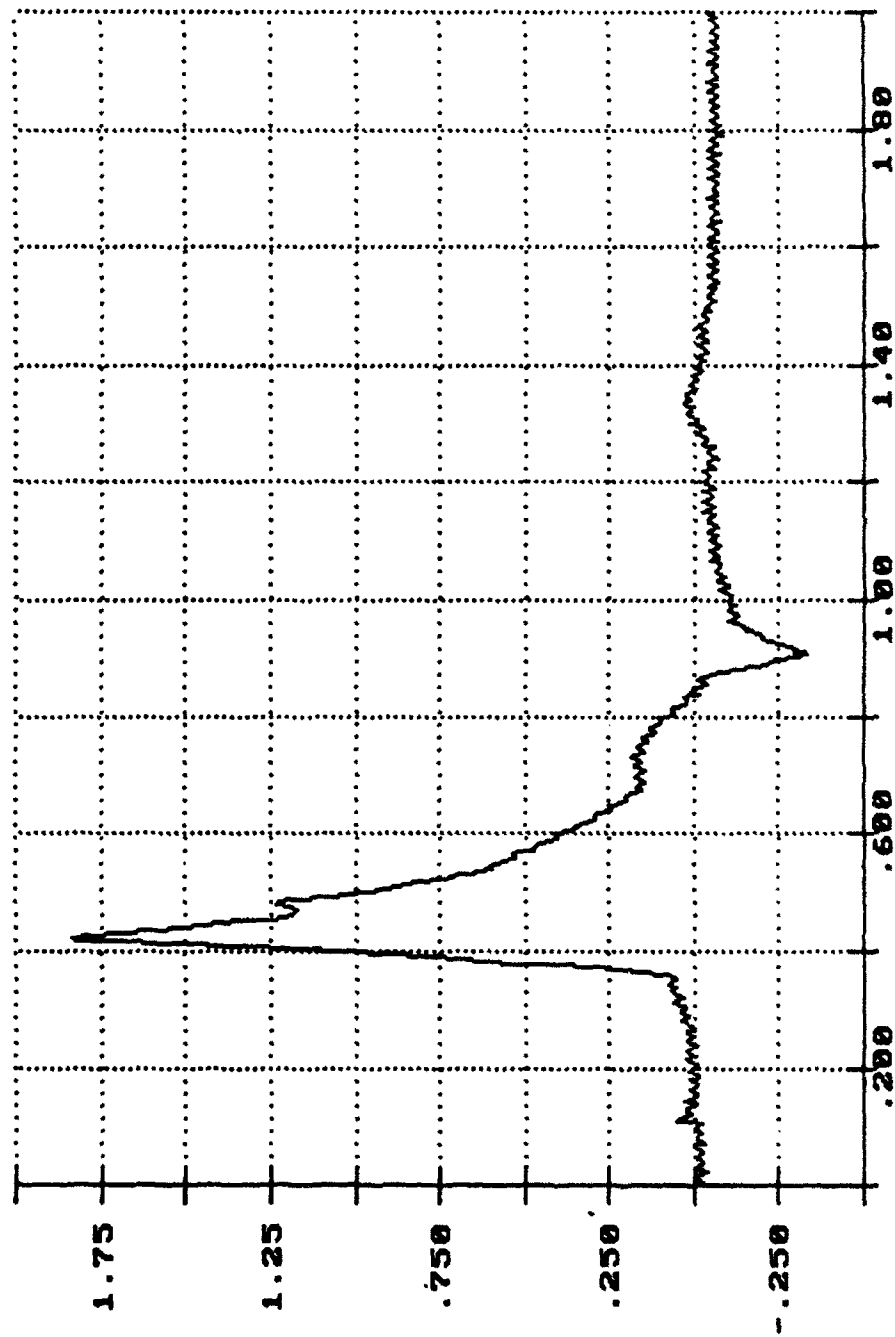
Sample Time in Seconds

X 1.0000

Vertical Acceleration on Sill

in G's X 1.0000

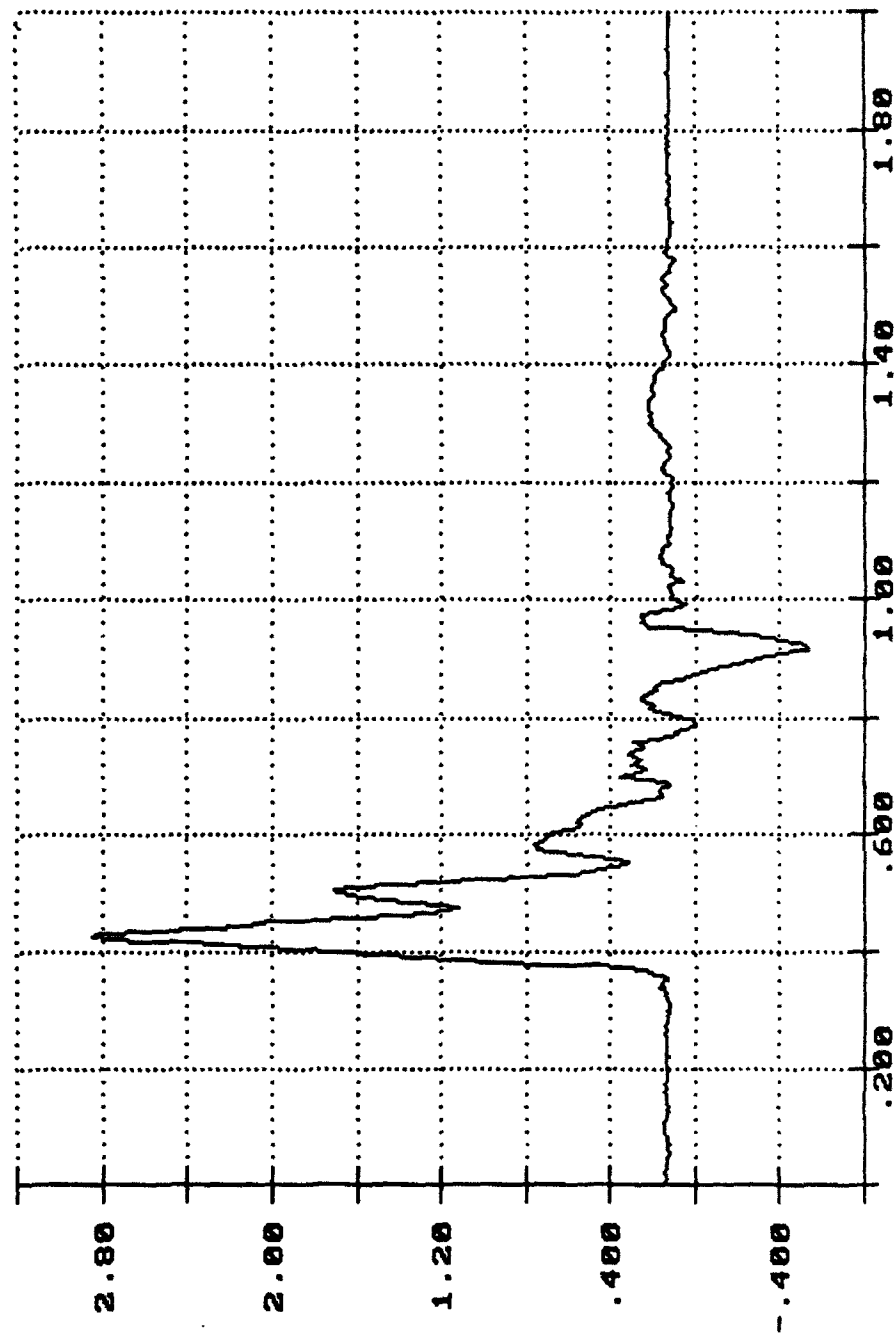
Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 3: 8.62 MPH



Rail Coupler Force
in Pounds X 10000.0000

Sample Time in Seconds
X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1998
Impact 3: 8.62 MPH

