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FEASIBILITY STUDY OF EARTH PENETRATION USING MECHANICAL VIBRATION (U)

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FEASIBILITY STUDY OF EARTH PENETRATION USING MECHANICAL VIBRATIONS (U)

Introduction

The object of this test series was to provide the test requestor with preliminary data which he could use to determine the feasibility of using mechanical vibrations to bury a package in the earth.

Tests were performed using three penetrator shapes: the nose and center case section of the TX-57, the nose portion of the "REB", and standard 2-3/4 inch and 2 inch well points.

This test was requested by G. H. Whiting, 5611, on September 3, 1964. R. A. Mikkelsen was the Test Project Engineer. Testing started September 15, 1964 and was completed October 5, 1964.

Summary

A series of tests were performed on three types of soil conditions to determine the feasibility of using mechanical vibrations to bury a package in the earth. Mechanical vibration input was supplied to the test penetrators with the use of a vibration exciter. The vibration exciter was attached to the penetrator and suspended from a crane with the use of a low spring constant suspension system.

The results of the test indicated that the frequency of vibration which appeared to cause the best penetration was independent of the penetrator construction and soil condition. This frequency, which is called the penetration frequency in this report, was found to be 30 cps. No simple explanation can be given at this point of the investigation as to why this frequency appears to give the best results for the different penetrators and soil conditions. The results of the test also seemed to indicate the difficulty which would be encountered in attempting to use mechanical vibrations to bury a package in hard undisturbed soil.

Procedure and Results

Three types of penetrator shapes were used during this test series:

1. The nose and center case section of the TX-57
2. The nose section of the "REB"
3. Standard 2 inch and 2-3/4 inch well point

The setup and procedure varied slightly between tests; however, a general discussion of the setup and procedure will be given at this point. Any changes will be noted in the discussions of the individual tests.

The VM-21 vibration exciter was used to generate the required mechanical vibrations for each of the test shapes. This vibration exciter is an MB model C25 exciter, capable of generating a maximum force of 3000 pounds and a maximum armature displacement of 0.50 inches.

The test shapes were attached to either the exciter table or body with the use of specially designed fixtures. The exciter and test shapes were suspended from a crane using 18 strands of 3/4 inch shock cord as shown in Figure 1. This type of suspension system was used in order to allow various dead loads to be placed on the test shapes and also to allow close monitoring of this load. A 10,000 pound load cell was placed between the shock cord and the exciter. A strain gage indicator, used to monitor the load cell, was zeroed for a given dead load; it was necessary only for the crane operator to keep the strain gage indicator zeroed throughout the test. The suspension system had a spring constant of approximately 30 pounds per inch. Because of this low spring constant, the crane operator was able to hold the dead load on the test shape within ±60 pounds of the required setting.

Three types of soil conditions were used during the test series; loose fill, lightly tamped loose fill, and undisturbed mesa. The preparation of the loose fill consisted of digging a hole and then back-filling the hole with the loosened dirt. The lightly tamped loose fill was prepared by digging a hold and lightly tamping the dirt as the hole was back-filled.

The general test procedure was as follows:

1. One of the three soil conditions was chosen for the test.
2. A given dead load was placed on the penetrator nose (this dead load was generally the smallest dead load in the dead load test range).
3. The maximum attainable input g level was set on the exciter control console.
4. The frequency was then varied within a predetermined frequency range.
5. The frequency which gave the best penetration rate was noted (this frequency is called the penetration frequency)
6. If no penetration was noted, the dead load was increased and steps 4 and 5 were repeated.
7. Using the penetration frequency, the input g level was varied within the values of the test range to determine the minimum g level required for penetration.
8. For some of the tests, the dead loads and input g levels were varied within the values of the test range to determine the effects on penetration.

In this report, the minimum dead load and the corresponding minimum g level are called the penetration dead load and penetration g respectively.