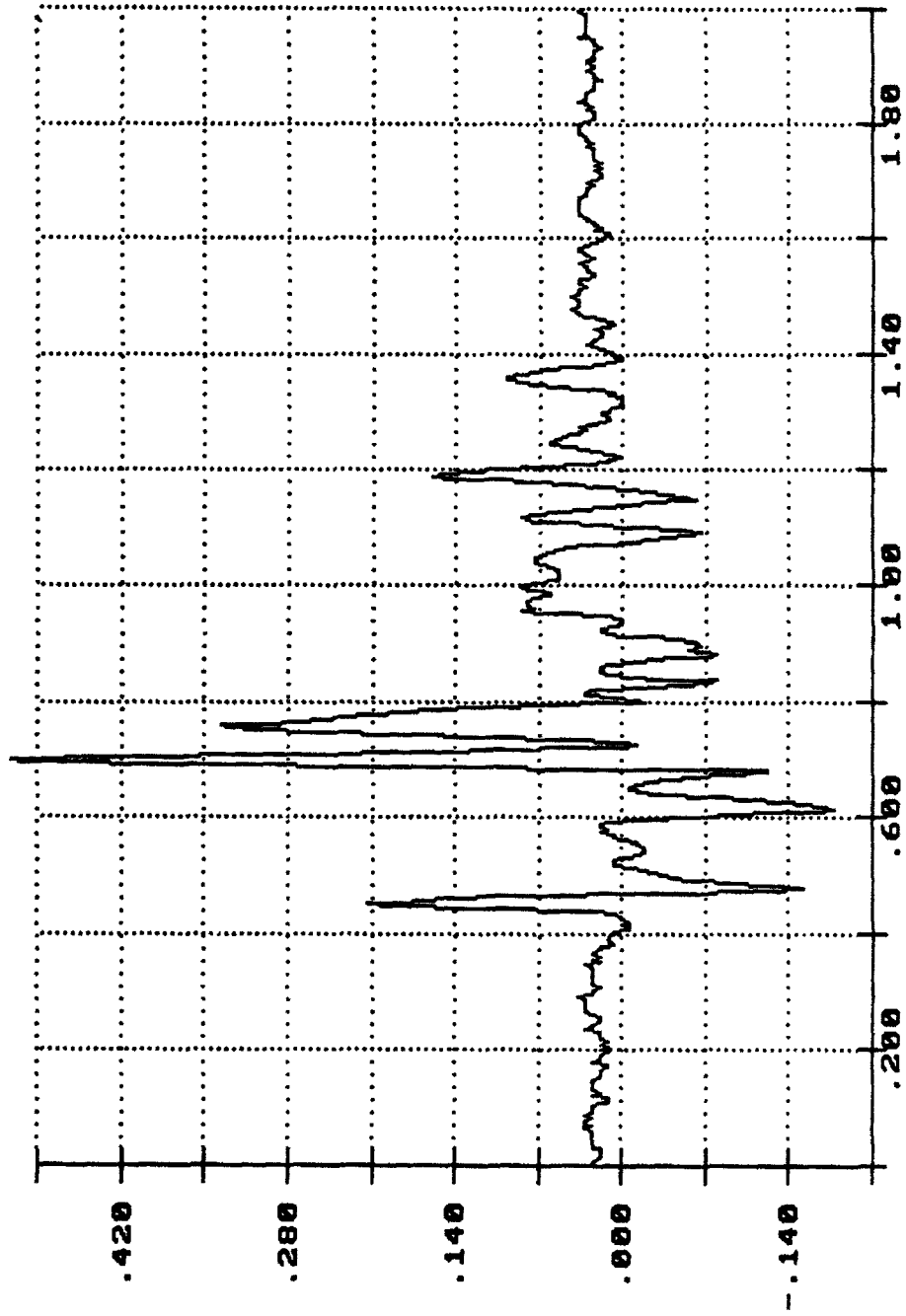


Sample Time in Seconds
X 1.0000

Longitudinal Acceleration on Frame

in G'S X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 3: 8.62 MPH



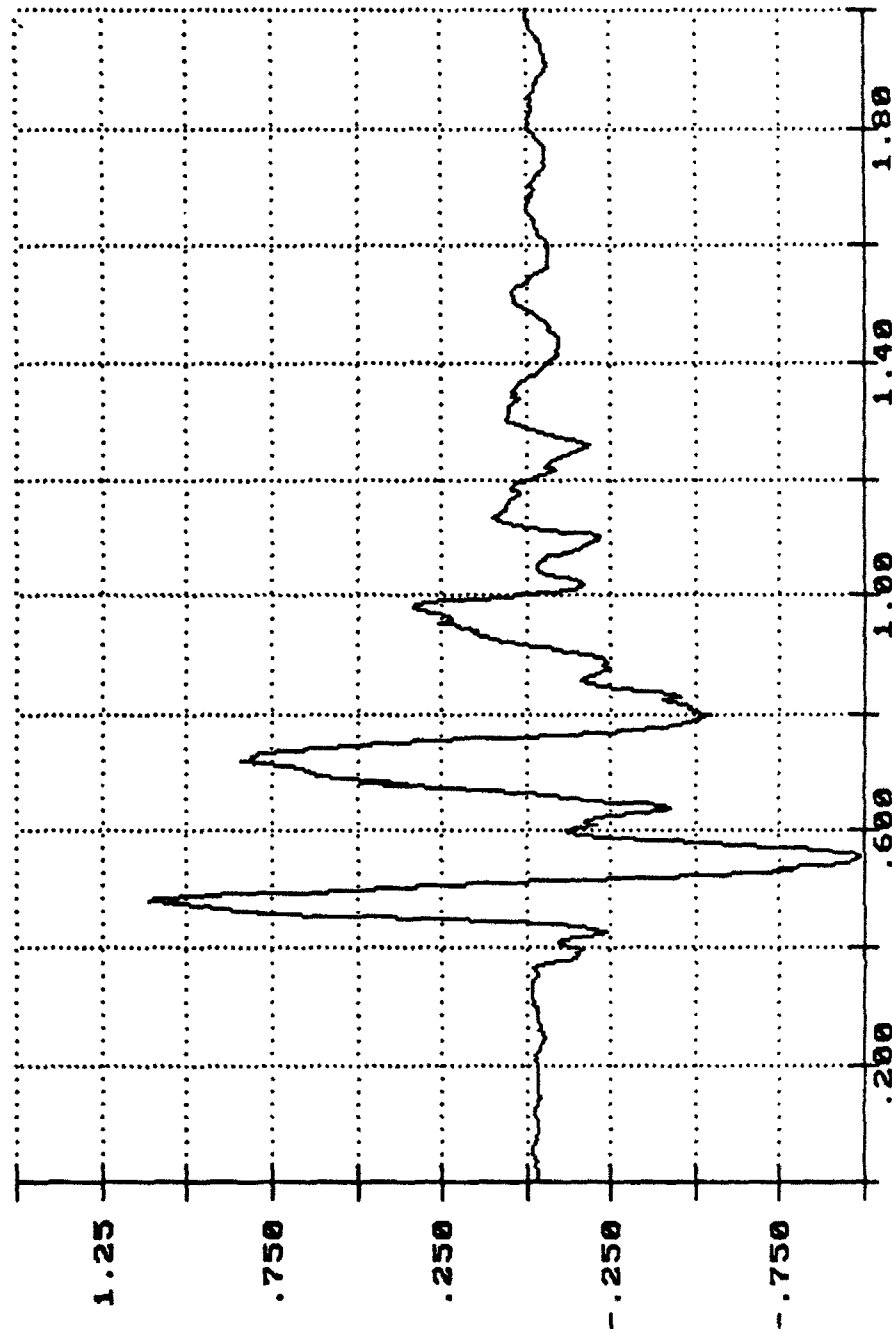
Lateral Acceleration on Frame

in G'S X 1.0000

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1998
Impact 3: 8.62 MPH

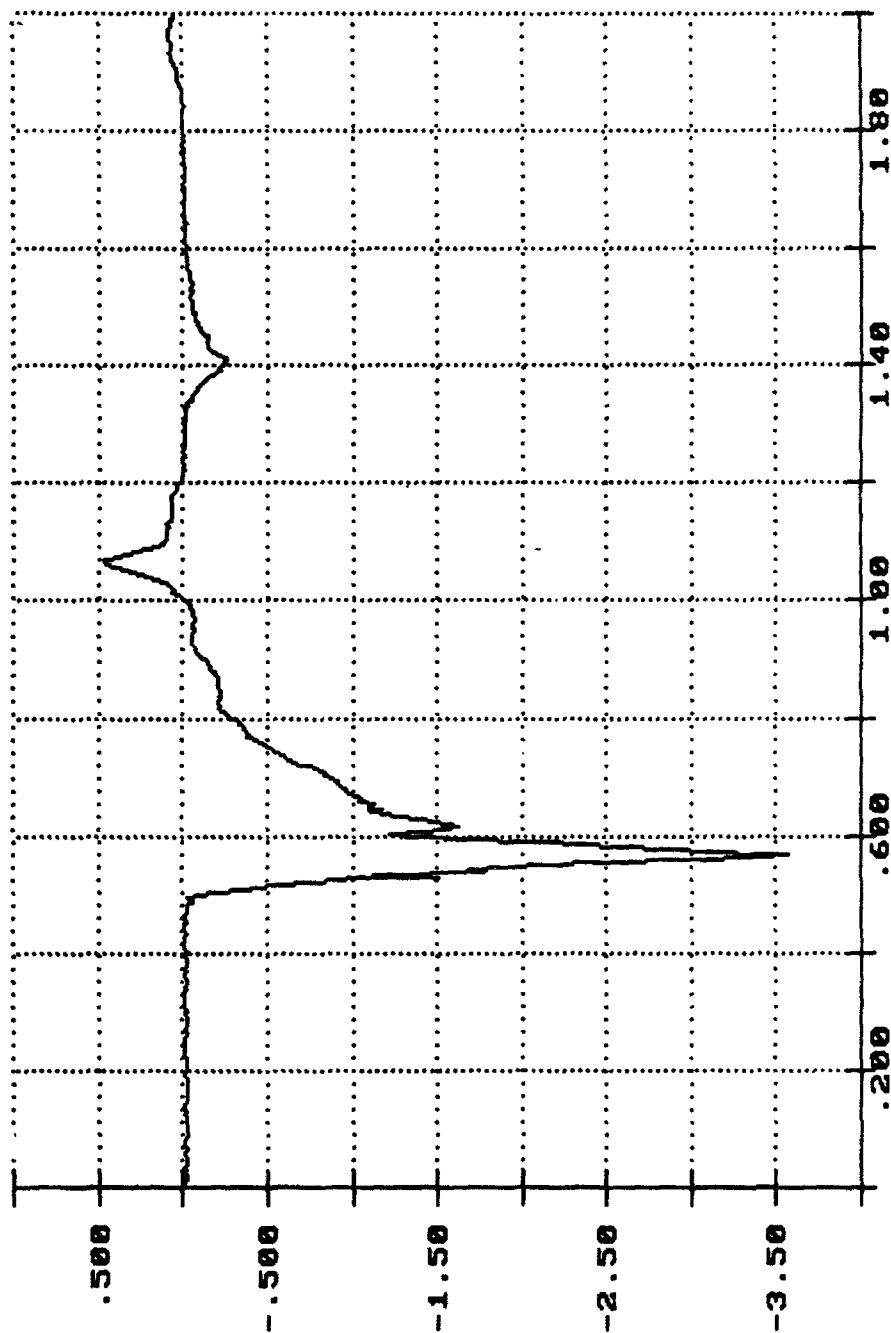


Sample Time in Seconds
X 1.0000

is G's X 1.0000

Vertical Acceleration on Frame