During each of the tests, the input g level was monitored using an accelerometer mounted on the test fixture, in the longitudinal direction of the test item, and at the base of the test item.

A tabulation of test range values and test results is shown in Table I.

Test Using the TX-57 Nose and Center Case Section

Two different methods were used to attach the TX-57 to the 025 exciter. The TX-57 was first attached to the exciter body as shown in Figure 2. A 50 pound weight was mounted on the exciter table. This setup was used first in order to eliminate certain problems which would be encountered if the exciter were turned over and the TX-57 attached to the table. The method of attaching the TX-57 to the body of the exciter limited the input g level to approximately 0.75g; however, it was thought that some preliminary data could be obtained by using this method. Triaxial accelerometers were placed inside the TX-57 at the nose, the midpoint of the center case section, and the top of the center case section. These accelerometers were placed inside the test unit to give correlation data between test item resonance frequencies and frequencies at which penetration was noted. It was initially thought that the best penetration rate would occur at one of the lower resonance frequencies of the test item.

Tests were performed on loose fill, and undisturbed mesa. Dead loads on the nose of the TX-57 were varied between 200 and 3000 pounds. The maximum input level of 0.75g and the frequency range of 20-2000 cps were used. Test item resonance frequencies were found around 380 cps, 1000 cps and 1100 cps. There was no evidence of penetration by the test item in either the undisturbed soil or loose fill at any frequency between 20 and 2000 cps. It was interesting to note that at the lower resonant frequencies, relatively high G levels of 100g to 200g were recorded at the nose of the TX-57. However, no penetration was noted at any of the lower modes.

In order to obtain higher input g levels, the exciter was turned over and the TX-57 was attached to the exciter table as shown in Figure 3. Tests were performed on the loose fill, lightly tamped loose fill, and undisturbed mesa. Dead loads and input g levels were varied between 200 and 1000 pounds, and 1g and 15g respectively. The frequency range of 20-2000 cps was again used for this test. The resonant frequencies of the TX-57 were found to be approximately the same as in the previous test. Again high g levels were recorded at the nose of the TX-57; however, penetration was noted only in the frequency range of 20-60 cps. It began to become evident at this point of the investigation that the assumption that penetration would occur at the lower resonant frequency of the test shape was false. Further investigations indicated that a frequency of 30 cps gave the best

penetration rates in both loose fill and lightly tamped loose fill. It was determined that a minimum dead load of 500 pounds and a corresponding minimum input level of 5g were required for penetration of the loose fill. A maximum dead load of 500 pounds and a corresponding minimum input level of 13g were required for penetration of the lightly tamped loose fill. A maximum dead load of 1000 pounds and a maximum input of 15g were used for the test on undisturbed mesa; however, no penetration was noted for any frequency between 20-2000 cps.

Test Using the Nose Section of the "REB"

The nose section of the "REB" was fastened to a piece of steel tubing which in turn was attached to a table mounted fixture. (See Figure 4). Tests were performed on loose fill, lightly tamped loose fill, and undisturbed mesa. The nose section of the "REB" and attached steel tubing weighed approximately 620 pounds. Because of this high weight, the maximum input was limited to approximately 5g. Dead loads on the test item were varied between 400 and 1000 pounds, and the frequency range of 20-1500 cps was used.

Penetration was noted in loose fill at a frequency of 30 cps, with a dead load of 620 pounds and a maximum input of 5g. The penetration rate was very slow and movement stopped after the unit had gone approximately 15 inches into the ground. An increase in the dead load to 1000 pound yielded no further penetration. No penetration was noted at any frequency in either the lightly tamped loose fill or the undisturbed mesa. Poor penetration using the nose section of the "REB was later attributed to the relatively low maximum input G which could be supplied to the test unit.

Tests Using 2-3/4 Inch and 2 Inch Well Points

Tests were performed on all three soil conditions using standard 2-3/4 inch well point. The well point was attached to 2-inch pipe which was fastened to a table-mounted fixture as shown in Figure 5. Dead loads on the well point were varied between 200 and 1000 pounds. Input levels were varied between 1g and 20g. Because of results obtained from previous tests, the frequency range between 20 and 70 cps was used.

The frequency of 30 cps was again found to give the best penetration rates with each soil condition. The minimum dead load and corresponding minimum G level for penetration of loose fill were 500 pounds and 5g respectively. Lightly tamped loose fill required 500 pounds and 11g.

A dead load of 500 pounds and an input level of 20g were required to obtain penetration of undisturbed mesa. With these levels, the penetration rate was slow and movement stopped after the point had gone approximately 36 inches into the ground. An increase in the dead load to 1000 pounds resulted in no further penetration.

Tests were made on lightly tamped loose fill and undisturbed mesa using the 2 inch well point.

The penetration frequency was found to be 30 cps for both soil conditions. A dead load of 500 pounds and an input level of 3g were required to penetrate the lightly tamped loose fill. A penetration depth of 36 inches was obtained in undisturbed mesa by using a 1100 pound dead load and 15g input level.

Discussion of Results

It is interesting to note that a frequency of 30 cps appears to give the best penetration results regardless of penetrator shape and soil condition. No explanation can be given why this particular frequency appeared to give the best results. The only portion of the test setup which essentially remained unchanged throughout the test series was the use of the VM 21 vibration exciter and its suspension system.

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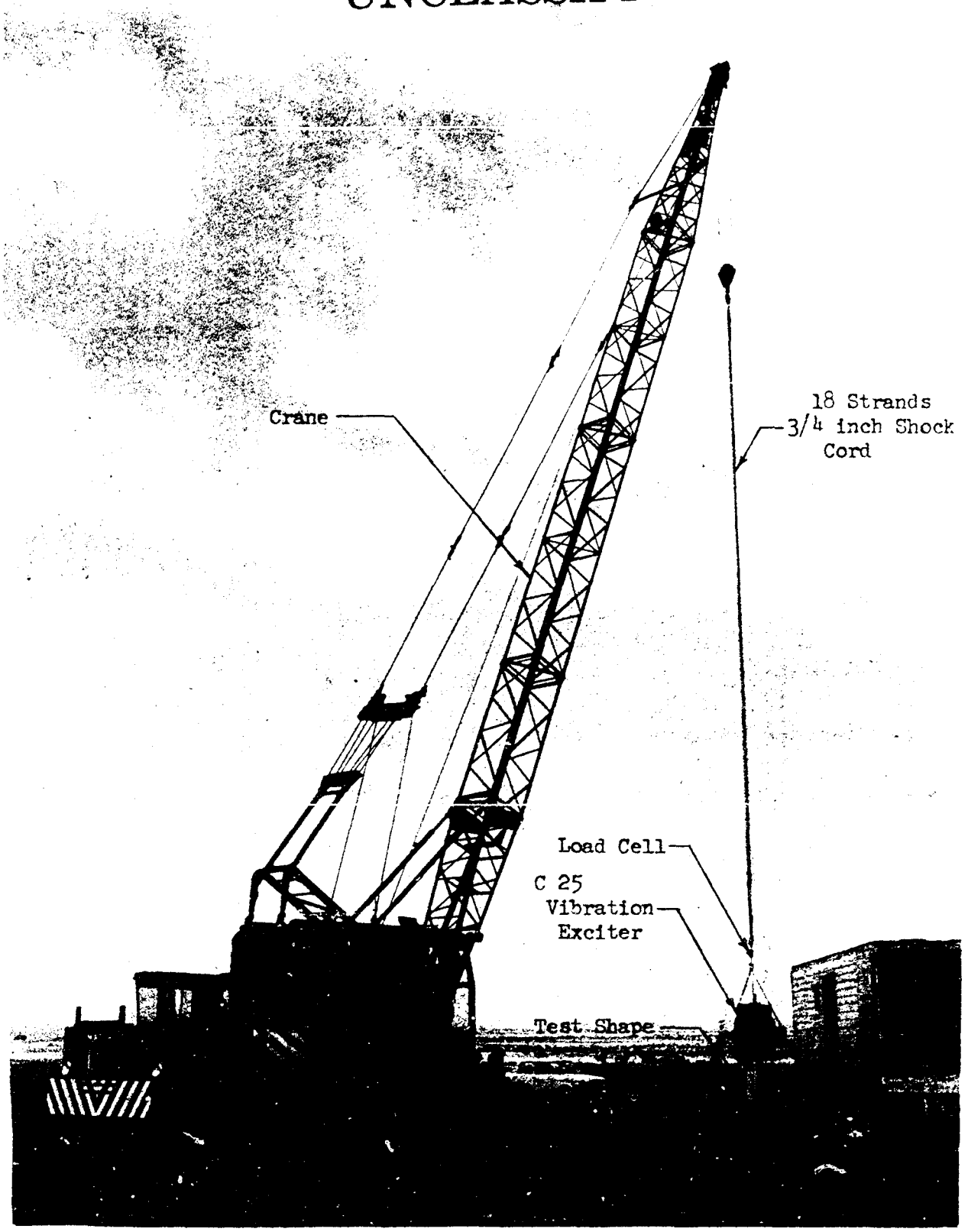