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH



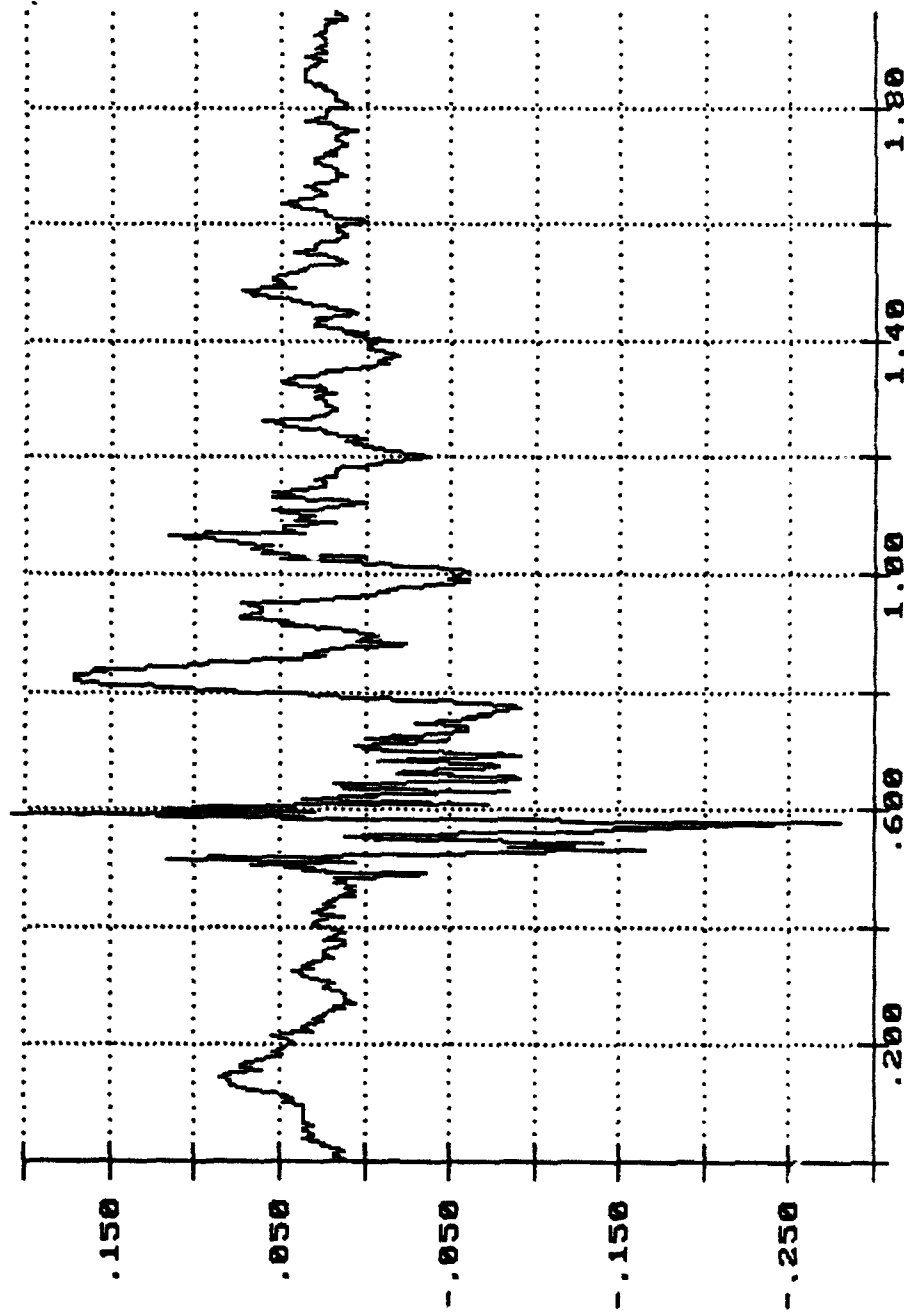
Longitudinal Acceleration on Sill

in G's X 1.0000

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH

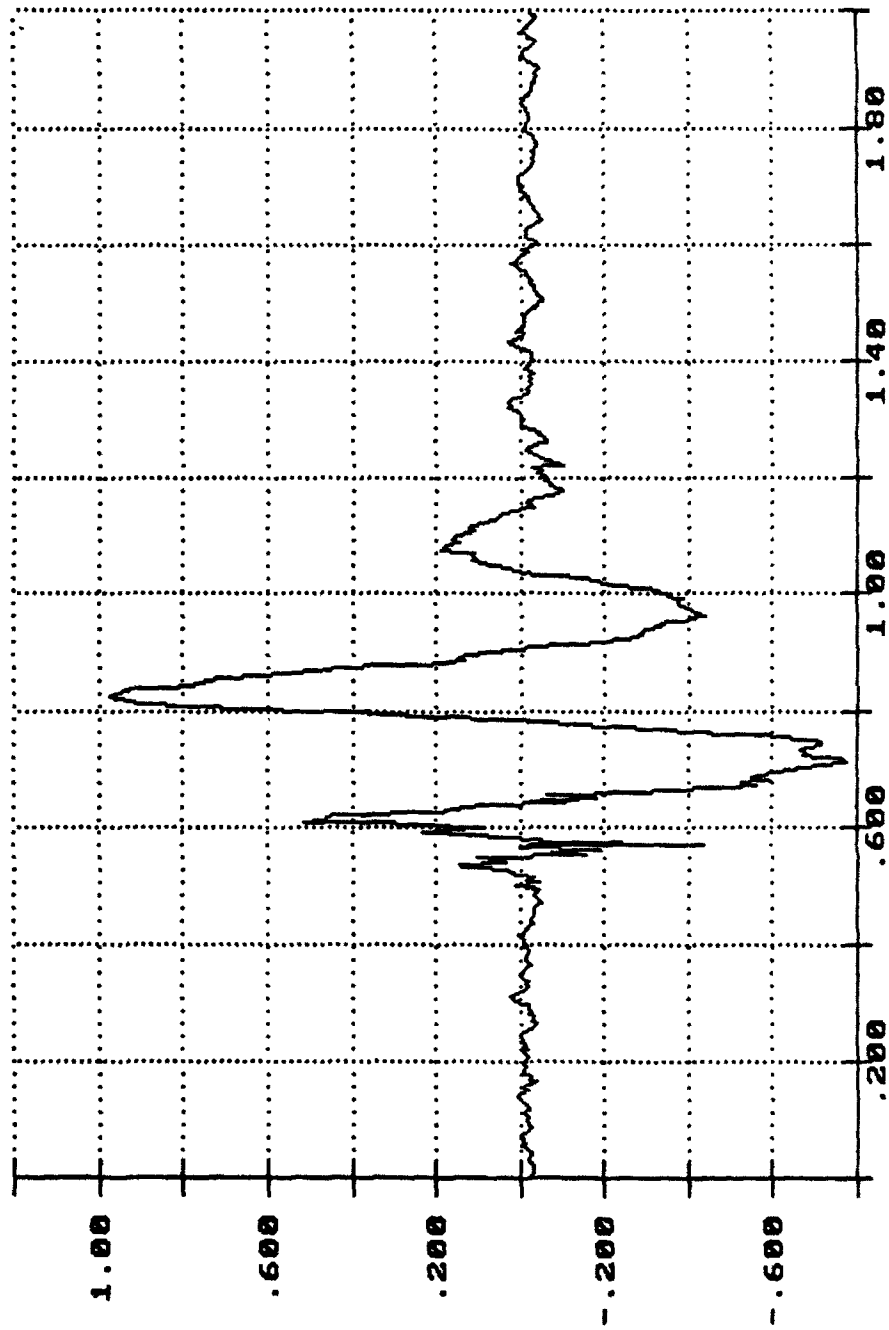