Figure 1 Exciter and Test Item Suspension System D#64-1483

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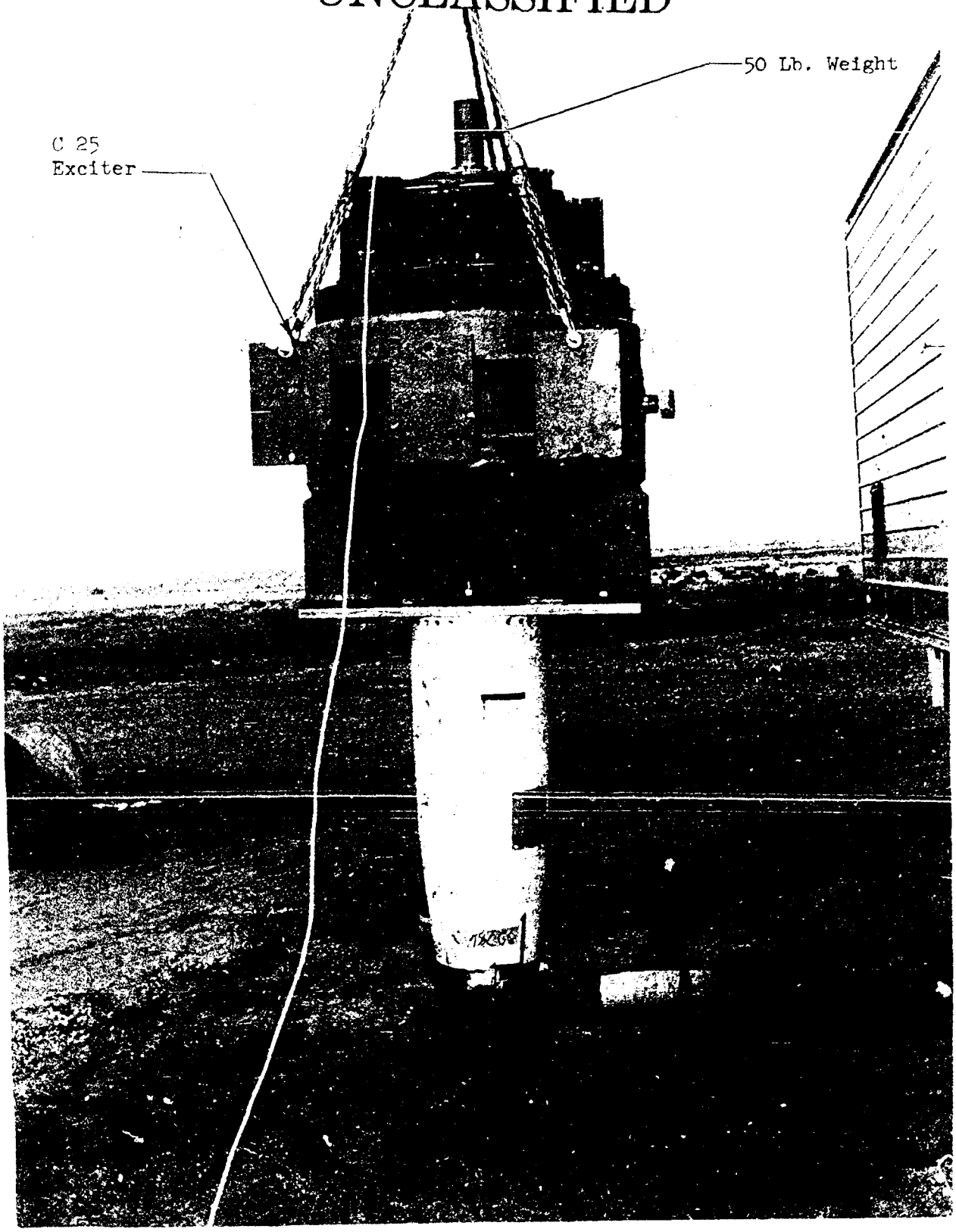