Lateral Acceleration on Sill

in G's X 1.0000

Sample Time in Seconds
X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH



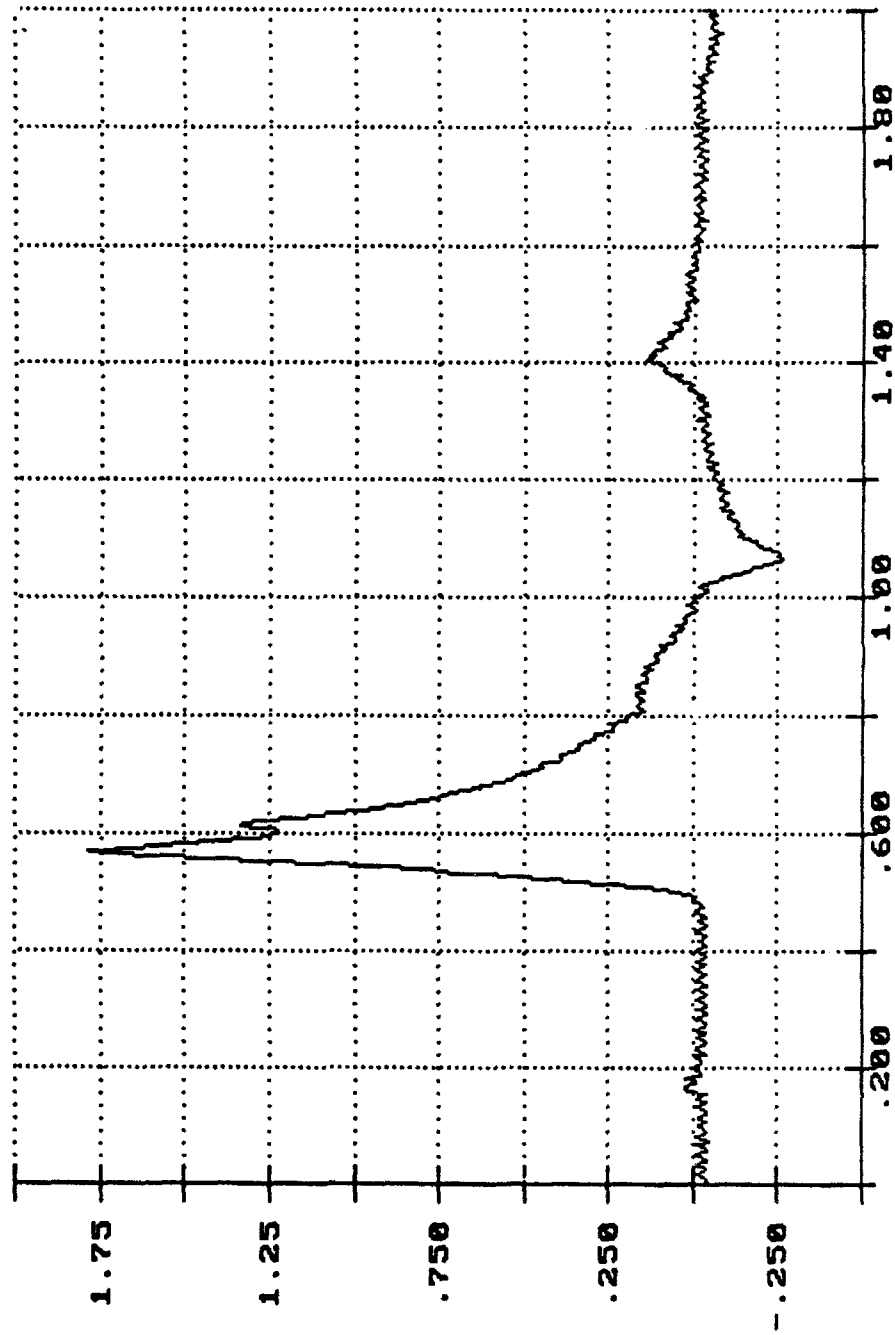
Sample Time in Seconds

X 1.0000

in G'S X 1.0000