Figure 2 TX 57 Attached to Exciter Body

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Figure 3 TX 57 Attached to Exciter Table

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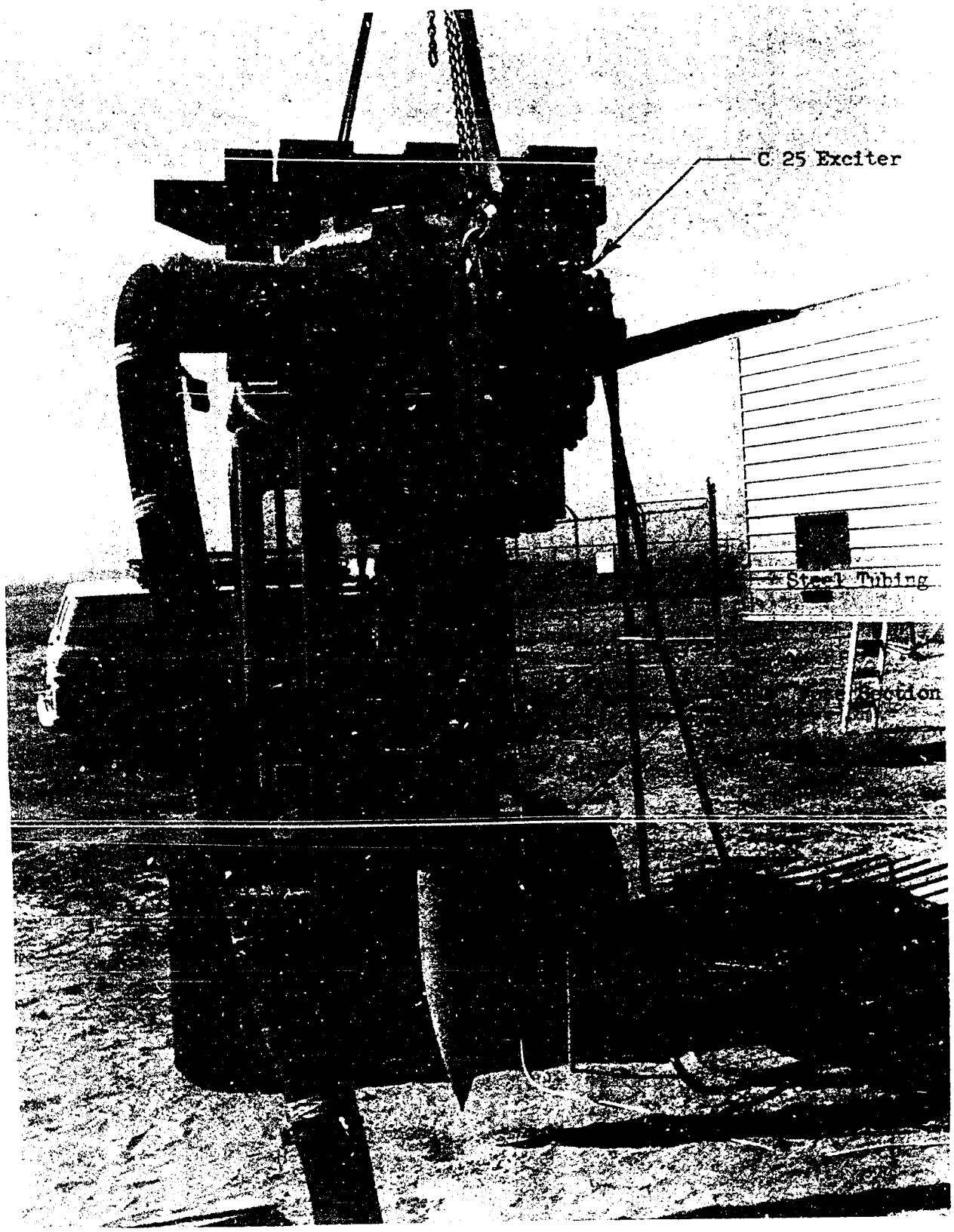