Vertical Acceleration on Sill

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH



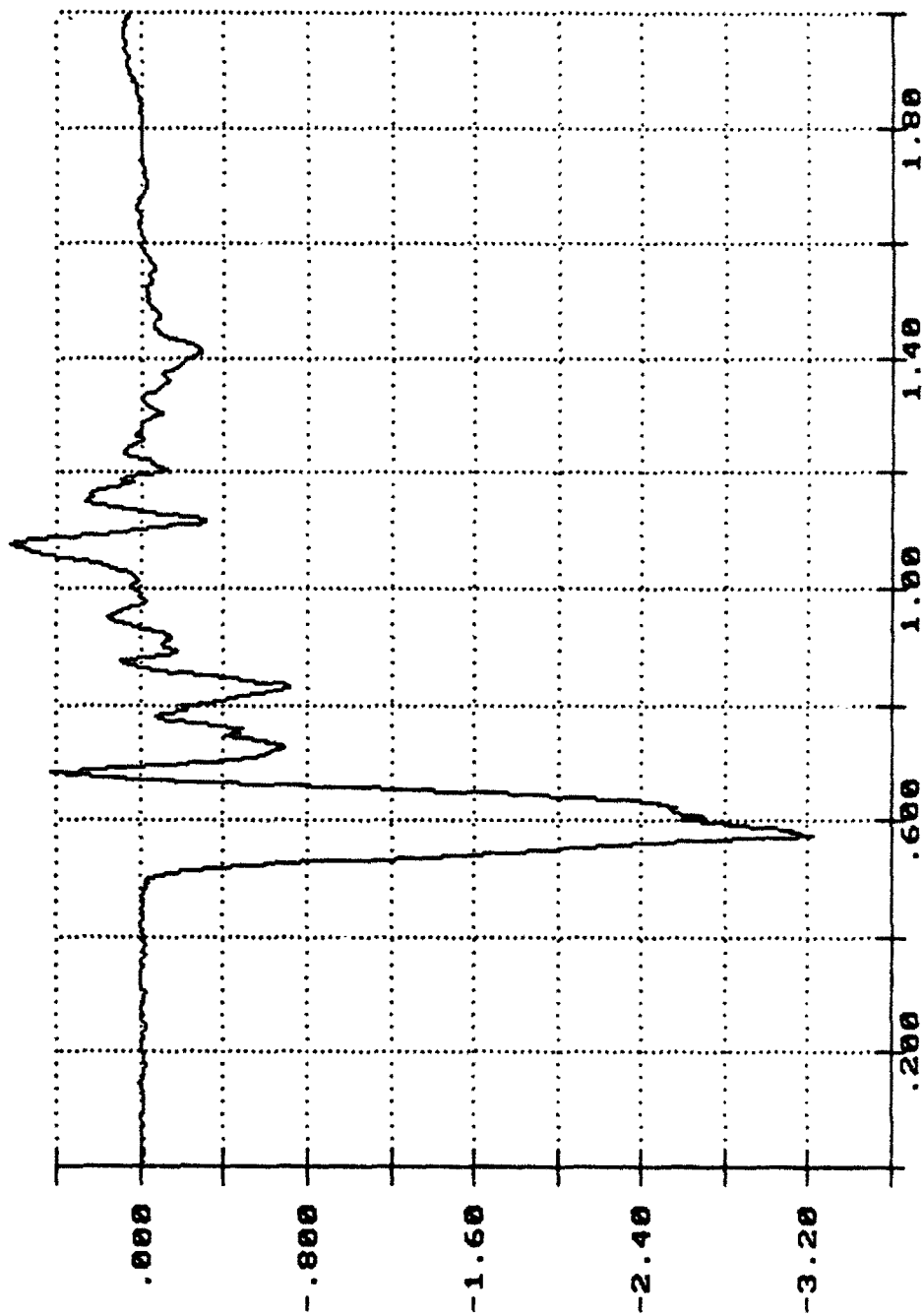
in Pounds X 100000.0000

Rail Coupler Force

Sample Time in Seconds

X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH



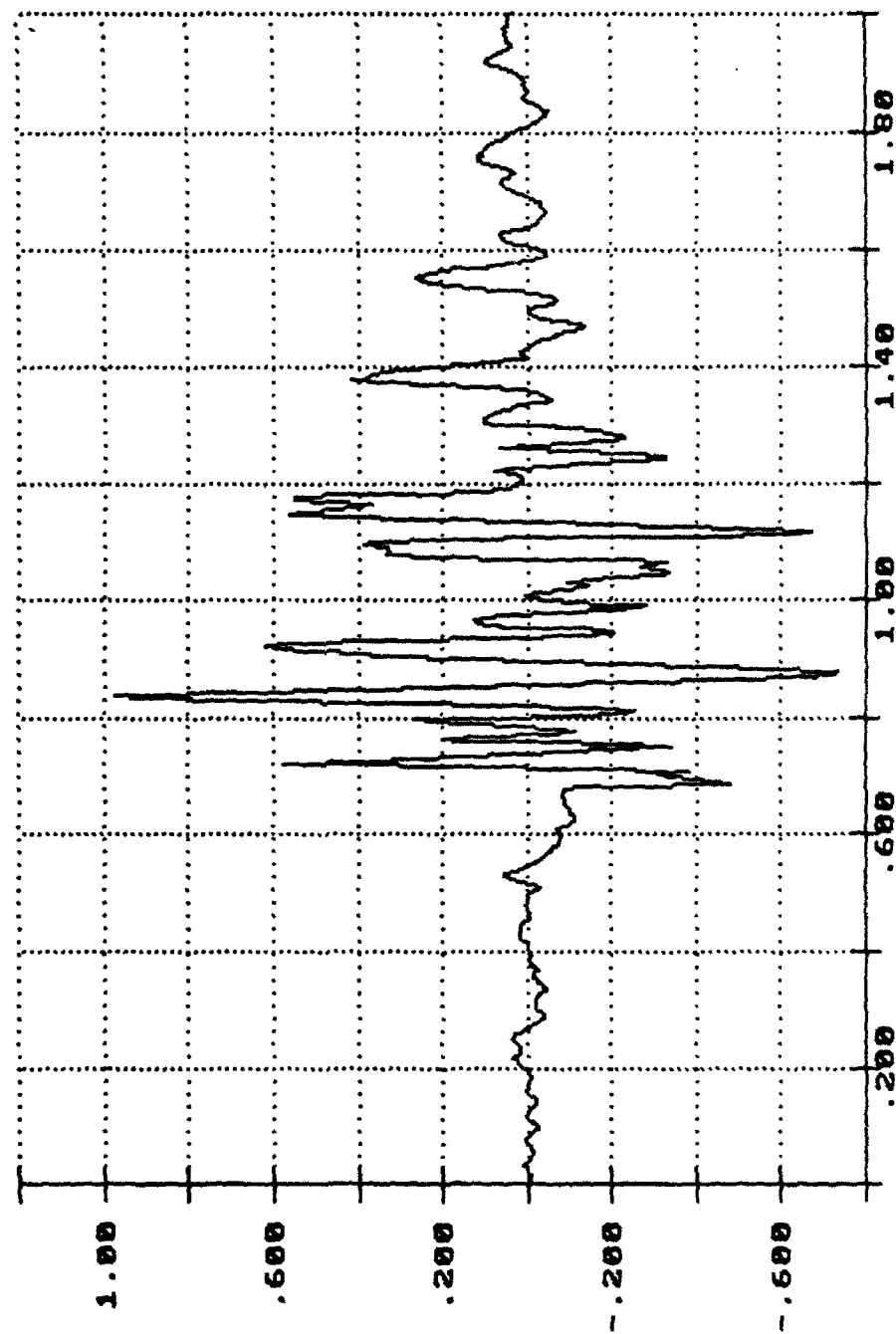
Sample Time in Seconds

X 1.0000

Longitudinal Acceleration on Frame

in G's X 1.0000

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH



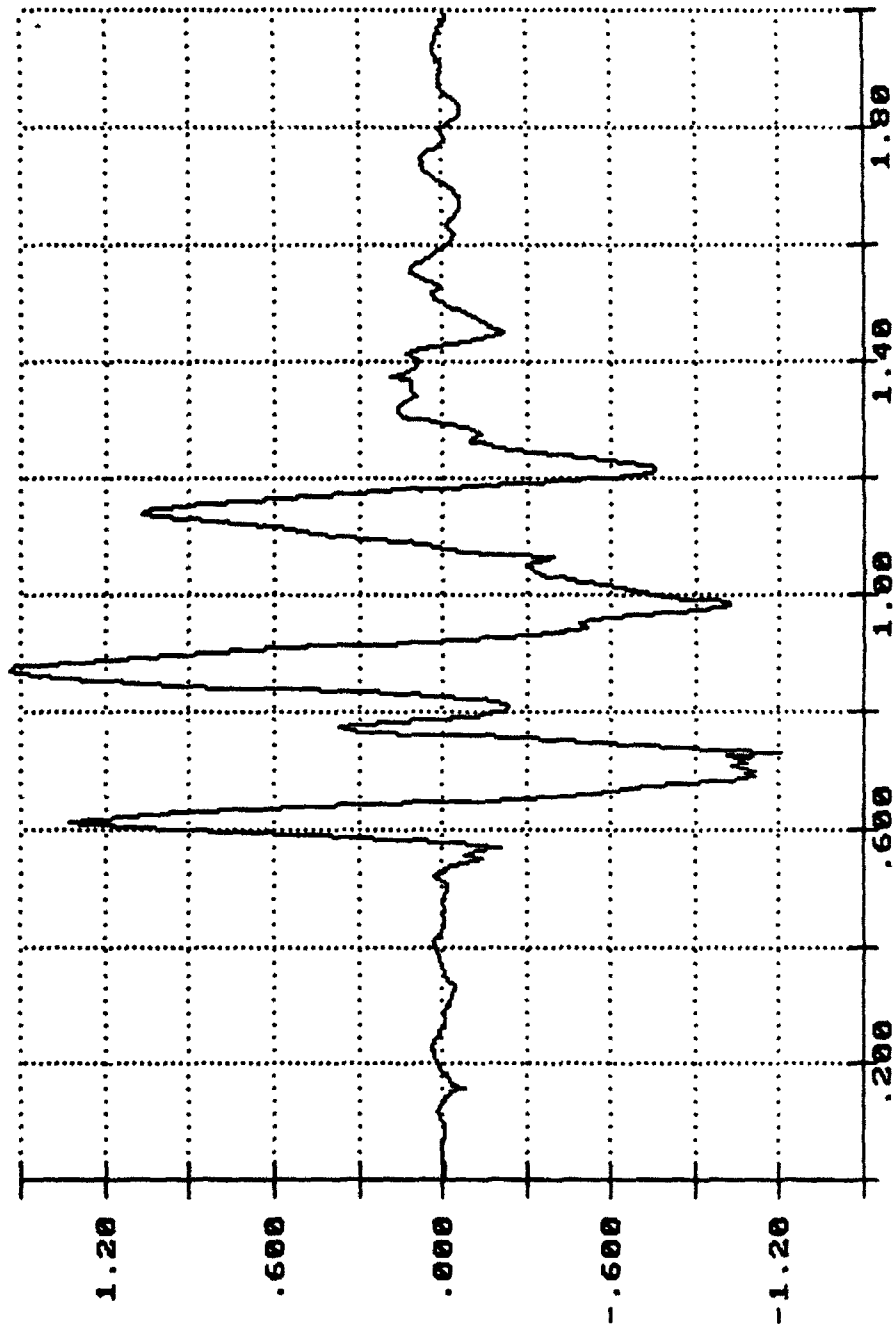
Sample Time in Seconds

X 1.0000

in G'S X 1.0000

Lateral Acceleration on Frame

Rail Impact Test of Rotary Towed Sweeper
Date: 21 August 1990
Impact 4: 8.52 MPH



Sample Time in Seconds

X 1.0000

in G'S X 1.0000

Vertical Acceleration on Frame