Figure 4 "EB" Nose Section Attached to Exciter Table #64-1500

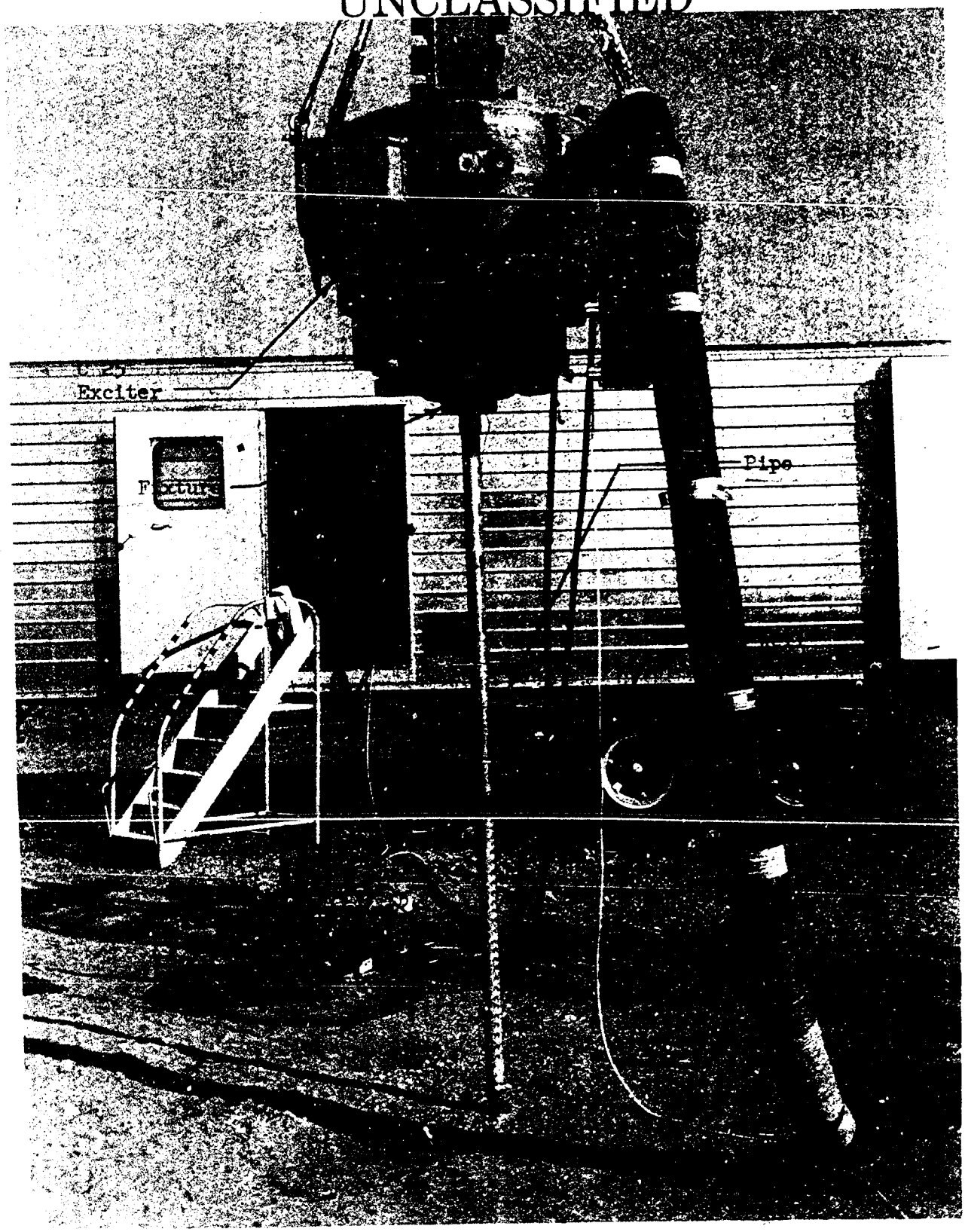

Figure [illegible] Point Attached to Exciter Table

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TEST CONDITIONS AND RESULTS

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SOIL CONDITIONS

TEST SHAPE	LOOSE FILL: FREQUENCY RANGE (CPS)	DEAD LOAD RANGE (LBS)	INPUT G RANGE (G)	PENETRATION FREQ (CPS)	PENETRATION DEAD LOAD (LBS)	PENETRATION G (G)	PENETRATION DEPTH (INCHES)	LIGHT TAMPED LOOSE FILL: FREQUENCY RANGE (CPS)	DEAD LOAD RANGE (LBS)	INPUT G RANGE (G)	PENETRATION FREQ (CPS)	PENETRATION DEAD LOAD (LBS)	PENETRATION G (G)	PENETRATION DEPTH (INCHES)	VERTICALLY [illegible] FILL: FREQUENCY RANGE (CPS)	DEAD LOAD RANGE (LBS)	INPUT G RANGE (G)	PENETRATION FREQ (CPS)	PENETRATION DEAD LOAD (LBS)	PENETRATION G (G)	PENETRATION DEPTH
TX 57	20 To 2000	200 To 1500	1 To 15	30	500	5	24	20 To 2,000	200 To 1,000	1 To 15	30	500	13	5	20 To 2000	200 To 1000	1 To 15	NO PENETRATION WITH MAXIMUM DEAD LOAD AND INPUT G.			
REB	20 To 1500	400 To 1000	1 To 5	30	620	5	15	20 To 1500	400 To 1,000	5	NO PENETRATION WITH MAXIMUM DEAD LOAD AND INPUT G.				20 To 1500	400 To 1,000	5	NO PENETRATION WITH MAXIMUM DEAD LOAD AND INPUT G.			
2 3/4 INCH WELL POINT	20 To 70	200 To 1000	1 To 20	30	500	5	72	20 To 70	200 To 1000	1 To 20	30	500	11	72	20 To 70	1 To 20	5 To 20	30	500	20	36
2 INCH WELL POINT	A TEST WAS NOT PERFORMED FOR THIS SOIL CONDITION							20 To 40	200 To 1,000	1 To 20	30	500	5	60	20 To 40	500 To 1100	5 To 20	20	1100	15	36

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